

APACHE CANADA LIMITED
HAMBURG 2-6 COMPRESSOR
STATION

HAMBURG, ALBERTA

LSD: 02-06-097-11 W6M

DATE: SEPTEMBER, 2000

S.O.#: 99420

OPERATING MANUAL
VOLUME 2

PROPAK COPY
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CPL-295



MAINTENANCE INSTRUCTIONS

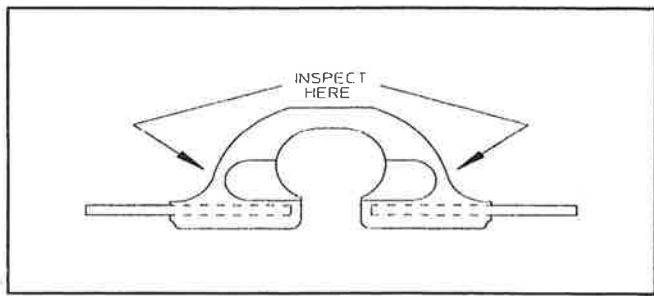
Rexnord Corporation
Elastomer Products Operation
16350 W. Glendale Drive
New Berlin, WI U.S.A. 53151
Phone: 414-796-4060 Fax: 414-796-4064

The Rexnord "OMEGA" coupling is a high quality elastomer type flexible coupling designed to accommodate shock loads, vibration and other reaction forces inherent to rotating equipment. The engineering grade polyurethane material used for the Omega flex element is formulated specifically to absorb these destructive forces resulting in smooth operation, longer component life and lower overall maintenance costs of connected equipment. As the sacrificial component of the drive system, **finite** flex element life can be expected (requiring replacement of the flex element). The Omega coupling's split-in-half bonded flex element design allows for quick and inexpensive replacement of the flex element with no need to disturb the hubs on the shaft or to move connected equipment.

PREVENTATIVE MAINTENANCE

Many Omega couplings have been in operation for 10 years or more with the original flex elements in place. Where feasible, a periodic visual inspection may be all that is necessary to evaluate the condition of the flex element.

When inspecting the element, look for fatigue cracks (over 1/2") originating near the stress relief grooves (approximately 1/4" - 1/2" above the metal shoe), discoloration (a darker faded orange color signals possible material degradation) or surface cracking if used in adverse conditions such as cooling towers or severe environments (pH<4 or >10).



In critical applications, the probability of unexpected downtime can be greatly diminished by scheduling flexible element replacement at regular intervals. The frequency of replacement will depend upon the severity of the application and environmental conditions. A properly sized element which is stored and operated under normal conditions (i.e. under 85% humidity and 85°F) should obtain a minimum of 6 to 8 years of service life after the date of manufacture. A production date sticker is applied to all elements for ease of inspection (I.E. 3Q93 indicates Third Quarter 1993 production).

After the coupling has been in operation for some time, a "torsional set" may develop in the flex element (up to 1/4" on a size E40, even more on larger sizes). This does not affect the performance of the coupling, as it is simply the material creeping under the applied stress. A very large torsional set may suggest a sizing problem and will warrant a close review of the application and coupling selection parameters. For ease of assembly/disassembly, elements should be re-installed in the same "position of rotation" in which they were removed.

ELEMENT REPLACEMENT/INSTALLATION

The unique two part split-in-half flex element was engineered for ease of maintenance/replacement. All half elements are weight matched and packaged in pairs for optimum field balance and smooth operation. For best performance, always install both half elements from the same box. Never replace just one half element, as matching an older and newer half element could create both torsional and balance inconsistencies. Refer to the Omega Coupling Installation Instructions for additional information, including recommended capscrew installation torques.

PREMATURE FAILURES

Should the Omega coupling fail to provide a reasonable service life, review the application parameters and verify the coupling selection before replacing the flex element. Other factors that may contribute to decreased service life include:

- Severe Environmental Conditions
- Severe Torsional Variations
- Excessive Misalignment of Connected Equipment
- Excessive Axial Movement of Connected Equipment
- Shock Loads/Peak Torque Loads Above Rating
- Drive System Critical Speed/Components Incompatibility

Experienced technical assistance is available from Rexnord to answer questions and/or provide failure analysis.

LIMITATIONS

Although the Omega coupling is designed for most general purpose coupling applications, certain limitations should be considered:

- Temperature - Maximum 200°F, Minimum -40°F. A combination of high temperature and high humidity will reduce coupling life. Contact Rexnord for specific application analysis.
- Chemical Environment - "Rule of Thumb" - Urethane resists most chemicals better than rubber. Refer to chemical resistance chart or factory for specifics.
- Space Limitations - Larger O.D. compared to all-metal couplings.
- Reciprocating Equipment - Higher service factors required (refer to Service Factor Table and footnotes on Page E-15 of Omega Bulletin #4000). Avoid applications where both driver and driven equipment are reciprocating.
- Axial Thrust Consideration - If installing on drive system containing sleeve bearings, herringbone gear sets or other systems sensitive to axial thrust, preloading during installation may be required. Consult Rexnord.
- Steam turbines - Steam leakage directly on the element will significantly reduce coupling life.

STORAGE CONDITIONS

As with any elastomer or rubber material, it is subject to aging effects. Flex elements exposed to continuous high temperature and humidity (above 85°F and 85% RH; i.e. tropical climates), while in extended storage, may experience some material degradation (hydrolysis). If these conditions cannot be avoided, elements may be ordered with special moisture-impervious packaging. To maximize service life, it is recommended that the oldest inventory always be used first. Note that flex elements in operation do not experience the same hydrolysis related deterioration rate due to the flexing heat generated. Omega elements made beginning July 1992 contain new additives for hydrolysis resistance which will significantly extend the element life in these environments.

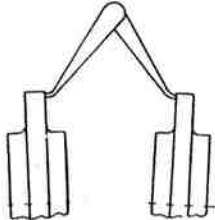
With proper application, the Rex "OMEGA" coupling will provide many years of service driving and protecting your machinery. Prompt, technical assistance is available from your Rexnord representative or direct from the factory at 414-796-4060 (FAX 414-796-4064).

ALINEAMIENTO DEL EQUIPO

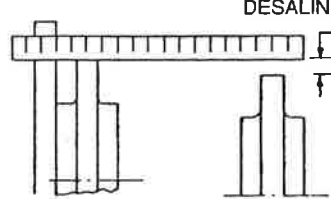
El alineamiento del cople está directamente relacionado a la duración del equipo y del cople.

Aunque los coples Omega pueden soportar desalineamiento notorio, se debe tener cuidado para obtener el mejor alineamiento posible para asegurar un rendimiento óptimo. A continuación se describe el procedimiento de alineamiento del calibrador/escantillón. Si se desea mayor exactitud en el alineamiento, se recomienda un método de indicador de cuadrante. Hay ocasiones en que los fabricantes del equipo requieren más tolerancias específicas de alineamiento en cuyo caso, se deben seguir las recomendaciones del fabricante.

1. Para corregir el desalineamiento angular, use calibres para examinar el espacio entre las mazas. Ajuste o acuñe el equipo hasta que el espacio sea el mismo en todos los puntos alrededor de las mazas.
2. Para corregir el desbalance paralelo, ponga un escantillón a través de las bridas de la maza en dos lugares a 90° uno del otro. Ajuste o acuñe el equipo hasta que el escantillón descansa plano en ambos lados.
3. Apriete el equipo conectado y vuelva a examinar el alineamiento.
4. Instale el elemento elástico, apretando todos los tornillos de ajuste a los valores que se muestran en la Tabla 1 como se describe en el lado inverso.
5. Si es factible, vuelva a examinar y apretar los tornillos de ajuste después de varias horas de operación.



AJUSTE DEL DESALINEAMIENTO ANGULAR



AJUSTE DEL DESALINEAMIENTO PARALELO

DESALINEAMIENTO PARALELO

DIMENSIONES Y NUMEROS DE PIEZAS

Números de Piezas de la Fábrica

ELEMENTO FLEXIBLE			TORNILLOS DE AJUSTE*			
Tamaño	Espaciador	Estándar	Acero al Carbón	Acero Inoxidable	Tamaño-pulg.	Ctd
2	7300075	7300005	7300910	7300938	1/4-20 x 3/8	8 + 8**
3	7300080	7300010	7300912	7300940	1/4-20 x 1/2	8 + 8**
4	7300085	7300015	7300918	7300946		8 + 8**
5	7300090	7300020				8 + 8**
10	7300095	7300025				12 + 8**
20	7300100	7300030	7300920	7300948	3/8-16 x 5/8	12
30	7300105	7300035	7300924	7300952		12
40	7300110	7300040				16
	7300115	7300045				16
	7300120	7300050	7300928	7300956	1/2-13 x 7/8	16
	7300125	7300055	7300934	7300965		16
80	7300130	7300060				7300936
			7385753	7385702		1.0-8 x 1-1/2

Mazas*

Tamaño	Barreno Piloto		Barreno Estándar (Pieza y Márgenes)		TAPER-LOCK™ Mazas		TAPER-LOCK™	Q.D.	Q.D.	Manguito Estándar Ext.
	STD ²	Acero	STD ²	Acero	Hierro	Acero	Buje ¹	Acero	Buje ¹	Acero
2	7300215	7369822	7300220-7300235	7390419-7390422	-	7300730	731008	-	-	-
3	7300240	7369823	7300245-7300265	7390423-7390428	7300800	7300740	731008	7300860	JA	7369575
4	7300270	7369824	7300275-7300300	7390429-7390433	7300805	7300745	731108	7300865	SH	7369576
5	7300305	7369825	7300310-7300335	7390434-7390437	7300810	7300750	731310	7300870	SDS	7369577
10	7300340	7369826	7300345-7300370	7390438-7390442	7300815	7300755	731610	7300875	SK	7369578
20	7300650	7300375	7300651-7300659	7300380-7300400	7300820	7300760	732012	7300880	SF	7369579
30	7300660	7300405	7300661-7300668	7300408-7300425	7300825	7300765	732517	7300885	E	7369580
40	7300670	7300430	7300669-7300679	7300431-7300455	7300830	7300770	732517	7300890	E	7369581
50	7300680	7300460	7300681-7300686	7300461-7300470	7300835	7300775	733020	7300895	F	7369582
60	7300690	7300475	7300692-7300698	7300480-7300495	7300840	7300780	733535	7300900	J	7369583
70	7300700	7300500	-	-	7300845	7300785	734040	7300905	M	7369584
80	7300710	7300525	-	-	7300850	**	734545	**	M	7369834
100	7300720	7300550	-	-	7300855	**	735050	**	N	7369835
120	7300725	7300575	-	-	7300857	**	737060	7300908**	P	-

* Las mazas son intercambiables tanto para el espaciador como para el cople estándar.

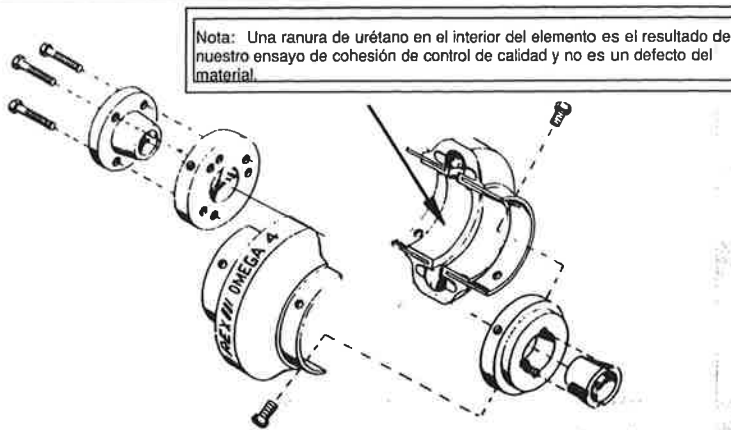
** Consulte a la Fábrica

*** Hierro

1 No provisto por Rexnord

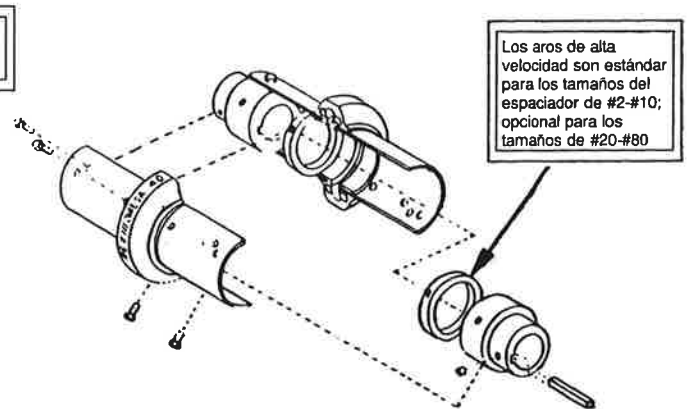
2 Especificaciones del material de la maza estándar: acero sinterizado de alta resistencia (Tamaños #2 - #10), y Hierro Fundido (Tamaños #20 y más altos).

COPE ESTANDAR REX OMEGA



Nota: Una ranura de urétano en el interior del elemento es el resultado de nuestro ensayo de cohesión de control de calidad y no es un defecto del material.

COPE ESPACIADOR REX OMEGA



Los aros de alta velocidad son estándar para los tamaños del espaciador de #2-#10; opcional para los tamaños de #20-#80

Nota: Las mazas Omega son intercambiables ya sea con los elementos estándar o flexibles del espaciador; por ejemplo, se pueden usar las mazas guarnecidas ahusadas con elementos espaciadores y las mazas de agujero recto se pueden usar con los elementos estándar.

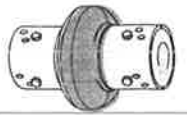
EMPLAZO DEL ELEMENTO: Si se requiere reemplazar el elemento, es importante cambiar ambas mitades de los elementos, nunca reemplace solamente una mitad del elemento. Esto es importante ya que las propiedades de rigidez del elemento pueden cambiar a través del tiempo, y los elementos se empaquetan en pares de igual peso para un mejor equilibrio en las aplicaciones de alta velocidad.



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™ TAPER-LOCK™ es una marca comercial de Reliance Electric Company.

OMEGA COUPLING INSTALLATION INSTRUCTIONS



WARNING

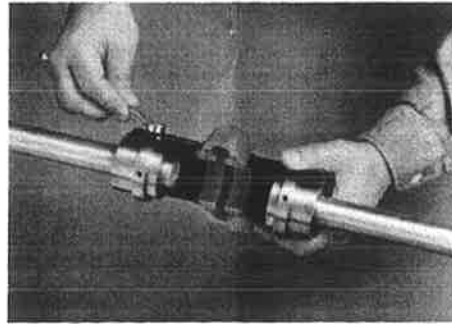
- Because of the possible danger to person(s) or property from accidents which may result from improper use or installation of products, it is extremely important to follow the proper installation, maintenance and operational procedures.
- All rotating power transmission products are potentially dangerous and can cause serious injury. They must be properly guarded in compliance with OSHA and A.N.S.I. standards for the speeds and applications in which they are used. It is the responsibility of the user to provide proper guarding.
- Failure to secure capscrews properly could cause coupling component(s) to become dislodged during operation; resulting in personal injury. Both "Inch" and "Metric" capscrew/hub designs are in service worldwide. Do not attempt to install "Inch" capscrews into a "Metric" hub or visa versa.
- **Do not start motor or jog without the complete coupling being properly secured to driver and driven equipment shafts.**
- Before installing this coupling on any system containing sleeve bearings, herringbone gear sets or other devices sensitive to axial thrust, consult Rexnord.
- It is the responsibility of the user to consider the coupling's stiffness (available from Rexnord) as it relates to the drive system frequency.

STEP 1



Inspect both driving and driven shafts and hub bores making sure they are free from dirt and burrs. Be sure they keys fit shafts properly. Mount both hubs to the shafts securing only one hub; the other hub should be loose for minor adjustment of spacing. Where tapered bushings are used, follow bushing manufacturer's instructions. If hub is bored for an interference fit, we recommend heating the hub in water, oil bath or an oven and quickly positioning it on the shaft. Do not spot heat hub as it may cause distortion.

STEP 2

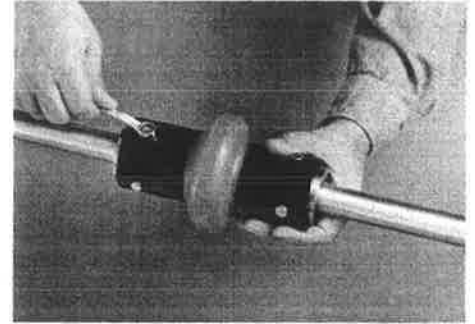


Place half of the elastomer element around hubs and secure with self-locking capscrews. The elastomer element will space the other hub. It is important to have capscrew properly tightened. See Table 1 below for recommended capscrew torques and instructions. Now secure the other hub to the shaft.

HELPFUL HINT:

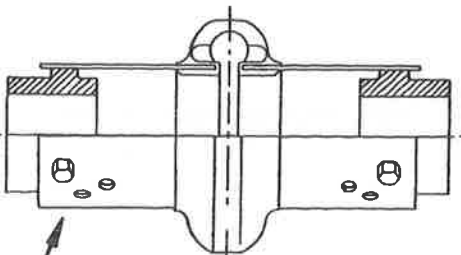
If the capscrew holes in the element do not line up properly with the hubs due to equipment misalignment, rotate the shafts (if possible) slightly as you install each capscrew. On larger coupling sizes, first install the capscrews that are located in the center of the half element.

STEP 3

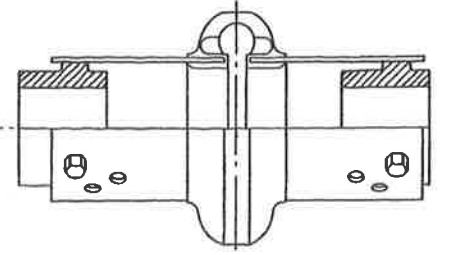


Mount other half of the elastomer element to hubs. Be sure to secure rings to the spacer element if provided. Tighten all capscrews to the recommended capscrew torques in Table 1 and you are done!

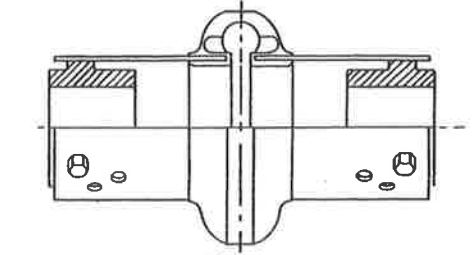
Spacer coupling installation is shown; the same procedure applies for the standard design coupling.



Standard Method
Both hubs mounted outward.



Optional Method
One hub mounted inward; one hub mounted outward.

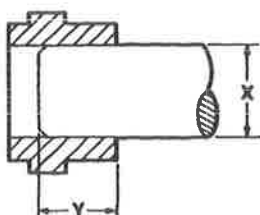


Optional Method
Both hubs mounted inward.

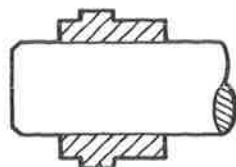
Additional mounting positions are possible with the optional assembly holes on the spacer element. Select the combination which most closely matches the dimension desired between shaft ends.

ALLOWABLE SHAFT ENGAGEMENTS

Shafts can be flush with the hub (not shown), recessed below the face of the hub, or extended beyond the hub face.



Dimension Y should be equal to, or greater than, .8 times dimension X.



The shaft may extend beyond the hub, as long as there is sufficient keyway length available.

TABLE 1

CPLG SIZE	TORQUE - DRY		
	IN. LBS.	FT. LBS.	Nm
2	204	17	23
3			
4			
5			
10			
20	360	30	40
30			
40			
50			
60			
70	900	75	100
80			
100			
120	3240	270	370
140			

RECOMMENDED CAPSCREW TORQUES FOR PROPER INSTALLATION

- IMPORTANT -

Capscrews have self-locking patches which should *not* be reused more than twice.

Capscrews can be further used with application of a thread-locking adhesive.

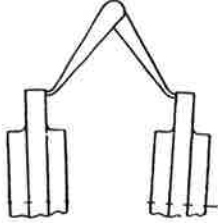
Do Not Lubricate Capscrew Threads

EQUIPMENT ALIGNMENT

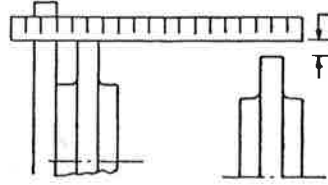
Coupling alignment is directly related to equipment and coupling life.

Although Omega couplings can withstand gross misalignment, care should be taken for best possible alignment to assure optimum performance. The caliper/straightedge alignment procedure is described below. If greater alignment accuracy is desired, a dial indicator method is recommended. There are occasions when equipment manufacturers require more specific alignment tolerances, in which case, the manufacturer's recommendations should be followed.

- To correct for angular misalignment, use calipers to check the gap between hubs. Adjust or shim equipment until the gap is the same at all points around the hubs.
- To correct parallel offset, place a straightedge across the hub flanges in two places at 90° to each other. Adjust or shim equipment until the straightedge lays flat on both sides.
- Tighten down connected equipment and recheck alignment.
- Install elastomer element, tightening all capscrews to the values shown in Table 1 as described on the reverse side.
- If practical, recheck and tighten capscrews after several hours of operation.



ADJUST FOR ANGULAR MISALIGNMENT



ADJUST FOR PARALLEL OFFSET

PARALLEL OFFSET

DIMENSIONS AND PART NUMBERS

Factory Part Numbers

FLEXIBLE ELEMENT			CAPSCREWS*			
Size	Spacer	Standard	Carbon Steel	Stainless Steel	Size-In	Qty
2	7300075	7300005	7300910	7300938	1/4-20 x 3/8	8 + 8**
3	7300080	7300010	7300912	7300940	1/4-20 x 1/2	8 + 8**
4	7300085	7300015				8 + 8**
5	7300090	7300020	8 + 8**			
10	7300095	7300025	7300918	7300946	12 + 8**	
20	7300100	7300030	7300920	7300948	3/8-16 x 5/8	12
	7300105	7300035	7300924	7300952		12
	7300110	7300040				16
	7300115	7300045				16
70	7300120	7300050	7300928	7300956	1/2-13 x 7/8	16
	7300125	7300055	7300934	7300965		16
	7300130	7300060				16
	7300130	7300060				16
100	-	7300065	7300934	7300965	3/4-10 x 1-1/2	20
120	-	7300070	7300936	7300967	-	24
140	-	7300071	7385753	7385702	1.0-8 x 1-1/2	32

Hubs*

Size	Stock Bore				TAPER-LOCK®		TAPER-LOCK®	O.D.	O.D.	Standard
	Rough Bore		(Part & Ranges)		Hubs		LOCK®	Hubs	Bush-	Sleeve
	STD ††	Steel	STD ††	Steel	Iron	Steel	Bushing †	Steel	ing †	Ext.
2	7300215	7369822	7300220-7300235	7390419-7390422	-	-	731008	-	-	-
3	7300240	7369823	7300245-7300265	7390423-7390428	-	7300730	731008	-	-	-
4	7300270	7369824	7300275-7300300	7390429-7390433	7300800	7300740	731008	7300860	JA	7369575
5	7300305	7369825	7300310-7300335	7390434-7390437	7300805	7300745	731108	7300865	SH	7369576
10	7300340	7369826	7300345-7300370	7390438-7390442	7300810	7300750	731310	7300870	SDS	7369577
20	7300650	7300375	7300651-7300659	7300380-7300400	7300815	7300755	731610	7300875	SK	7369578
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40	7300670	7300430	7300669-7300679	7300431-7300455	7300825	7300765	732517	7300885	E	7369580
50	7300680	7300460	7300681-7300686	7300461-7300470	7300830	7300770	732517	7300890	E	7369581
60	7300690	7300475	7300692-7300698	7300480-7300495	7300835	7300775	733020	7300895	F	7369582
70	7300700	7300500	-	-	7300840	7300780	733535	7300900	J	7369583
80	7300710	7300525	-	-	7300845	7300785	734040	7300905	M	7369584
100	7300720	7300550	-	-	7300850	**	734545	**	M	7369834
120	7300725	7300575	-	-	7300855	**	735050	**	N	7369835
140	7300727	7300580	-	-	7300857	**	737060	7300908***	P	-

Cap screws have self-locking patches which should not be lubricated or reused more than twice

** Extra cap screws provided for spacer couplings with rings.

* Hubs are interchangeable for both the spacer and the standard coupling.

** Consult Factory

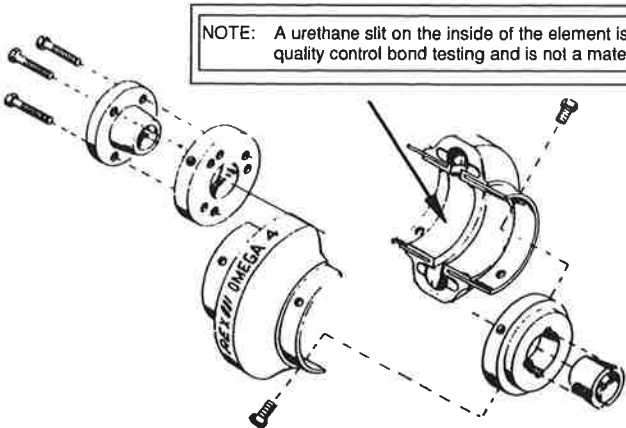
*** Iron

† Not supplied by Rexnord.

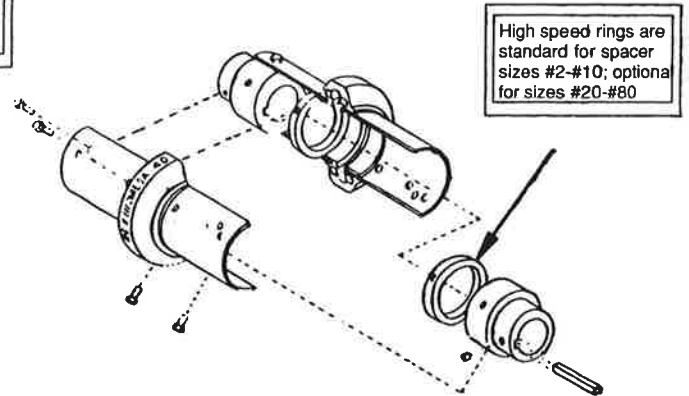
†† Standard hub material specifications: High strength sintered steel (Sizes #2 - #10), and Cast iron (Sizes #20 and above).

REX OMEGA STANDARD COUPLING

REX OMEGA SPACER COUPLING



NOTE: A urethane slit on the inside of the element is the result of our quality control bond testing and is not a material defect.



High speed rings are standard for spacer sizes #2-#10; optional for sizes #20-#80

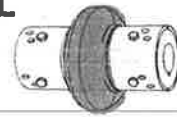
NOTE: Omega hubs are interchangeable with either standard or spacer flex elements; i.e., taper bushed hubs can be used with spacer elements and finished straight bore hubs can be used with standard elements.

ELEMENT REPLACEMENT: If element replacement is required, it is important to change both half elements, never replace just one half element. This is important because the element stiffness properties may change over time, and elements are packaged in weight matched pairs for better balance on high speed applications.

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ADVERTENCIA

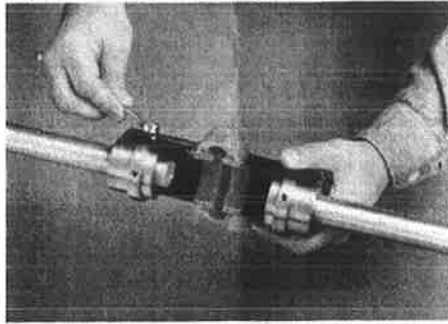
- Debido al posible daño a personas o propiedades por accidentes que puedan resultar por el uso o instalación inapropiada del producto, es extremadamente importante que las instrucciones de instalación, mantenimiento y operación sean seguidas de forma apropiada.
- Todos los productos giratorios de transmisión de potencia son extremadamente peligrosos y pueden causar daños serios. Deben estar debidamente protegidos de acuerdo a los estándares de la OSHA y A.N.S.I para las velocidades y aplicaciones en las que se usan. El usuario tiene la responsabilidad de proporcionar protección adecuada.
- El hecho de no asegurar los tornillos de ajuste adecuadamente podría causar que el(los) componente(s) del cople se salgan durante la operación, resultando en daños personales. Los diseños para tornillo de ajuste/maza tanto en "Pulgadas" como "Métrico" se usan mundialmente. No trate de instalar tornillos de ajuste de "Pulgadas" en una maza "Métrica" o viceversa.
- No arranque ni haga sacudir el motor sin haber asegurado adecuadamente el cople completo en el impulsor y en los ejes del equipo de impulsión.
- Antes de instalar este cople en cualquier sistema que contenga chumaceras de Buje, conjuntos de engranes con dientes angulares u otros dispositivos sensitivos al empuje axial, consulte a Rexnord.
- El usuario tiene la responsabilidad de considerar la rigidez del cople (Disponible en Rexnord) según se relaciona a la frecuencia del sistema de transmisión.

PASO 1



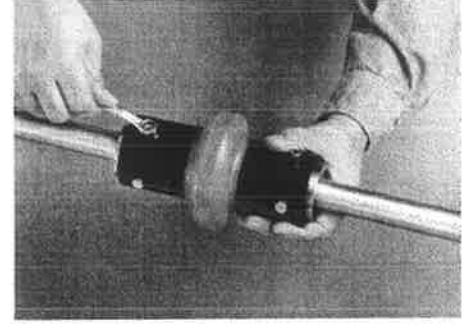
Inspeccione tanto los ejes impulsores como los impulsados y los agujeros de la maza cerciorándose de que estén libres de polvo y rebabas. Asegúrese de que las chavetas se ajusten a los ejes adecuadamente. Instale ambas mazas en los ejes asegurando sólo una maza; la otra maza debe quedar floja para hacer ajustes menores de espacio. Cuando se usan bujes ahusados, siga las instrucciones del fabricante de los bujes. Si la maza está perforada para un ajuste de interferencia, recomendamos calentar la maza en agua, baño de aceite o un horno y colocarlo rápidamente en el eje. No caliente la maza en un solo lugar ya que podría causar torcimiento.

PASO 2



Ponga la mitad del elemento elastomero alrededor de las mazas y asegure con tornillos de ajuste de seguridad. El elemento elástico espaciará la otra maza. Es importante apretar adecuadamente el tornillo de ajuste. Vea la Tabla 1 abajo para las torsiones e instrucciones del tornillo de ajuste recomendadas. Ahora asegure la otra maza al eje.

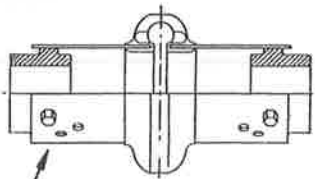
PASO 3



Instale la otra mitad del elemento elástico a las mazas. Cerciórese de asegurar los aros al elemento del espaciador si viene con éste. Apriete todos los tornillos de ajuste de acuerdo a las torsiones recomendadas en la Tabla 1 y ¡ya ha terminado! Se muestra la instalación del cople espaciador; el mismo procedimiento se aplica para el cople de diseño estándar.

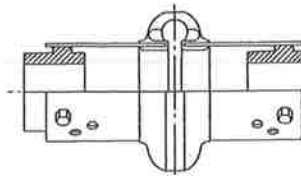
CONSEJO PRACTICO:

Si los agujeros del tornillo de ajuste en el elemento no se alinean adecuadamente con las mazas debido al desalineamiento del equipo, gire los ejes (si es posible) ligeramente mientras instala cada tornillo de ajuste. En tamaños de acoplamiento más grandes, primero instale los tornillos de ajuste que están localizados en el centro de la mitad del elemento.



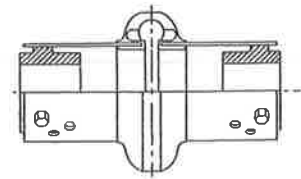
Método Estándar

Ambas mazas montadas hacia afuera



Método Opcional

Una maza montada hacia adentro; una maza montada hacia afuera



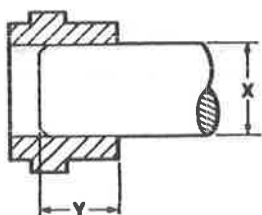
Método Opcional

Ambas mazas montadas hacia adentro

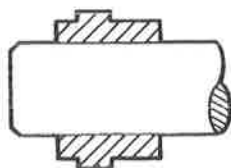
Es posible tener posiciones adicionales de montaje con los agujeros de ensamblado opcional en el elemento espaciador. Elija la combinación que encaje mejor la dimensión deseada entre los extremos del eje

ACOPLAMIENTOS DE FLECHA PERMITIDOS

Las flechas pueden emparejarse con la maza (no se muestra), medidas dentro de la maza, o extendidas más allá de la maza.



La dimensión Y debe ser igual, o mayor que, 8 veces la dimensión X.



La flecha puede extenderse más allá de la maza, mientras haya disponible suficiente longitud de la ranura de chaveta.

TABLA 1

TAMAÑO Del cople	TORQUE - SECO		
	Pulg. LBS.	Pies LBS.	Nm
2			
3			
4	204	17	23
5			
10			
20			
30	360	30	40
40			
50			
60			
70	900	75	100
80			
100			
120	3240	270	370
140	7080	590	800

TORQUE DEL TORNILLO DE AJUSTE RECOMENDADO PARA LA INSTALACION ADECUADA

- IMPORTANTE -
Los tornillos de ajuste tienen clavijeros de seguridad los cuales no deben usarse más de 2 veces.

Los tornillos de ajuste pueden usarse en otra ocasión con una aplicación de adhesivo de trabado de rosca.

No Lubrique Las Roscas del Tornillo de Ajuste.

KD-200

Waukesha[®]

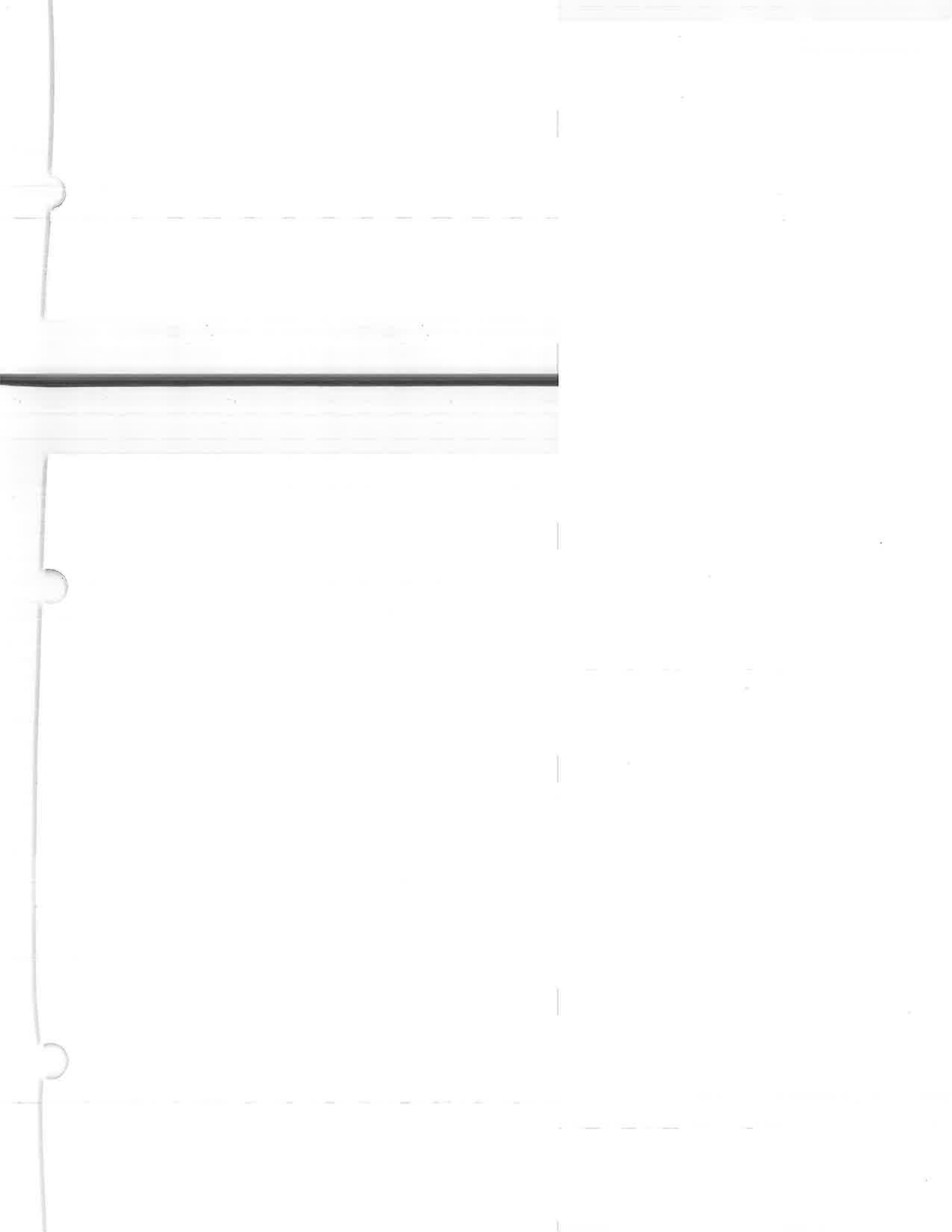
IM[™]

Custom Engine Control
Ignition Module
Installation, Operation &
Maintenance

First Edition



Form 6272



Waukesha[®]

IM[™]

Custom Engine Control Ignition Module Installation, Operation & Maintenance

First Edition

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Printed on Recycled Paper

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**Waukesha Engine Division - Dresser Industries,
Inc.**

Express Limited Warranty For Custom Engine Control®

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Your purchase of a Custom Engine Control® Ignition Module was a wise investment. In the industrial engine field the name, Waukesha Engine, stands for quality and durability. With normal care and maintenance this equipment will provide many years of reliable service.

Before placing the Ignition Module in service read Chapter 1 very carefully. This chapter covers Safety and General Information.

Section 1.00 - Safety Section - Provides a list of warnings and cautions to make you aware of the dangers present during operation and maintenance of the engine. - **READ THEM CAREFULLY AND FOLLOW THEM COMPLETELY** -

Section 1.05 - General Information - Provides conversion tables, wiring information, power requirements for Custom Engine Control® products, and capacitive discharge and grounding information.

Section 1.10 - Description of Operation - Provides basic data on the Ignition Module such as: system description, theory of operation, and definitions.

ALWAYS BE ALERT FOR THE SPECIAL WARNINGS WITHIN THE MANUAL TEXT. THESE WARNINGS PRECEDE INFORMATION THAT IS CRUCIAL TO YOUR SAFETY AS WELL AS OTHER PERSONNEL WORKING ON OR NEAR THE ENGINE. CAUTIONS OR NOTES IN THE MANUAL CONTAIN INFORMATION THAT RELATES TO POSSIBLE DAMAGE TO THE ENGINE OR ITS COMPONENTS DURING ENGINE OPERATION OR MAINTENANCE PROCEDURES.

This manual contains installation, operation, and maintenance instructions for the CEC Ignition Module. There are five chapters within the manual and each chapter contains one or more sections. The title of each chapter or section appears at the top of each page. To locate information on a specific topic, refer to the Table of Contents at the front of the manual or the Index at the back of the manual.

Recommendations and data contained in the manual are the latest information available at the time of this printing and are subject to change without notice. Since engine accessories may vary due to customer specifications consult your local Distributor or Waukesha Engine Division Service Operations Department for any information on subjects beyond the scope of this manual.

HOW TO USE THIS MANUAL

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SECTION 1.05 - GENERAL INFORMATION

SECTION 1.10 - DESCRIPTION OF OPERATION

SECTION 1.00

SAFETY

SAFETY INTRODUCTION

The following safety precautions are published for your information. Waukesha Engine Division, Dresser Industries, Inc., does not, by the publication of these precautions, imply or in any way represent that they are the sum of all dangers present near industrial engines or fuel rating test units. If you are installing, operating, or servicing a Waukesha product, it is your responsibility to ensure full compliance with all applicable safety codes and requirements. All requirements of the Federal Occupational Safety and Health Act must be met when Waukesha products are operated in areas that are under the jurisdiction of the United States of America. Waukesha products operated in other countries must be installed, operated and serviced in compliance with any and all applicable safety requirements of that country.

For details on safety rules and regulations in the United States, contact your local office of the Occupational Safety and Health Administration (OSHA).

The words "danger," "warning," "caution," and "note" are used throughout this manual to highlight important information. Be certain that the meanings of these alerts are known to all who work on or near the equipment.

NOTE: *This symbol identifies information which is NECESSARY TO THE PROPER OPERATION, MAINTENANCE OR REPAIR OF THE EQUIPMENT.*

 **CAUTION** This symbol identifies information about hazards or unsafe practices. Disregarding this information could result in PRODUCT DAMAGE AND/OR PERSONAL INJURY.

 **WARNING**

This symbol identifies information about hazards or unsafe practices. Disregarding this information could result in SEVERE PERSONAL INJURY OR DEATH.

 **DANGER**

This symbol identifies information about immediate hazards. Disregarding this information will result in SEVERE PERSONAL INJURY OR DEATH.

SAFETY TAGS AND DECALS

 **WARNING**

To avoid severe personal injury or death, all warning tags and decals must be visible and legible to the operator while the equipment is operating.

EQUIPMENT REPAIR AND SERVICE

Proper maintenance, service, and repair are important to the safe, reliable operation of the unit and related equipment. Do not use any procedure not recommended in the Waukesha Engine manuals for this equipment.

 **WARNING**

To prevent severe personal injury or death, always stop the unit before cleaning, servicing, or repairing the unit or any driven equipment.

Place all controls in the OFF position and disconnect or lock out starters to prevent accidental restarting. If possible, lock all controls in the OFF position and take the key. Put a sign on the control panel warning that the unit is being serviced.

Close all manual control valves, disconnect and lock out all energy sources to the unit, including all fuel, electric, hydraulic, and pneumatic connections.

Disconnect or lock out driven equipment to prevent the possibility of the driven equipment rotating the disabled engine.

SAFETY

WARNING

To avoid severe personal injury or death, ensure that all tools and other objects are removed from the unit and any driven equipment before restarting the unit.

WARNING

Allow the engine to cool to room temperature before cleaning, servicing, or repairing the unit. Hot components or fluids can cause severe personal injury or death.

Some engine components and fluids are extremely hot even after the engine has been shut down. Allow sufficient time for all engine components and fluids to cool to room temperature before attempting any service procedure.

ACIDS

WARNING

Comply with the acid manufacturer's recommendations for proper use and handling of acids. Improper handling or misuse could result in severe personal injury or death.

BATTERIES

WARNING

Comply with the battery manufacturer's recommendations for procedures concerning proper battery use and maintenance. Improper maintenance or misuse could result in severe personal injury or death.

BODY PROTECTION

WARNING

Always wear OSHA approved body, sight, hearing and respiratory system protection. Never wear loose clothing, jewelry, or long hair around an engine. The use of improper attire or failure to use protective equipment may result in severe personal injury or death.

CHEMICALS

GENERAL

WARNING

Always read and comply with safety labels on all containers. Do not remove or deface the container labels. Improper handling or misuse could result in severe personal injury or death.

CLEANING SOLVENTS

WARNING

Comply with the solvent manufacturer's recommendations for proper use and handling of solvents. Improper handling or misuse could result in severe personal injury or death. Do not use gasoline, paint thinners or other highly volatile fluids for cleaning.

LIQUID NITROGEN/DRY ICE

WARNING

Comply with the liquid nitrogen/dry ice manufacturer's recommendations for proper use and handling of liquid nitrogen/dry ice. Improper handling or use could result in severe personal injury or death.

COMPONENTS

HEATED OR FROZEN

WARNING

Always wear protective equipment when installing or removing heated or frozen components. Some components are heated or cooled to extreme temperatures for proper installation or removal. Direct contact with these parts could cause severe personal injury or death.

INTERFERENCE FIT

WARNING

Always wear protective equipment when installing or removing components with an interference fit. Installation or removal of interference components may cause flying debris. Failure to use protective equipment may result in severe personal injury or death.

COOLING SYSTEM **WARNING**

Always wear protective clothing when venting, flushing or blowing down the cooling system. Operational coolant temperatures can range from 180 - 250° F (82 - 121° C). Contact with hot coolant or coolant vapor can cause severe personal injury or death.

 **WARNING**

Do not service the cooling system while the engine is operating or when the coolant is hot. Operational coolant temperatures can range from 180° - 250° F (82° - 121° C). Contact with hot coolant or vapor can cause severe personal injury or death.

ELECTRICAL**GENERAL** **WARNING**

Do not install, set up, maintain or operate any electrical components unless you are a technically qualified individual who is familiar with the electrical elements involved. Electrical shock can cause severe personal injury or death.

 **WARNING**

Disconnect all electrical power supplies before making any connections or servicing any part of the electrical system. Electrical shock can cause severe personal injury or death.

IGNITION **WARNING**

Avoid contact with ignition units and wiring. Ignition system components can store electrical energy and if contacted can cause electrical shocks. Electrical shock can cause severe personal injury or death.

 **WARNING**

Properly discharge any electrical component that has the capability to store electrical energy before connecting or servicing that component. Electrical shock can cause severe personal injury or death.

EXHAUST **WARNING**

Do not inhale engine exhaust gases. Exhaust gases are highly toxic and could cause severe personal injury or death.

Ensure exhaust systems are leak free and that all exhaust gases are properly vented.

 **WARNING**

Do not touch or service any heated exhaust components. Allow sufficient time for exhaust components to cool to room temperature before attempting any service procedure. Contact with hot exhaust system components can cause severe personal injury or death.

FIRE PROTECTION **WARNING**

Refer to local and federal fire regulations for guidelines for proper site fire protection. Fires can cause severe personal injury or death.

SAFETY

FUELS

GENERAL

WARNING

Ensure that there are no leaks in the fuel supply. Engine fuels are highly combustible and can ignite or explode causing severe personal injury or death.

GASEOUS

WARNING

Do not inhale gaseous fuels. Some components of fuel gas are odorless, tasteless, and highly toxic. Inhalation of gaseous fuels can cause severe personal injury or death.

WARNING

Shut off the fuel supply if a gaseous engine has been cranked excessively without starting. Crank the engine to purge the cylinders and exhaust system of accumulated unburned fuel. Failure to purge accumulated unburned fuel in the engine and exhaust system can result in an explosion resulting in severe personal injury or death.

LIQUID

WARNING

Do not ingest liquid fuels or breathe in their vapors. Liquid fuels may be highly toxic and can result in severe personal injury or death.

WARNING

Use protective equipment when working with liquid fuels and related components. Liquid fuel can be absorbed into the body resulting in severe personal injury or death.

INTOXICANTS AND NARCOTICS

WARNING

Do not allow anyone under the influence of intoxicants and/or narcotics to work on or around industrial engines. Workers under the influence of intoxicants and/or narcotics are a hazard both to themselves and other employees and can cause severe personal injury or death to themselves or others.

PRESSURIZED FLUIDS/GAS/AIR

WARNING

Never use pressurized fluids/gas/air to clean clothing or body parts. Never use body parts to check for leaks or flow rates. Pressurized fluids/gas/air injected into the body can cause severe personal injury or death.

Observe all applicable local and federal regulations relating to pressurized fluid/gas/air.

PROTECTIVE GUARDS

WARNING

Provide guarding to protect persons or structures from rotating or heated parts. Contact with rotating or heated parts can result in severe personal injury or death.

It is the responsibility of the engine owner to specify and provide guarding.

SPRINGS

WARNING

Use appropriate equipment and protective gear when servicing or using products that contains springs. Springs, under tension or compression, can eject if improper equipment or procedures are used. Failure to take adequate precautions can result in serious personal injury or death.

TOOLS

ELECTRICAL

 **WARNING**

Do not install, set up, maintain, or operate any electrical tools unless you are a technically qualified individual who is familiar with them. Electrical tools use electricity and if used improperly could cause severe personal injury or death.

HYDRAULIC

 **WARNING**

Do not install, set up, maintain, or operate any hydraulic tools unless you are a technically qualified individual who is familiar with them. Hydraulic tools use extremely high hydraulic pressure and if used improperly could cause severe personal injury or death.

 **CAUTION** Always follow recommended procedures when using hydraulic tensioning devices. Improper use of hydraulic tensioning tools can cause severe engine damage.

PNEUMATIC

 **WARNING**

Do not install, set up, maintain, or operate any pneumatic tools unless you are a technically qualified individual who is familiar with them. Pneumatic tools use pressurized air and if used improperly could cause severe personal injury or death.

WEIGHT

 **WARNING**

Always consider the weight of the item being lifted and use only properly rated lifting equipment and approved lifting methods. Failure to take adequate precautions can result in serious personal injury or death.

 **WARNING**

Never walk or stand under an engine or component while it is suspended. Failure to adhere to this could result in severe personal injury or death.

WELDING


GENERAL

 **WARNING**

Comply with the welder manufacturer's recommendations for procedures concerning proper use of the welder. Improper welder use can result in severe personal injury or death.

ON ENGINE

 **CAUTION** Ensure that the welder is properly grounded before attempting to weld on or near an engine. Failure to properly ground the welder could result in severe engine damage.

 **CAUTION** Disconnect the ignition harness before welding on or near an engine to eliminate charging of an ignition system capacitor. Failure to disconnect the ignition harness could result in severe engine damage.

SECTION 1.05

GENERAL INFORMATION

Table 1.05-1. English To Metric Formula Conversion Table

CONVERSION	FORMULA	EXAMPLE
Inches to Millimeters	Inches and any fraction in decimal equivalent multiplied by 25.4 equals millimeters.	2-5/8 in. = 2.625 x 25.4 = 66.7 mm
Cubic Inches to Litres	Cubic inches multiplied by 0.01639 equals litres.	9388 cu. in. = 9388 x 0.01639 = 153.9 L
Ounces to Grams	Ounces multiplied by 28.35 equals grams.	21 oz. = 21 x 28.35 = 595 g
Pounds to Kilograms	Pounds multiplied by 0.4536 equals kilograms.	22,550 lb. = 22,550 x 0.4536 = 10,229 kg
Inch Pounds to Newton-meters	Inch pounds multiplied by 0.113 equals Newton-meters.	360 in-lb = 360 x 0.113 = 40.7 N·m
Foot Pounds to Newton-meters	Foot pounds multiplied by 1.3558 equals Newton-meters.	145 ft-lb = 145 x 1.3558 = 197 N·m
Pounds per Square Inch to Bars	Pounds per square inch multiplied by 0.0690 equals bars.	9933 psi = 9933 x 0.0690 = 685 Bar
Pounds per Square Inch to Kilograms per Square Centimeter	Pounds per square inch multiplied by 0.0703 equals kilograms per square centimeter.	45 psi = 45 x 0.0703 = 3.2 kg/cm ²
Pounds per Square Inch to Kilopascals	Pounds per square inch multiplied by 6.8947 equals kilopascals.	45 psi = 45 x 6.8947 = 310 kPa
Fluid Ounces to Cubic Centimeters	Fluid ounces multiplied by 29.57 equals cubic centimeters.	8 oz. = 8 x 29.57 = 237 cc
Gallons to Litres	Gallons multiplied by 3.7853 equals litres.	148 gal. = 148 x 3.7853 = 560 L
Degrees Fahrenheit to Degrees Centigrade	Degrees Fahrenheit minus 32 divided by 1.8 equals degrees Centigrade.	212° F - 32 + 1.8 = 100° C

Table 1.05-2. Metric To English Formula Conversion Table

CONVERSION	FORMULA	EXAMPLE
Millimeters to Inches	Millimeters multiplied by 0.03937 equals inches.	67 mm = 67 x 0.03937 = 2.6 in.
Litres to Cubic Inches	Litres multiplied by 61.02 equals cubic inches.	153.8 L = 153.8 x 61.02 = 9385 cu. in.
Grams to Ounces	Grams multiplied by 0.03527 equals ounces.	595 g = 595 x 0.03527 = 21.0 oz.
Kilograms to Pounds	Kilograms multiplied by 2.205 equals pounds.	10,228 kg = 10,228 x 2.205 = 22,553 lb.
Newton-meters to Inch Pounds	Newton-meters multiplied by 8.85 equals inch pounds.	40.7 N·m = 40.7 x 8.85 = 360 in-lb
Newton-meters to Foot Pounds	Newton-meters multiplied by 0.7375 equals foot pounds.	197 N·m = 197 x 0.7375 = 145 ft-lb
Bars to Pounds per Square Inch	Bars multiplied by 14.5 equals pounds per square inch.	685 Bar = 685 x 14.5 = 9933 psi
Kilograms per Square Centimeter to Pounds per Square Inch (psi)	Kilograms per square centimeter multiplied by 14.22 equals pounds per square inch.	3.2 kg/cm ² = 3.2 x 14.22 = 46 psi
Kilopascals to Pounds per Square Inch (psi)	Kilopascals multiplied by 0.145 equals pounds per square inch.	310 kPa = 310 x 0.145 = 45.0 psi
Cubic Centimeters to Fluid Ounces	Cubic centimeters multiplied by 0.0338 equals fluid ounces.	236 cc = 236 x 0.0338 = 7.98 oz.
Litres to Gallons	Litres multiplied by 0.264 equals gallons.	560 L = 560 x 0.264 = 148 gal.
Degrees Centigrade to Degrees Fahrenheit	Degrees Centigrade multiplied by 1.8 plus 32 equals Degrees Fahrenheit.	100° C = 100 x 1.8 + 32 = 212° F

GENERAL INFORMATION

WIRING

All electrical equipment and wiring shall comply with applicable local codes. This Waukesha standard defines additional requirements for Waukesha engines.

WARNING

Do not install, set up, maintain, or operate any electrical components unless you are a technically qualified individual who is familiar with the electrical elements involved. Electrical shock can cause severe personal injury or death.

WARNING

Disconnect all electrical power supplies before making any connections or servicing any part of the electrical system. Electrical shock can cause severe personal injury or death.

1. Whenever two or more wires run together, they should be fastened together at no more than four (4) to six (6) inch intervals, closer where necessary, with "cable ties." Power wires (24 volts or greater) should never be run together with any other instrument or control wires. Spacing for these types of wires should be six (6) inches minimum to eliminate electrical "noise" problems in the instrument or control wires.

2. All wires should be mounted off hot areas of the engine with insulated clips, at intervals of no more than twelve (12) inches, closer where necessary. Wires must never be run closer than six (6) inches to exhaust manifolds, turbochargers, or exhaust pipes.

3. In cases where wires do not run over the engine, they should be fastened to rigid, non-moving bodies with insulated clips when possible or "cable-ties." Fasteners should be spaced at no more than twelve (12) inch intervals.

4. When wires run through holes, rubber grommets should be installed in holes to protect the wires. Wires should never be run over rough surfaces or sharp edges without protection (see Item 11).

 **CAUTION** Do not use non-electrical grade RTVs. Non-electrical RTVs can emit corrosive gases that can damage electrical connectors.

5. An electrical grade RTV should be applied around the wires entering all electrical devices such as Murphy Junction Boxes and gas valves, Syncro Start speed switches, microswitch boxes used in conjunction with safety equipment, solenoids, etc. An electrical grade RTV is to be applied immediately after wire installation and prior to the engine entering the test room.

6. A small "drip loop" should be formed in all wires before entering the electrical devices. This drip loop will reduce the amount of moisture entering electrical device via the wires if an electrical grade RTV does not seal completely.

7. The following procedures should be followed for wires entering engine junction boxes:

- Bottom entrance best and side entrance second best.
- Insert grommet in opening to protect wires.
- Wires to contain "drip loop" before entering box, except where using bottom entrance.
- When installing flexible conduit, use straight connector for side entrance. If top entrance is required, use elbow connector.

8. If wire harness has a covering, clamp harness so openings of covering are downward.

9. The routing of wires should be determined for reliability and appearance and not by shortest distance.

10. Installation connection wire must be coiled and secured to provide protection during shipment.

11. Each end of flexible metal conduit *must* have an insulating sleeve to protect wires from chafing.

WARNING

Always label "HIGH VOLTAGE" on engine mounted equipment over 24 volts. Failure to adhere to this warning could result in personal injury or death.

12. All engine mounted electrical equipment over 24 volts shall have "HIGH VOLTAGE" warning decal. Decal to be attached to all the equipment and junction boxes on visible surface (vertical surface whenever possible).

13. Wiring that is routed in rigid or flexible conduit shall have all wire splices made only in junction boxes, outlet boxes or equipment boxes. Wire splices shall not be located in the run of any conduit.

POWER REQUIREMENTS FOR CUSTOM ENGINE CONTROL® PRODUCTS

Table 1.05-3 provides you with the power requirements for Waukesha's Custom Engine Control® (CEC) products. An oscilloscope must be used to verify ripple limitations. All power connections must be in accordance with the applicable electrical codes.

NOTE: To power the CEC Ignition Module, a nominal supply of 24 VDC with less than a 2 volt peak-to-peak ripple is recommended for compatibility with other CEC products.

CAPACITIVE DISCHARGE AND GROUNDING

A Capacitive Discharge (CD) ignition system, such as the CEC Ignition Module, requires an external power source and special wiring requirements.

This ignition system contains several large energy storage capacitors. When firing a spark plug, the energy stored in one of these capacitors is rapidly discharged into an ignition coil which converts it to the high tension ignition voltage. Having been discharged, the energy storage capacitor must then be recharged to be ready to fire again. The storage capacitor is typically recharged by drawing

energy from the power supply as quickly as possible, resulting in a high current flow (typically 30 amps or more) in the power supply wiring for a short period of time.

The average ignition system current remains low (1 or 2 amps depending on the number of cylinders, engine speed, and supply voltage) since the high current only flows for the short period of time and virtually no current flows the rest of the time. However, the wiring must be sized for the high instantaneous currents. In addition, the grounding, particularly where the ground is "referenced," becomes more critical when electronic controls are used on engines having this type of CD ignition system.

With ignition power supply currents of approximately 30 amps, the resistive voltage drop of the wiring can easily reach a volt or two. As a result, it is necessary to reference all of the grounds to the same point. Since many electronic sensors are internally grounded, the engine crankcase has been chosen as THE GROUND reference to minimize problems with sensor signals. By following the recommended wiring and grounding procedures, the concerns associated with the ignition power supply wiring voltage drops can be greatly reduced or eliminated.

Table 1.05-3. Power Requirements For Waukesha Custom Engine Control® Products

CEC PRODUCT	NOMINAL VOLTAGE (volts DC)	TOLERANCE	OPERATING RANGE (volts DC)	PEAK-TO-PEAK RIPPLE (volts AC)	OPERATING CURRENT (amps)
Ignition Module (IM)	24	+33%, -58%	10.0 - 32.0*	less than 2*	2 (typical)
Detonation Sensing Module (DSM) System	24	+25%, -10%	21.6 - 30.0	less than 2	1.5
Air/Fuel Module (AFM) System	24	+25%, -10%	21.6 - 30.0	less than 2	2.5 (all rich burn applications) 18.0 (lean burn applications on VHP 6 cylinder and all VGF engines) 32.0 (lean burn applications on all AT and VHP 12 & 16 cylinder engines)
Turbocharger Control Module (TCM) System	24	+25%, -10%	21.6 - 30.0	less than 2	1.5

NOTE: *For compatibility with other CEC products, a nominal supply of 24 VDC with less than a 2 volt peak-to-peak ripple is recommended to power the IM.

GENERAL INFORMATION

SECTION 1.10

DESCRIPTION OF OPERATION

WAUKESHA CUSTOM ENGINE CONTROL[®] IGNITION MODULE

SYSTEM DESCRIPTION

The Custom Engine Control[®] (CEC) Ignition Module (IM) is a microcircuit-based, digital ignition system (see Figure 1.10-1). The IM is designed to enhance the performance and cost-effectiveness of your Waukesha engine. The IM provides accurate and reliable ignition timing resulting in optimum stationary engine operation. The IM system has no wearing parts and uses the capacitor discharge principle providing high energy, precision timed spark for maximum engine performance. The IM's technology also provides full output at cranking speeds for better engine startup. With the IM installed, your engine will perform better and more powerful, emit lower emissions, decrease downtime, and increase spark plug life.



Figure 1.10-1. CEC Ignition Module

With the engine running, an electronic Hall-effect pickup reads magnetic reference marks mounted on a gear or timing disc to determine the exact position of the crankshaft. The Hall-effect pickup sends an electrical signal to the IM. Electronically the IM interprets the Hall-effect pickup's electrical signal based on an index

magnet so the IM knows exactly which cylinder is supposed to fire. Then the IM directs a charge of voltage to the appropriate ignition coil for spark plug firing to achieve accurate timing.

Ignition timing is changed with the two 16 position (0 - 15) timing switches on the right side of the IM (see Figure 1.10-2). With the two 16 position timing switches, the engine can be set up for dual fuel applications, two distinct fuel gases or load conditions.

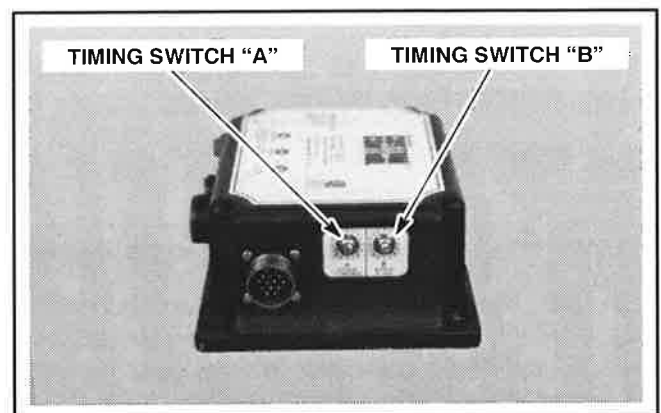


Figure 1.10-2. Ignition Module 16 Position
Timing Switches

For example: On dual fuel applications, you can set timing switch "A" for one fuel and the timing on switch "B" for the other fuel. This allows you to switch from one timing setting to the other when you switch fuels and have the proper ignition timing for both fuels.

Switch position 15 gives the most advanced timing on the active timing switch, either switch "A" or "B." Switch "A" has a more advanced timing range than switch "B." The timing retards/advances 1.0 degree between each switch position. Although there are two timing switches on the IM, only one is active at any one time. The switch that is active is determined by the status of the "D" lead in the Power Pickup Harness (7 pin connector). If the "D" lead is grounded, switch "A" is active; if the "D" lead is not grounded, switch "B" is active.

DESCRIPTION OF OPERATION

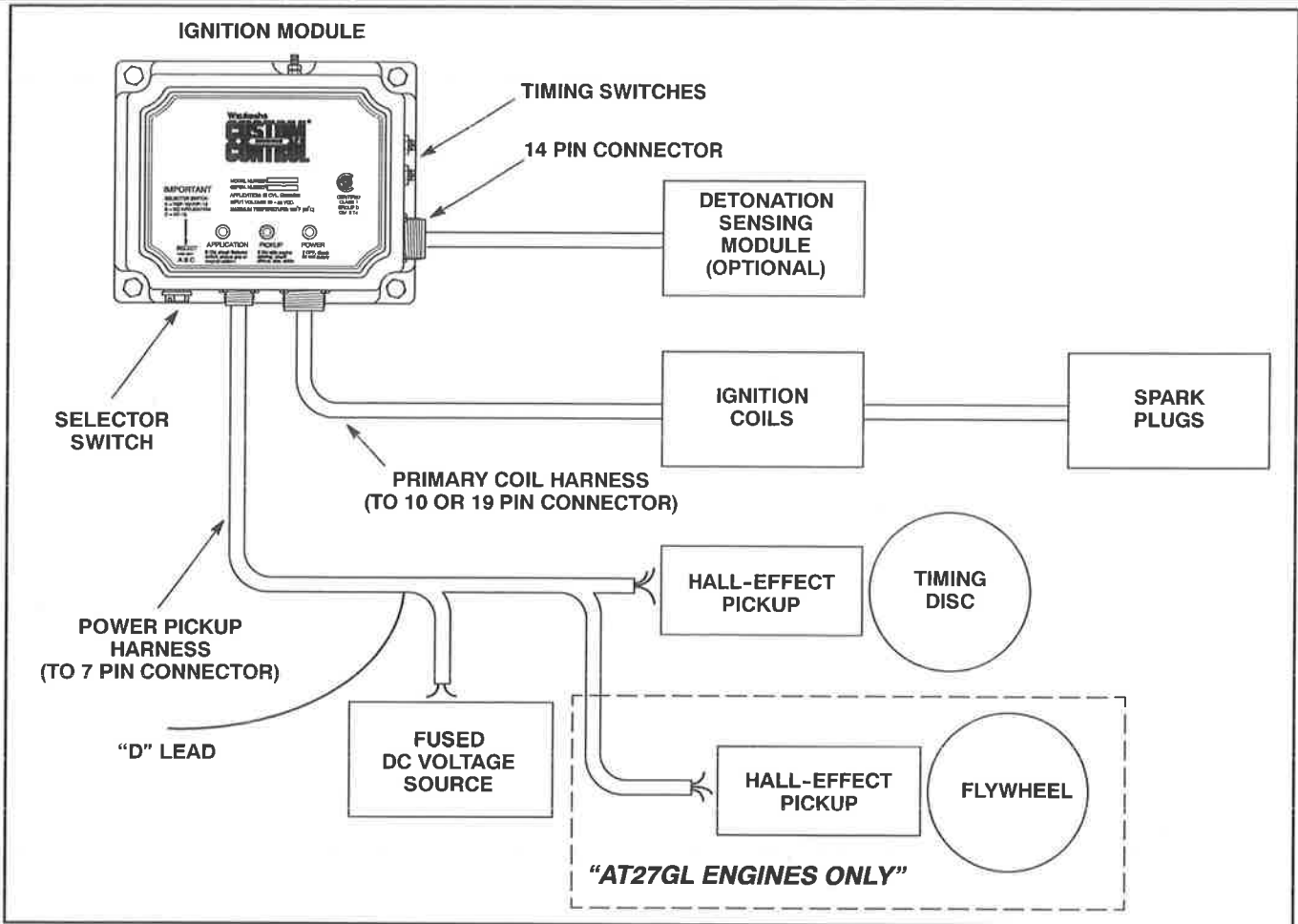


Figure 1.10-3. Ignition Module Harness Connections

The IM has three external cable connectors (see Figure 1.10-3). The Power Pickup Harness connects to the 7 pin connector and includes leads for DC power, the Hall-effect pickup, and the "D" lead which determines which timing switch is used. The Primary Coil Harness connects to the IM and includes leads to the ignition coils. The third connector (14 pin) is used to interface with the CEC Detonation Sensing Module (see next section, "Interface With CEC Detonation Sensing Module").

NOTE: The 14 pin connector on the IM is not used unless the Detonation Sensing Module is in operation on the engine.

The IM also features a three position Selector Switch for setting the engine model (see Figure 1.10-3). The Selector Switch programs the IM for a specific engine model—6 versus 8 cylinder, AT versus VHP. If the magnet pattern sensed by the Hall-effect pickup is not correct for the application selected on the Selector Switch (such as an 8 cylinder application selected on a 6 cylinder engine), an LED will light on the IM and the ignition will not fire.

INTERFACE WITH CEC DETONATION SENSING MODULE

The IM interfaces with the CEC Detonation Sensing Module (DSM) system (see Figure 1.10-4). The DSM system is designed to protect Waukesha spark-ignited gas engines from damage due to detonation. The DSM system functions with the IM and connects to the IM's 14 pin connector. The two CEC systems, when connected together, provide defense against engine detonation which can lead to severe engine damage.

With the DSM system connected, the timing switches on the IM become non-functional and timing varies individually among the cylinders from a range of preset values. This individual cylinder timing allows maximum advance for cylinders that are not experiencing detonation to a predetermined setting.

Detonation is the autoignition of end gas during combustion in an engine's combustion chamber. Avoiding detonation conditions is critical since detonation is detrimental to engine components.

NOTE: Refer to the Custom Engine Control® Detonation Sensing Module Installation, Operation, and Maintenance Manual (Form 6268) for information on DSM system installation and programming.



Figure 1.10-4. CEC Detonation Sensing Module

COMPONENTS

The IM system consists of an electronic module (IM), wiring harnesses, timing disc or gear, ignition coils, high tension leads, and a Hall-effect pickup (two for AT27GL engines).

A diagram of the IM system’s inputs and outputs is shown in Figure 1.10-3.

ENGINES SERVED

The IM is designed to function with Waukesha’s gaseous fueled AT, VHP, and VGF engines. The IM can also be installed as a retrofit on engines in the field. Retrofit kits include all the required IM components, mounting hardware, and installation instructions.

All Waukesha Engine models are covered by three IM control boxes. Table 1.10-1 lists the IM models and their engine applications.

Table 1.10-1. Ignition Module Applications

IGNITION MODULE MODELS		
Model 811	Model 1211	Model 1611
VHP 6 Cylinder Engines	VHP 12 Cylinder Engines	VHP 16 Cylinder Engines
VGF 6 and 8 Cylinder Engines	VGF 12 Cylinder Engines	VGF 16 Cylinder Engines
AT 8 Cylinder Engines	AT 12 Cylinder Engines	AT 16 Cylinder Engines

OPERATOR INTERFACE

The IM is equipped with three diagnostic LEDs on front of the IM housing: “Power,” “Pickup,” and “Application” (see Figure 1.10-5). These LEDs give operators visual confirmation on (1) incoming power, (2) Hall-effect pickup signal, and (3) proper application settings.

- The green “Power” LED is lit any time power is applied to the IM. The power LED confirms to the operator that connection has been made to the IM from the VDC power supply.
- The red “Pickup” LED is lit when there is no Hall-effect pickup signal being detected by the IM due to a failed pickup, an incorrect air gap setting, and/or incorrect (bad) wiring. The pickup LED will also be lit when the engine is at rest.
- The red “Application” LED is lit whenever the IM detects a magnet pattern that does not match the application for which the IM Selector Switch is set (6 versus 8 cylinder) or when the incorrect IM model is installed (inline IM model versus vee engine IM model). Additionally, this LED will light when one Hall-effect pickup is lost (disconnected or failed) on a two pickup system (AT engines), or if a magnet is lost or is very weak. The application LED will also light when the Selector Switch is in the “B” position (no application).

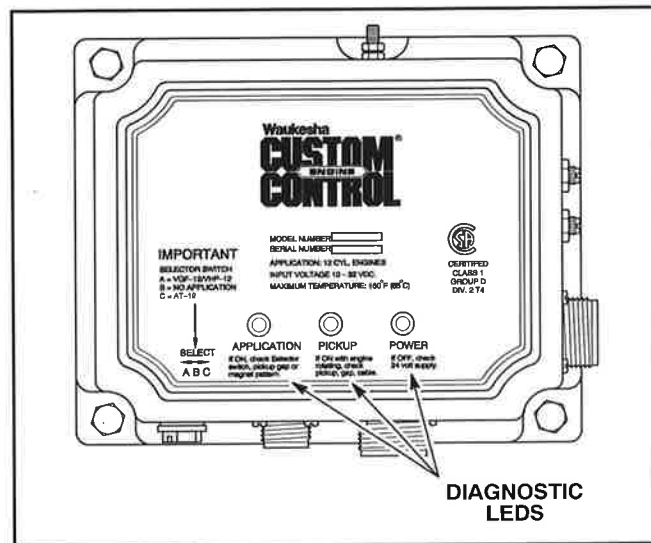


Figure 1.10-5. IM Diagnostic LEDs

DESCRIPTION OF OPERATION

THEORY OF OPERATION

IGNITION MODULE OPERATION

The IM operates as a high energy capacitor discharge solid state ignition system. The IM first steps up the input voltage from 10 - 32 volts to approximately 160 volts. This voltage is then used to charge up energy storage capacitors.

A gear or aluminum disc rotates at 1/2 engine speed. Several magnets are imbedded in this gear or disc. These magnets signal the position of the engine crankshaft to the logic circuit in the IM through the use of a Hall-effect pickup.

When the IM and its internal microcircuits receive the signal from the Hall-effect pickup, the IM triggers SCRs (silicon controlled rectifiers) to release the energy stored in the capacitors. The voltage is then stepped up by the ignition coils to fire the spark plugs. The IM releases this energy in a programmed, timed sequence that varies with the application.

NOTE: For AT27GL engines, the two Hall-effect pickup system operates similar to the single pickup system, except one pickup is signalled by magnets in the flywheel and the other by a single magnet in a disc on the camshaft.

Timing is changed with two 16 position (0 - 15) timing switches located on the side of the IM. Each switch can be set to separate ignition timing settings for different applications. Switch position 15 gives the most advanced timing on the active timing switch, either switch "A" or "B." Switch "A" has a more advanced timing range than switch "B." The timing advances/retards 1.0 degree between each switch position. Grounding lead "D" in the Power Pickup Harness (7-pin connector) activates the timing selected by switch "A." Ungrounded lead "D" will activate the timing selected by switch "B."

On dual fuel applications, it is possible to set the timing switch "A" for one fuel and the timing on switch "B" for the other fuel. This allows you to switch from one control to the other when you switch fuels and have the proper ignition timing in place automatically for each fuel.

HALL-EFFECT PICKUP VERSES MAGNETIC PICKUP

The Hall-effect pickup is a three wire solid state electronic device that requires the sensing of a magnet to trigger the pickup (see Figure 1.10-6). A magnetic pickup is a two wire electrical device that produces a voltage with the aid of a magnet as steel teeth move by. A magnetic pickup can look identical to a Hall-effect pickup but is self-powered and only has two connections (see Figure 1.10-7). Magnetic pickup devices **do not** work with the IM.

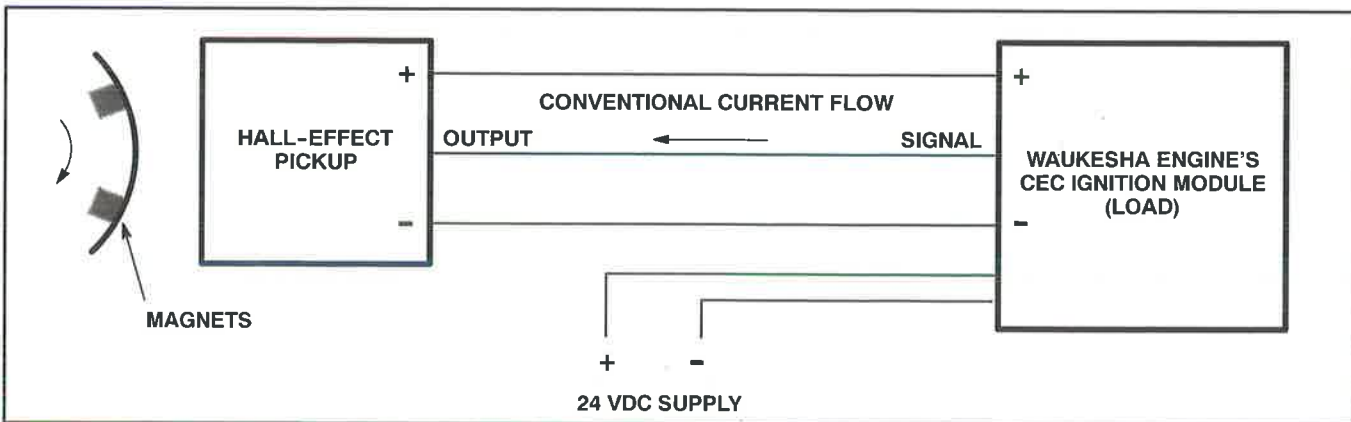


Figure 1.10-6. Sinking Type Hall-effect Pickup

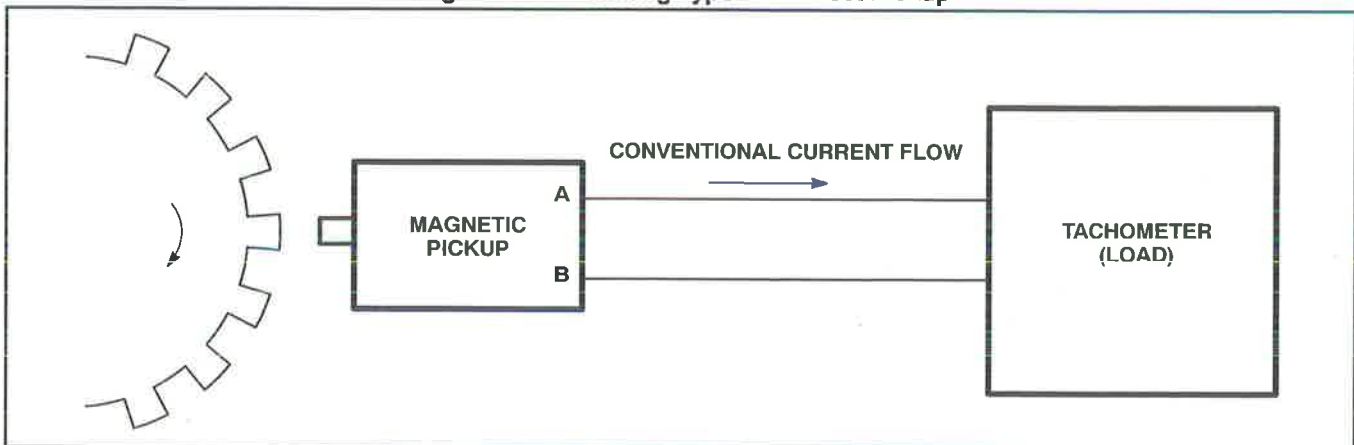


Figure 1.10-7. Magnetic Pickup

DEFINITIONS

Commercial Quality Natural Gas: Natural gas that has been processed to remove heavy hydrocarbon components. The heat value normally ranges from 900 - 1000 Btu/ft³ SLHV (33.54 - 37.26 J/cm³). Holland's pipeline gas has a heat value of 820 Btu/ft³ SLHV (30.5 J/cm³).

Detonation: Detonation occurs when part of the air/fuel charge cannot wait for the normal flame-front, which was started by the spark plug, to pass completely through the combustion chamber. The advancing flame-front heats and squeezes the unburned mixture until it ignites on its own. A good comparison is a grass fire. Normal combustion is similar to a grass fire. It begins at one end of a field, and the flame-front progresses in an orderly manner through the field. When all of the grass is burned, the combustion stops. During "grass-detonation," the grass would begin burning normally, but before the flames could sweep through the length of the field, some portion of the unburned grass would burst into flames. When this happens in the combustion chamber of an engine, two pressure waves, associated with the two flame-fronts, slam together and cause an audible "ping" or "knock."

Digester Gas: A fuel gas formed by the decomposition of organic matter in a digester. It is composed primarily of methane (CH₄) and carbon dioxide (CO₂). The heat value normally ranges from 500 - 600 Btu/ft³ SLHV (18.63 - 22.36 J/cm³). Hydrogen sulfide (H₂S) is a typical trace component.

Field Gas: Raw or partially processed natural gas as taken from an extracting well. The heat value normally ranges from 900 - 1500 Btu/ft³ SLHV (33.54 - 55.898 J/cm³).

Hall-effect Pickup: A three wire solid state electronic device that requires the sensing of a magnet to trigger it.

HD-5: A commercial quality propane with the following minimum requirements: 90 percent by liquid volume propane.

Landfill Gas: A fuel gas formed by the decomposition of landfill refuse. It is composed primarily of methane (CH₄) and carbon dioxide (CO₂). The heat value normally ranges from 450 - 550 Btu/ft³ SLHV (16.77 - 20.39 J/cm³). Chlorine and fluorine bearing compounds are typical trace components.

LED: Light Emitting Diode. A semiconductor that emits light (not a light bulb) and is used as power and alarm indicators, located on the front of the IM.

Low Btu Fuel: Fuel having less than 700 Btu/ft³ (26.08 J/cm³), such as landfill gas.

Magnetic Pickup: A two wire electrical device that produces a voltage and current flow as steel teeth move by the pickup. Magnetic pickup devices **do not** work with the IM.

Natural Gas: A naturally occurring mixture of hydrocarbon and other gases found beneath the earth's surface, often in connection with liquid petroleum. The principle component is usually methane (CH₄). Minor components are heavier hydrocarbons and other gases such as nitrogen (N₂), carbon dioxide (CO₂), helium (He), argon (Ar), oxygen (O₂), and hydrogen sulfide (H₂S). Seldom used in its raw state and normally processed to commercial quality natural gas.

Propane: A fuel gas made of carbon (C₃) and hydrogen (H₈). Often used as a backup fuel.

Sinking Output: In a sinking output device, the output signal (current) flows from the control to the pickup.

Sourcing Output: In a sourcing output device, the output signal (current) flows from the pickup to the control.

WKI: Waukesha Knock Index. Waukesha Engine's procedure for reading the knock resistance or detonation resistance of gaseous fuels.

DESCRIPTION OF OPERATION

CONTENTS

**SECTION 2.00 - IGNITION MODULE OPERATION ON
VHP ENGINES**

**SECTION 2.05 - VHP IGNITION MODULE
ELECTRICAL CONNECTIONS**

SECTION 2.10 - VHP IGNITION MODULE TIMING ADJUSTMENTS

SECTION 2.00

IGNITION MODULE OPERATION ON VHP ENGINES

IGNITION MODULE OPERATION ON VHP ENGINES

The purpose of this section is to describe IM operation on VHP engines, location of the Hall-effect pickup, timing disc alignment, and air gap setting.

VHP 6 AND 12 CYLINDER TIMING DISC ALIGNMENT

The IM uses a Hall-effect pickup, a magnetic switching device, to read magnetic reference marks on a disc attached to the governor drive gear hub. This method of timing determines the exact position of the crankshaft. The microcircuit-based, digital IM interprets the pickup's impulses to set optimum ignition timing. The IM then directs a precisely timed voltage to the appropriate ignition coil.

Location Of Hall-effect Pickup

The Hall-effect pickup is located on the governor drive gear hub (see Figure 2.00-1, Figure 2.00-2, and Figure 2.00-3). The pickup senses each magnet as it passes and trips the logic circuit of the IM to fire.

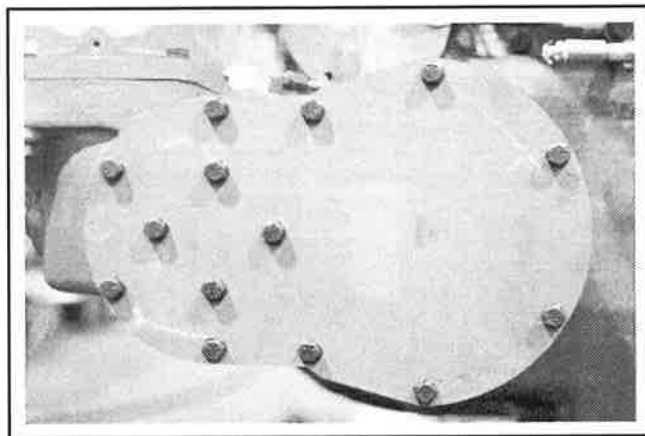


Figure 2.00-1. Governor Drive Housing

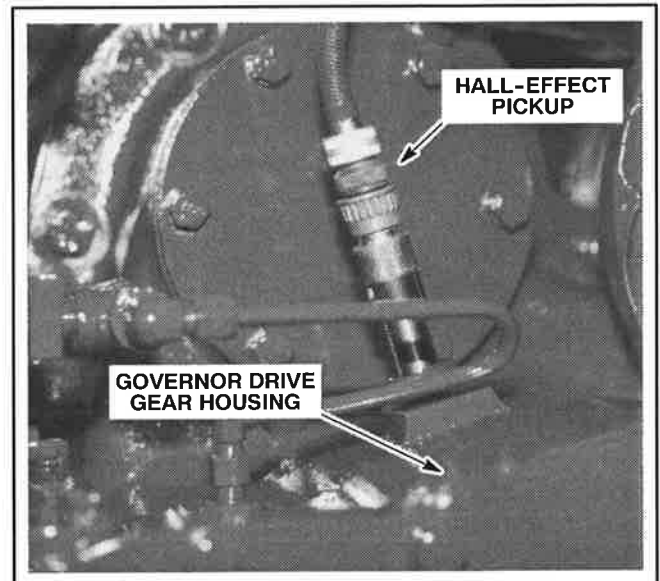


Figure 2.00-2. Hall-effect Pickup Installed On Governor Drive Gear Hub

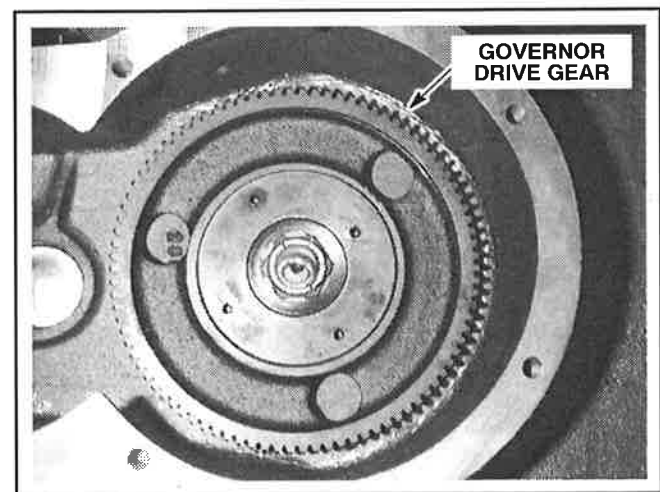


Figure 2.00-3. Governor Drive Gear

IGNITION MODULE OPERATION ON VHP ENGINES

Timing Disc Alignment And Air Gap Setting

1. Locate the first cylinder in the firing order sequence. Refer to the engine's nameplate for firing order sequence.

2. Check the engine's nameplate to determine the exact timing for the primary fuel.

3. Bar the engine over in a counterclockwise direction (facing the flywheel) until the valves of the first cylinder in the firing order, which is the #1R cylinder (12 cylinder engines), #1 cylinder (6 cylinder engines) are at top dead center (compression stroke) (see Figure 2.00-5).

To determine when this condition exists, watch the rocker arms and valves on its mating cylinder (see Figure 2.00-5). As the exhaust valves on the mating cylinder are closing, the intake valves begin to open. At this point, the mating cylinder is in valve overlap (all four valves partially open). This means that all four valves on the #1R cylinder (12 cylinder engines), #1 cylinder (6 cylinder engines) are fully closed. The cylinder is now at top dead center (compression stroke).

NOTE: Timing marks on the flywheel timing tape should be visible through the timing opening located in the flywheel housing when approaching top dead center (TDC) of the first firing cylinder on the compression stroke (see Figure 2.00-4).

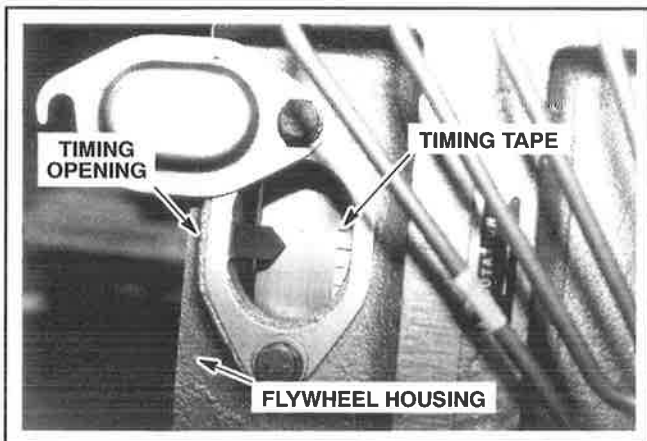


Figure 2.00-4. Flywheel Timing Opening

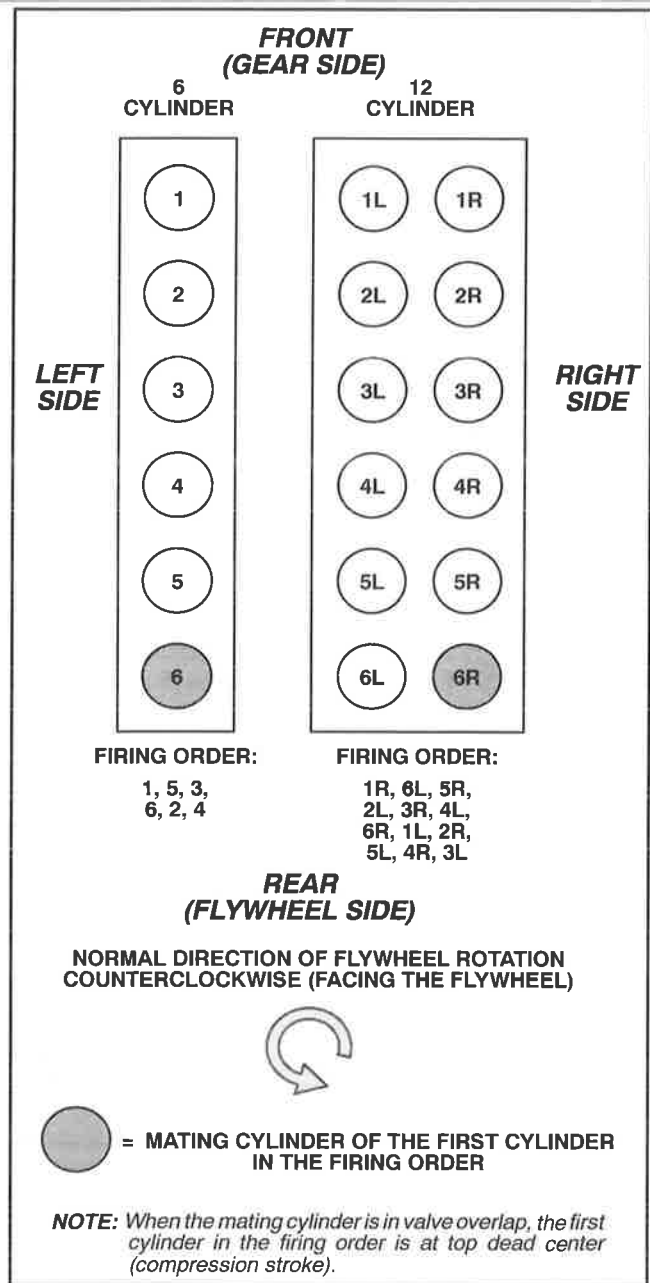


Figure 2.00-5. Engine Firing Order - 6 And 12 Cylinder VHP Engines

IGNITION MODULE OPERATION ON VHP ENGINES

4. Bar the engine over in a clockwise direction (facing the flywheel), to a point at least 30 degrees prior to the point of desired timing.

5. Slowly bar the engine over in a counterclockwise direction (facing the flywheel), carefully observing the flywheel timing tape and pointer. Stop rotating the flywheel exactly at the correct timing desired.

CAUTION By rotating the crankshaft past the desired timing, and then backing up to the desired timing, the disc drive gear backlash will be on the wrong side of the gear teeth. The timing could therefore be incorrect by several degrees.

6. Thread the timing disc alignment tool (P/N 474022) into the governor drive housing (see Figure 2.00-6).

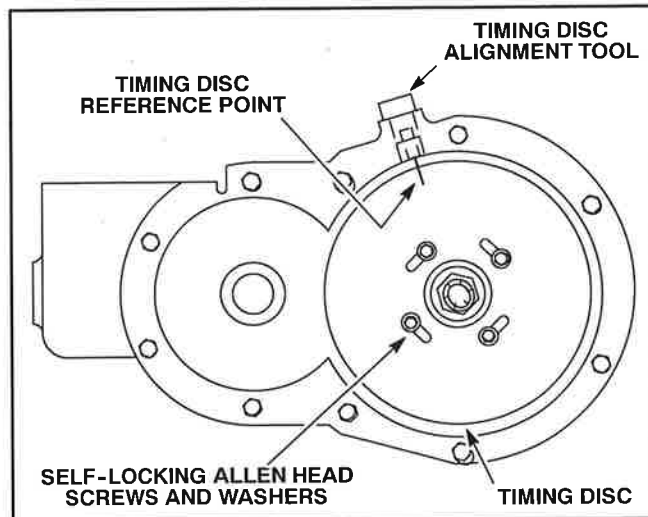


Figure 2.00-6. Ignition Timing Disc

7. Loosen the self-locking allen head screws, and rotate the timing disc so the timing disc reference point aligns with the point of the alignment tool.

8. Once aligned, torque the self-locking allen head screws on the timing disc to 43 - 45 in-lb (4.86 - 5.08 N·m) oiled.

9. Remove the alignment tool and install the Hall-effect pickup. Refer to the following steps to set the the gap between the pickup and the timing disc.

- A. Thread the Hall-effect pickup into the governor drive housing until the pickup comes in contact with the timing disc.
- B. Scribe a reference mark on the Hall-effect pickup and at the same point mark the governor drive housing.

C. Using the reference mark on the pickup as the starting point, rotate the Hall-effect pickup $\frac{3}{4}$ of a turn ($\pm 1/16$ of a turn) counterclockwise to set the pickup to timing disc clearance.

D. After the clearance is set, snug the locking nut.

CAUTION DO NOT turn on the fuel until the ignition timing is verified to be at an acceptable setting, to prevent possible engine damage. Use a timing light to check the ignition timing while the engine is cranking in a NO-FUEL state.

10. Apply a fast setting contact-type gasket shellac, such as 3M Weather Strip Cement, Permatex[®] High-Tac or equivalent, on the gasket surfaces of the governor drive cover plate. Install a new governor drive cover gasket.

NOTE: During Step 11, the governor drive cover must first be installed on the ball bearing retainer, four capscrews, and lockwashers to prevent the gaskets from sliding during installation of the governor drive assembly. Allow the gasket shellac to cure following the manufacturer's recommendations.

11. With the WED part number facing outside, install the governor drive cover to the ball bearing retainer (4 capscrews, $\frac{3}{8}$ x $\frac{3}{4}$ inch, with lockwashers). Install the remaining fasteners (10 capscrews, $\frac{3}{8}$ x 1 inch, with lockwashers) (see Figure 2.00-7).

12. Refer to Section 2.10, VHP Ignition Module Timing Adjustments, to set engine ignition timing.

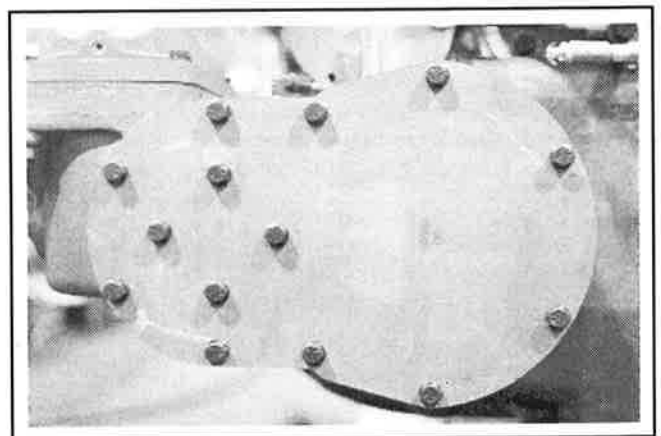


Figure 2.00-7. Governor Drive Housing

IGNITION MODULE OPERATION ON VHP ENGINES

VHP 5115GL AND 16 CYLINDER TIMING DISC ALIGNMENT

Location Of Hall-effect Pickup

The Hall-effect pickup is located on the governor drive gear. The pickup senses each magnet as it passes and trips the logic circuit of the IM to fire.

Timing Disc Alignment And Air Gap Setting

1. Locate the first cylinder to fire in the firing order sequence. Refer to the engine's nameplate and Figure 2.00-9 for firing order sequence.
2. Check the engine's nameplate to determine the exact timing (or most advanced) for the primary fuel.
3. Bar the engine crankshaft over in a counterclockwise (facing the flywheel) direction until the valves of the first cylinder in the firing order, which is the #1R cylinder, are at top dead center (compression stroke).

To determine when this condition exists, watch the rocker arms and valves on its mating cylinder (see Figure 2.00-5). As the exhaust valves on the mating cylinder are closing, the intake valves begin to open. At this point, the mating cylinder is in valve overlap (all four valves partially open). This means that all four valves on the #1R cylinder (12 cylinder engines), #1R cylinder (for 16 cylinder engines) are fully closed. The cylinder is now at top dead center (compression stroke).

NOTE: Timing marks on the flywheel timing tape should be visible through the timing opening located in the flywheel guard on 16 cylinder engines, or flywheel housing on 5115GL engines (see Figure 2.00-8) when approaching top dead center (TDC) of the first firing cylinder on the compression stroke.

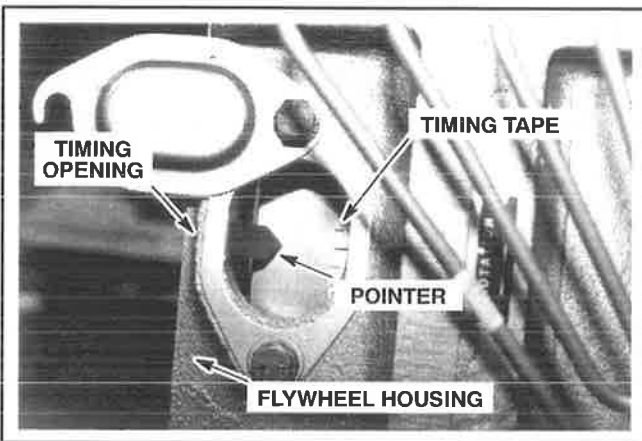


Figure 2.00-8. Flywheel Timing Opening

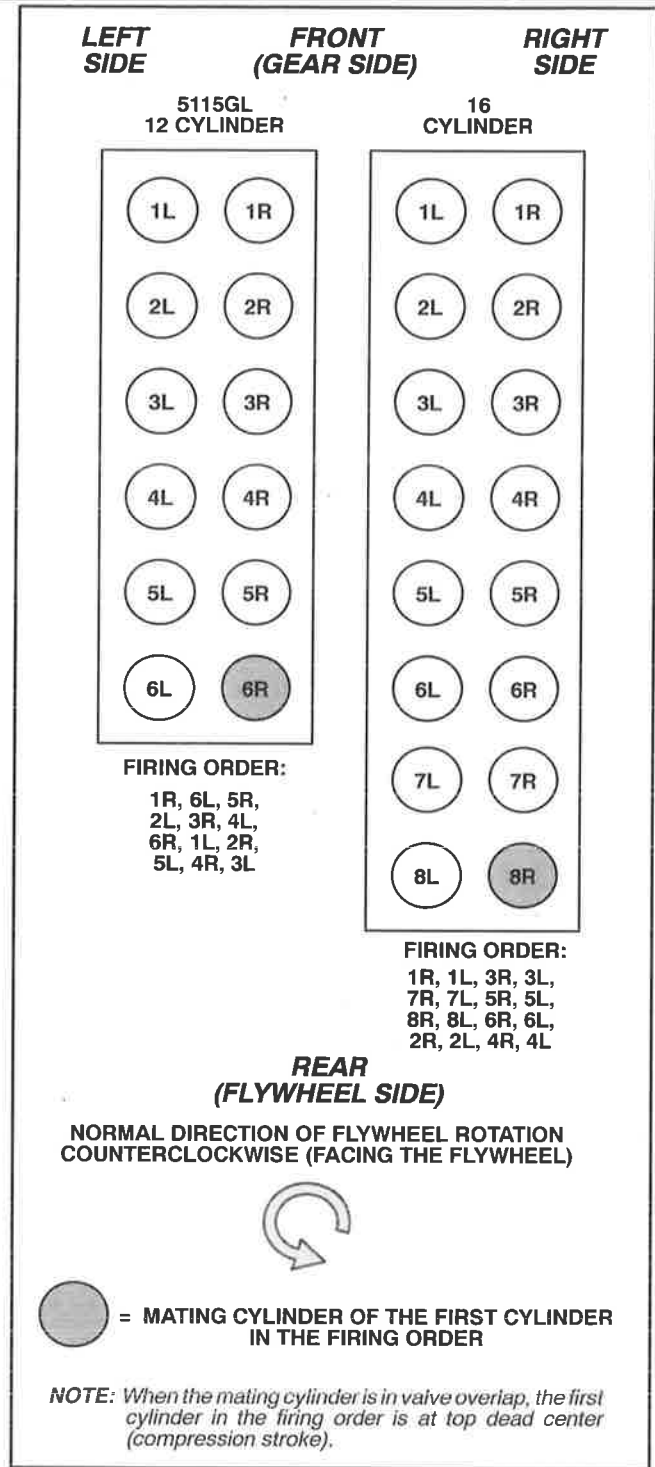


Figure 2.00-9. Engine Firing Order - 12 And 16 Cylinder VHP Engines

4. Bar the engine over in a clockwise direction (facing the flywheel) to a point at least 30 degrees prior to the point of desired timing.
5. Slowly bar the engine over in a counterclockwise direction (facing the flywheel), carefully observing the flywheel timing tape and pointer. Stop rotating the flywheel exactly at the correct timing desired.

CAUTION By rotating the crankshaft past the desired timing, and then backing up to the desired timing, the disc drive gear backlash will be on the wrong side of the gear teeth. The timing could therefore be incorrect by several degrees. Disregarding this information could result in product damage and/or personal injury.

6. Remove the Hall-effect pickup from the magneto housing (see Figure 2.00-10).
7. Thread the timing disc alignment tool (P/N 474022) into the magneto housing.
8. Loosen the self-locking allen head screws, and rotate the timing disc so the timing disc reference point aligns with the point of the alignment tool.
9. Once aligned, torque the self-locking allen head screws to 43 - 45 in-lb (4.86 - 5.08 N·m) to secure disc in place.
10. Remove the alignment tool and install the Hall-effect pickup. Refer to the following steps to set the the gap between the pickup and the timing disc.
 - A. Thread the Hall-effect pickup into the governor drive housing until the pickup comes in contact with the timing disc.
 - B. Scribe a reference mark on the Hall-effect pickup and at the same point mark the governor drive housing.
 - C. Using the reference mark on the pickup as the starting point, rotate the Hall-effect pickup $\frac{3}{4}$ of a turn ($\pm \frac{1}{16}$ of a turn) counterclockwise to set the pickup to timing disc clearance.
 - D. After the clearance is set, snug the locking nut.
11. Replace the magneto drive cover.
12. Refer to Section 2.10, *VHP Ignition Module Timing Adjustments*, to set engine ignition timing.

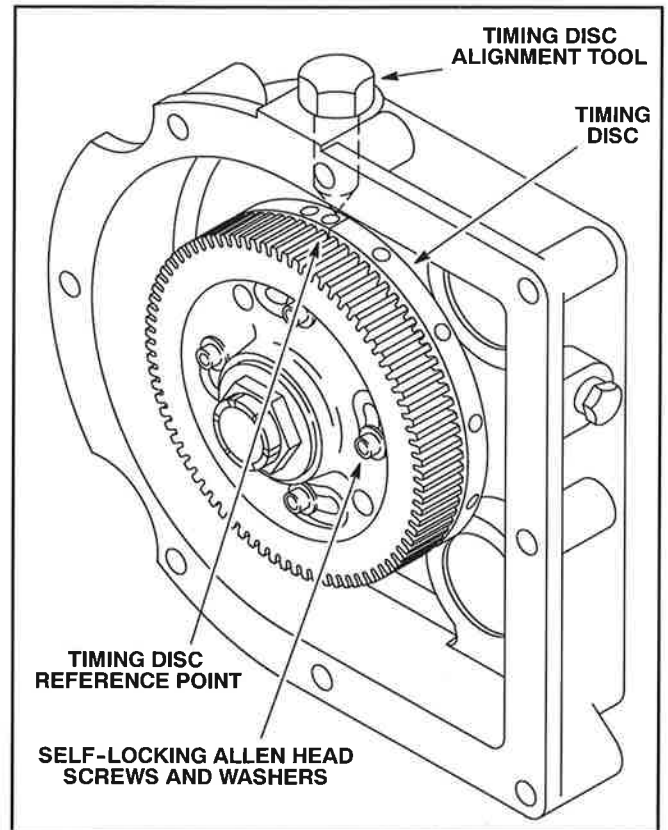


Figure 2.00-10. Magneto Drive Gear And Timing Disc

IGNITION MODULE OPERATION ON VHP ENGINES

SECTION 2.05

VHP IGNITION MODULE ELECTRICAL CONNECTIONS

MOUNTING THE IGNITION MODULE

Mount the IM using the vibration isolators supplied with the IM (see Figure 2.05-1). Note the following:

- The outside temperature of IM casing should not exceed 150° F (65° C) in operation.

CAUTION Do not weld on or around engine unless the Ignition Module has been unplugged. Failure to do so may damage the Ignition Module.

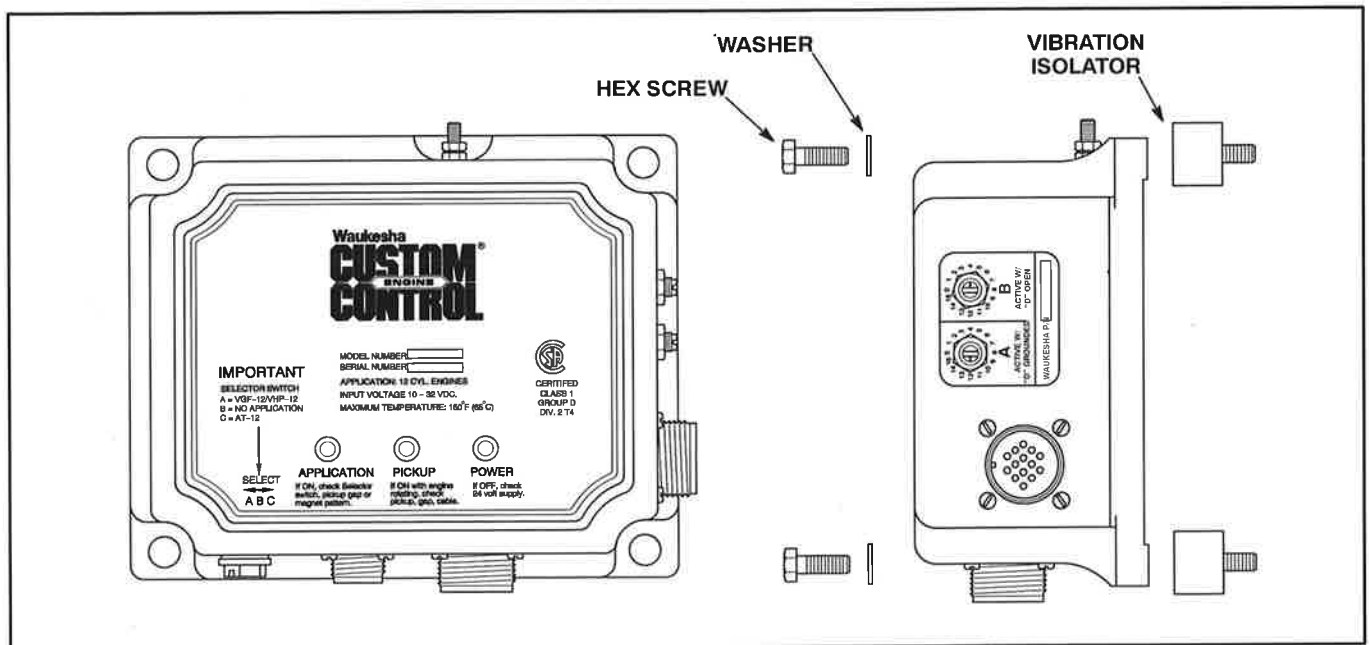


Figure 2.05-1. Mounting The Ignition Module - VHP Engines

VHP IGNITION MODULE ELECTRICAL CONNECTIONS

ELECTRICAL CONNECTIONS

IGNITION MODULE POWER REQUIREMENTS

The power connections made for the IM must be in accordance with the applicable local electrical codes. The IM is suitable for installation in Canadian Standards Association (CSA) Class I, Group D, Division 2 locations. All power sizing must be in accordance with Figure 2.05-3, "Waukesha CEC Products Power Wiring Requirements."

See Table 2.05-1 for IM power requirements.

NOTE: An AC to DC power supply is not preferred unless care is taken to eliminate the possibility of a momentary loss of AC power which will result in an engine shutdown. A DC voltage filter (battery) is recommended to eliminate voltage fluctuations.

NOTE: For compatibility with other CEC products, a nominal supply of 24 VDC with less than a 2 volt peak-to-peak ripple is recommended to power the IM.

NOTE: Refer to Section 1.05, General Information, "Power Requirements for Custom Engine Control® Products," for the power requirements of all Waukesha Engine CEC products.

POWER SOURCE WIRING SIZING AND GROUNDING

The IM, a capacitive discharge (CD) ignition system, requires an external power source which presents special wiring requirements. The IM will function properly with a power source as defined in Table 2.05-1. However, if the supply is capable of providing a pulse current (higher current level for a shorter period of time such that the average current is the same), the IM will utilize that pulse capability. In this case, the voltage fluctuations on the supply wiring, including the ground return to the power source, may interfere with the operation of other electrical devices. For this reason, it is recommended that the IM power source wiring, specifically the ground return, be sized for at least 30 amps even though the average current will be less than 2 amps (typical).

In addition, the grounding, particularly where the ground is "referenced," is critical. It is necessary to reference all of the grounds to the same point. The engine crankcase has been chosen as THE GROUND reference to minimize interference with sensor signals. By following the recommended wiring and grounding procedures, the concerns associated with the ignition power supply wiring voltage drops can be greatly reduced or eliminated.

NOTE: For additional information on capacitive discharge and grounding, see Section 1.05, General Information, "Capacitive Discharge And Grounding."

WIRING HARNESS CONNECTIONS

The IM has three external wiring harness connectors (see Figure 2.05-2). The Power Pickup Harness connects to the 7 pin connector on the IM and includes leads for DC power, the Hall-effect pickup, and the "D" lead which determines which timing switch is used. The Primary Coil Harness connects to the IM and includes leads to the ignition coils. The 14 pin connector is used to interface with the CEC Detonation Sensing Module (DSM). The 14 pin connector is only used when the DSM is installed on the engine.

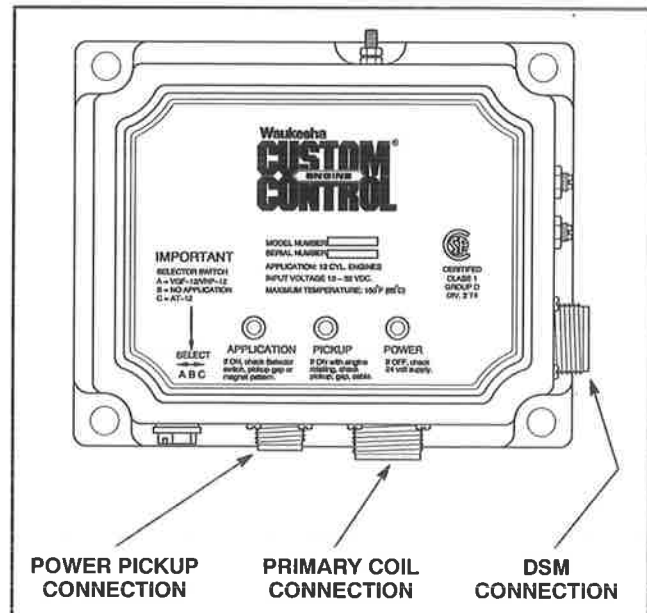


Figure 2.05-2. Ignition Module Wiring Harness Connections

VHP IGNITION MODULE ELECTRICAL CONNECTIONS

Table 2.05-1. Power Requirements For The Ignition Module

CEC PRODUCT	NOMINAL VOLTAGE (volts DC)	TOLERANCE	OPERATING RANGE (volts DC)	PEAK-TO-PEAK RIPPLE (volts AC)	OPERATING CURRENT (amps)
Ignition Module	24	+33%, -58%	10.0 - 32.0*	less than 2*	2 (typical)

NOTE: *For compatibility with other CEC products, a nominal supply of 24 VDC with less than a 2 volt peak-to-peak ripple is recommended to power the IM.

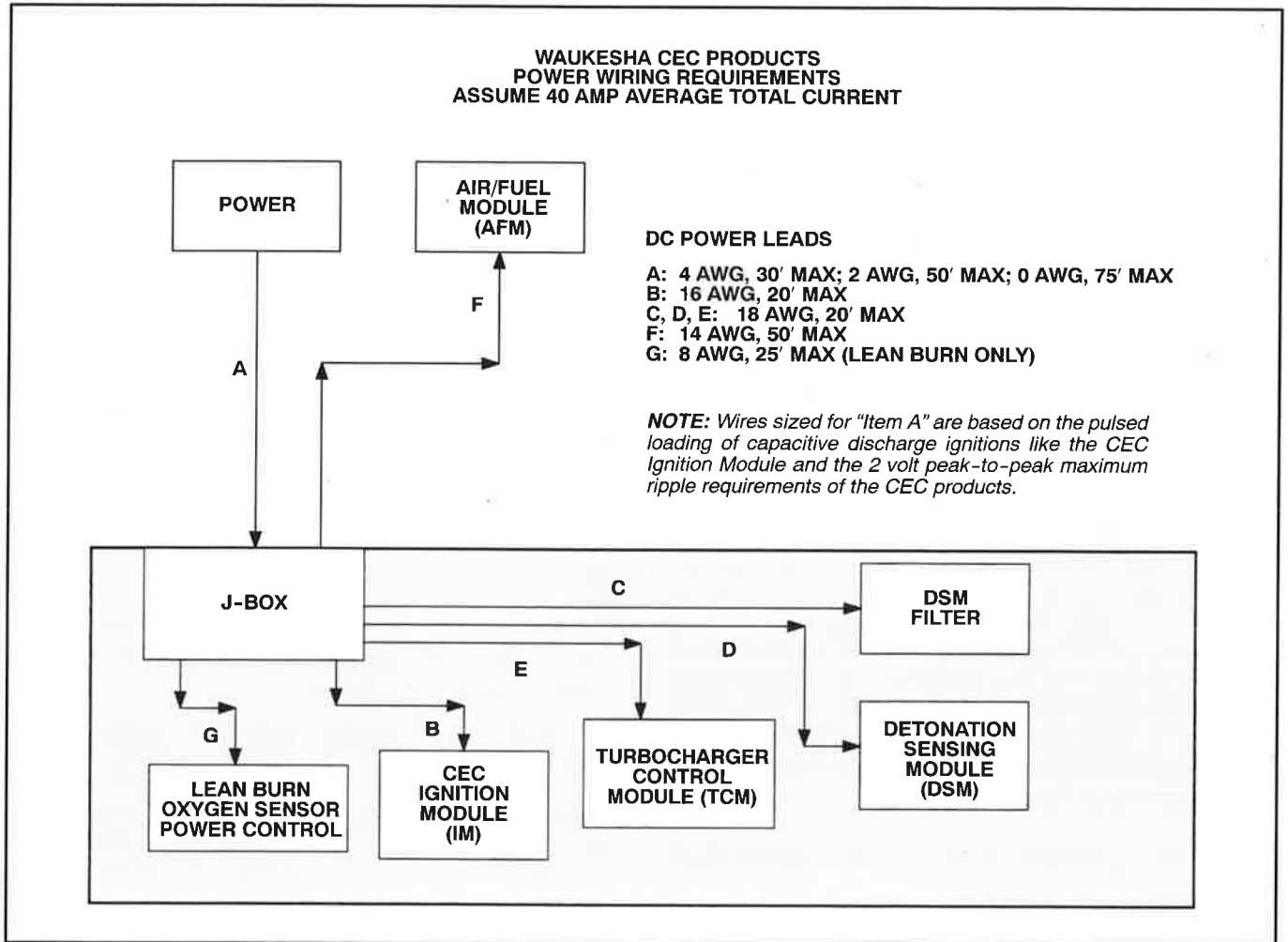


Figure 2.05-3. Waukesha CEC Products Power Wiring Requirements

VHP IGNITION MODULE ELECTRICAL CONNECTIONS

COMPLETING IGNITION MODULE WIRING

Complete IM electrical connections by following the steps below. Refer to Figure 2.05-5 through Figure 2.05-11 for IM wiring diagrams. Table 2.05-2 lists the page numbers of the wiring diagrams for each VHP wiring diagram.

NOTE: The wiring diagrams included in this manual are to be used as a reference only. Refer to the wiring diagrams received with the IM when making electrical connections.

Table 2.05-2. Page Locations Of VHP Wiring Diagrams

WIRING DIAGRAM	PAGE NUMBER
Figure 2.05-5. VHP 6 Cylinder (With Murphy Gas Valves) IM Wiring Diagram	2.05-6
Figure 2.05-6. VHP 6 Cylinder (Without Murphy Gas Valves) IM Wiring Diagram	2.05-7
Figure 2.05-7. VHP 12 Cylinder (With Murphy Gas Valves) IM Wiring Diagram	2.05-8
Figure 2.05-8. VHP 12 Cylinder (Without Murphy Gas Valves) IM Wiring Diagram	2.05-9
Figure 2.05-9. VHP 5115GL 12 Cylinder Engine IM Wiring Diagram	2.05-10
Figure 2.05-10. VHP 16 Cylinder (With Murphy Gas Valves) IM Wiring Diagram	2.05-11
Figure 2.05-11. VHP 16 Cylinder (Without Murphy Gas Valves) IM Wiring Diagram	2.05-12

WARNING

Do not install, set up, maintain, or operate any electrical components unless you are a technically qualified individual who is familiar with the electrical elements involved. Electrical shock can cause severe personal injury or death.

1. Connect a ground lead from the engine crankcase to the ground stud on the IM.
2. Connect the Primary Coil Harness to the IM connector.
3. Route the specified leads of the Primary Coil Harness to the ignition coils and cut to length (see applicable wiring diagram). Proper installation requires that the two end coils on 6 cylinder engines or the four corner coils on 12 and 16 cylinder engines are grounded to the engine. Install flashover protectors and new spark plugs to achieve optimum IM performance.

4. Connect the Power Pickup Harness to the Hall-effect pickup.

5. Connect the Power Pickup Harness from the Hall-effect pickup to the IM's 7 pin connector.

WARNING

Disconnect all electrical power supplies before making any power connections to the Ignition Module. Electrical shock can cause severe personal injury or death.

CAUTION

Engines that use TWO Murphy fuel shutoff valves for emergency fuel shutdowns must use an additional capacitor in parallel with the existing adapter. The additional capacitor is required to supply sufficient voltage to close both Murphy fuel shutdowns during emergency shutdowns.

CAUTION

Do not bundle the Ignition Module wiring and Hall-effect pickup wiring together. Maintain a minimum separation of at least six inches.

NOTE: All wiring and IM setup must be completed **BEFORE** the power supply is turned on.

6. Connect the power lead from the Power Pickup Harness to the DC power supply (see applicable wiring diagram and Figure 2.05-4).

7. Continue with Section 2.10, *VHP Ignition Module Timing Adjustments*, to adjust engine timing.

Before applying power to the IM and starting the engine, complete the "Prestart Checklist" in Section 2.10, *VHP Ignition Module Timing Adjustments*.

NOTE: Refer to Custom Engine Control® Detonation Sensing Module (DSM) Installation, Operation, And Maintenance Manual (*Form 6268*) for information on completing wiring connections between the DSM system and the IM.

VHP IGNITION MODULE ELECTRICAL CONNECTIONS

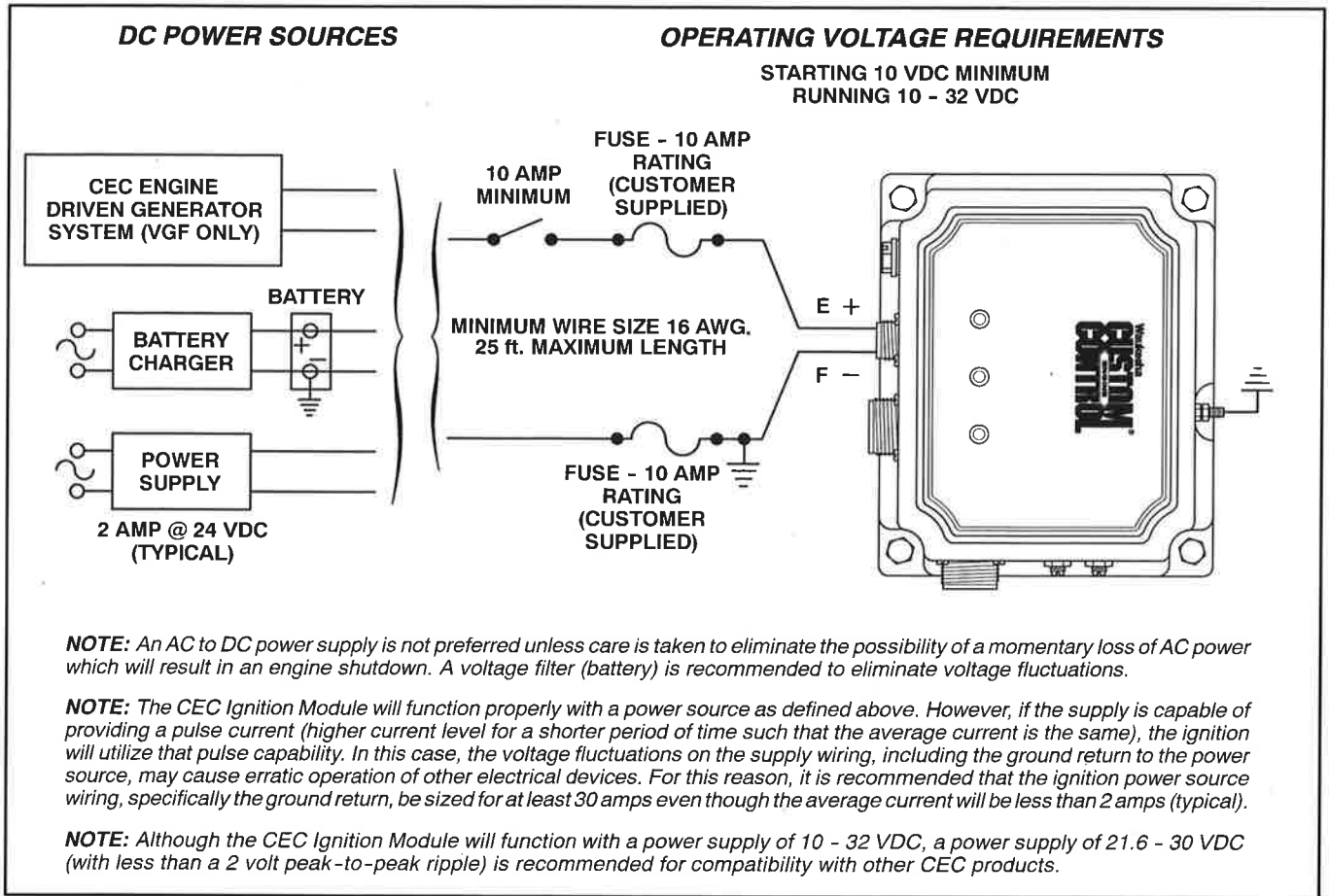


Figure 2.05-4. CEC Ignition Module Power Supply

VHP IGNITION MODULE ELECTRICAL CONNECTIONS

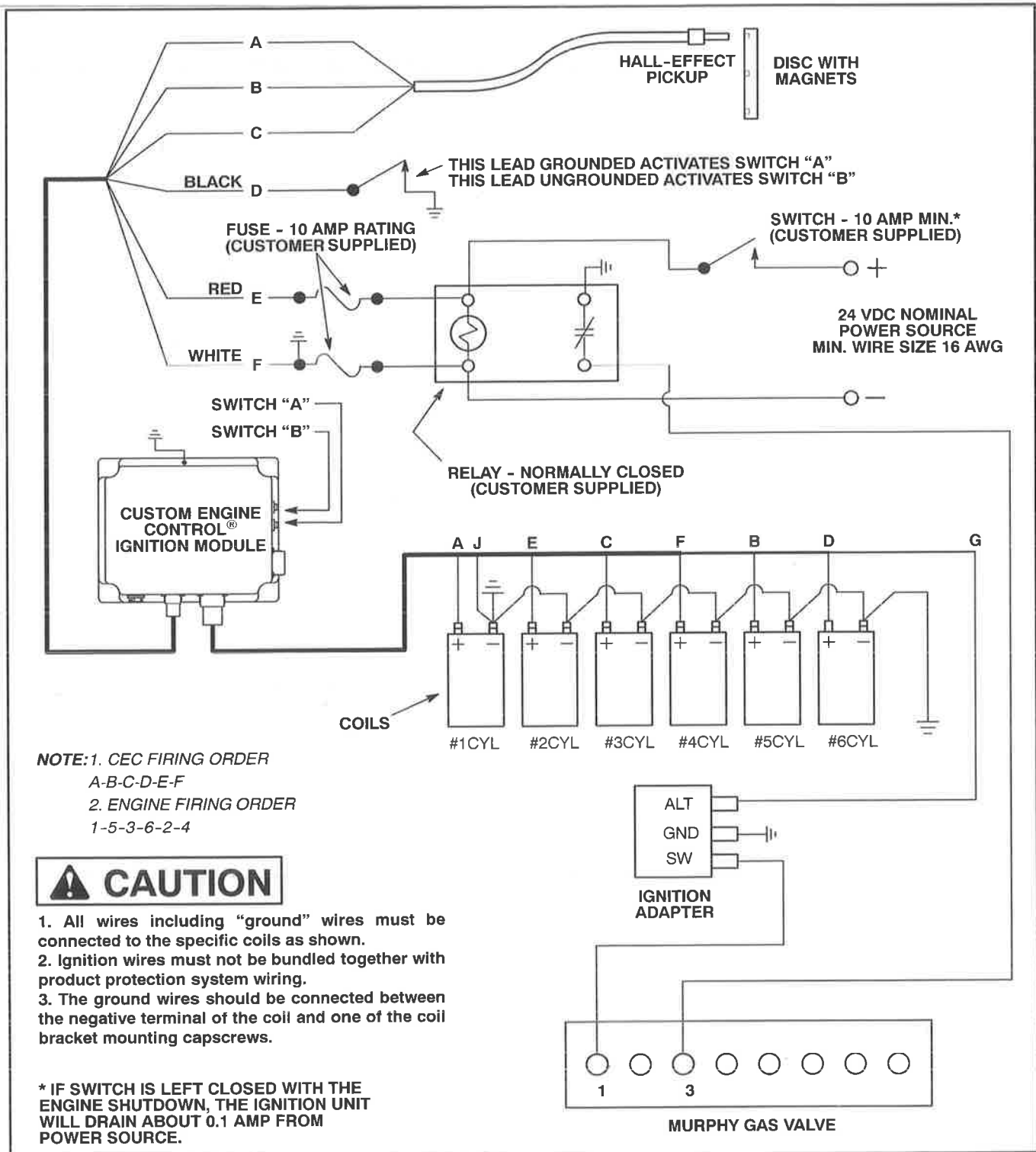


Figure 2.05-5. VHP 6 Cylinder (With Murphy Gas Valves) Ignition Module Wiring Diagram

VHP IGNITION MODULE ELECTRICAL CONNECTIONS

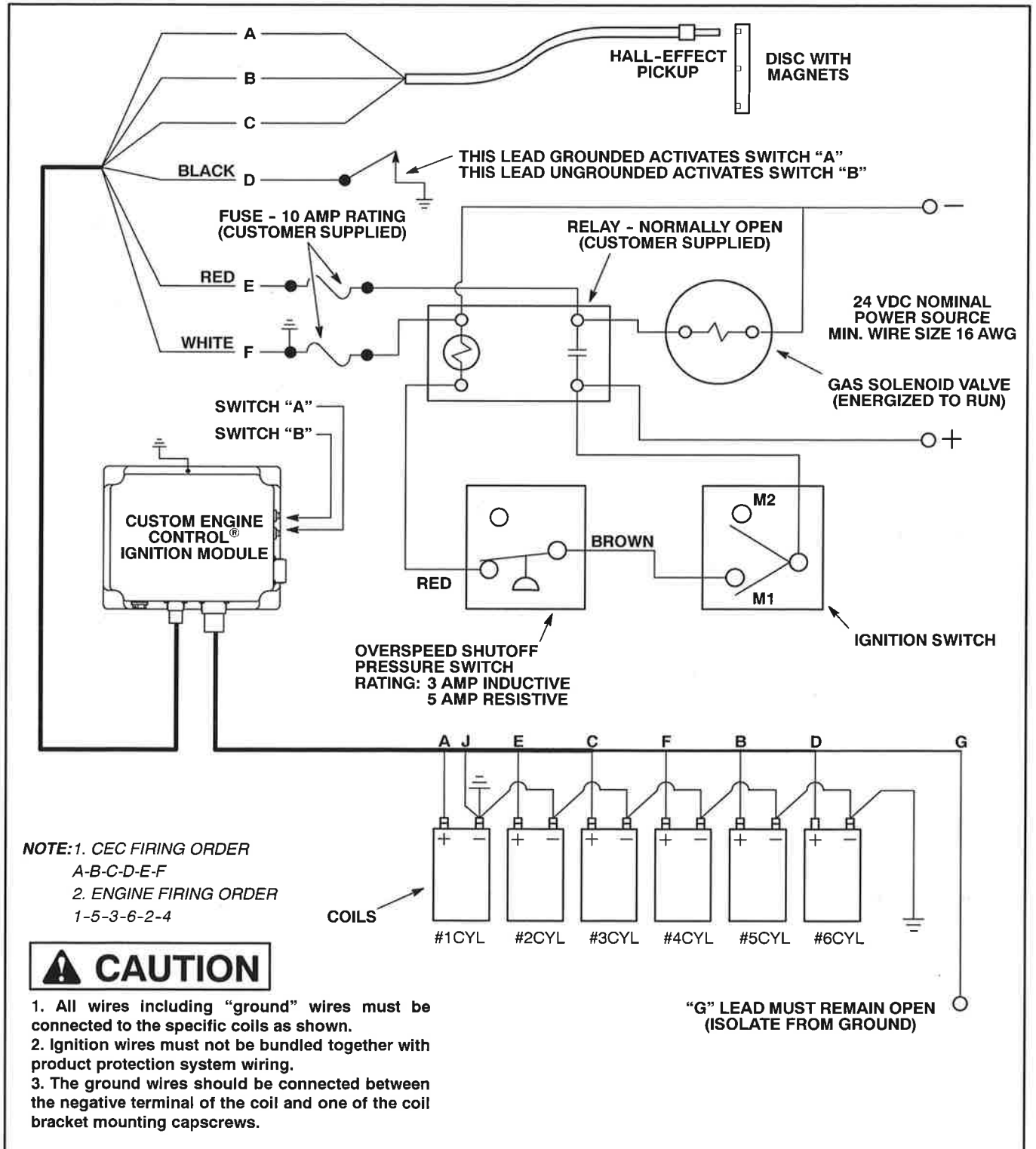


Figure 2.05-6. VHP 6 Cylinder (Without Murphy Gas Valves) Ignition Module Wiring Diagram

VHP IGNITION MODULE ELECTRICAL CONNECTIONS

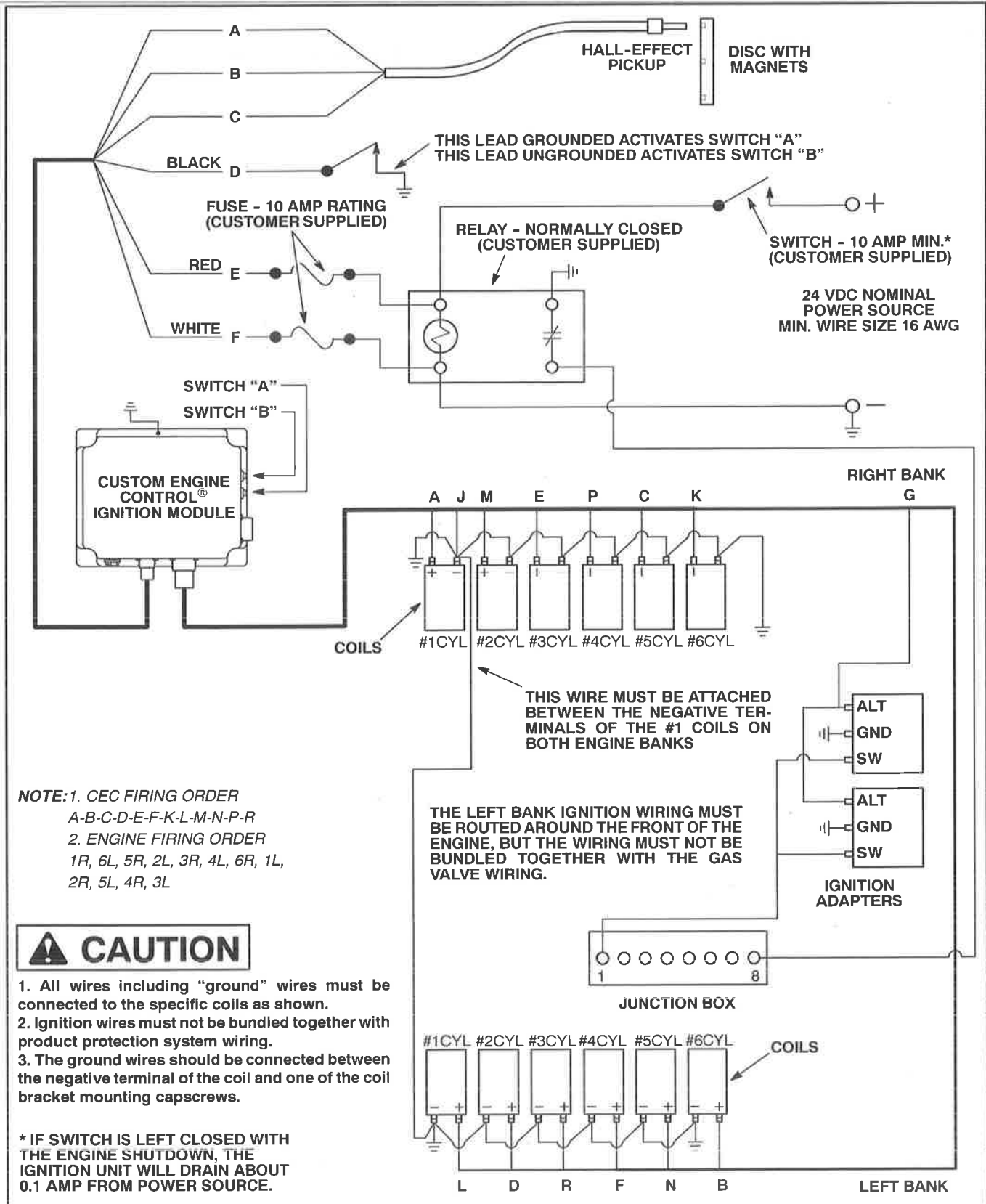


Figure 2.05-7. VHP 12 Cylinder (With Murphy Gas Valves) Ignition Module Wiring Diagram

VHP IGNITION MODULE ELECTRICAL CONNECTIONS

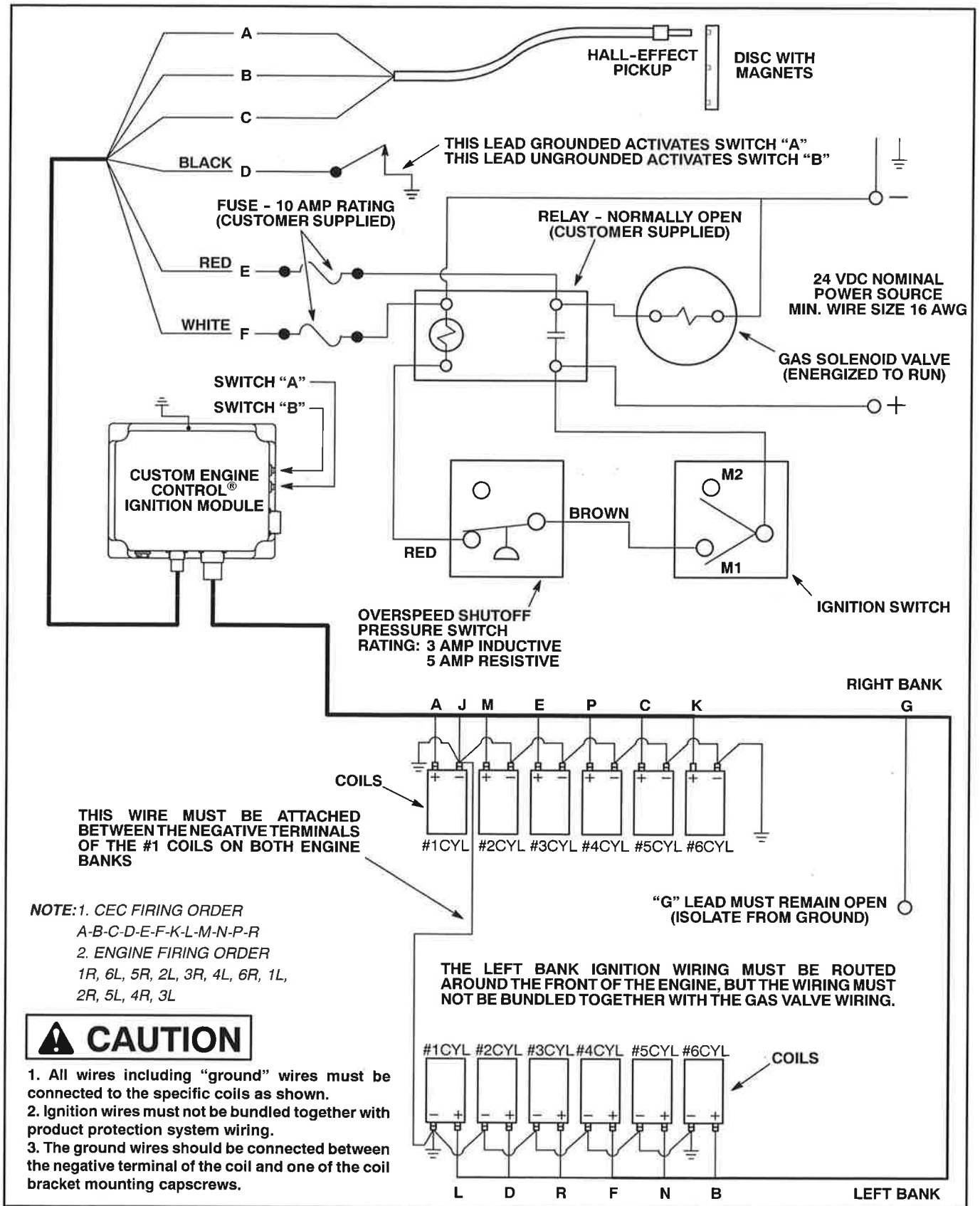
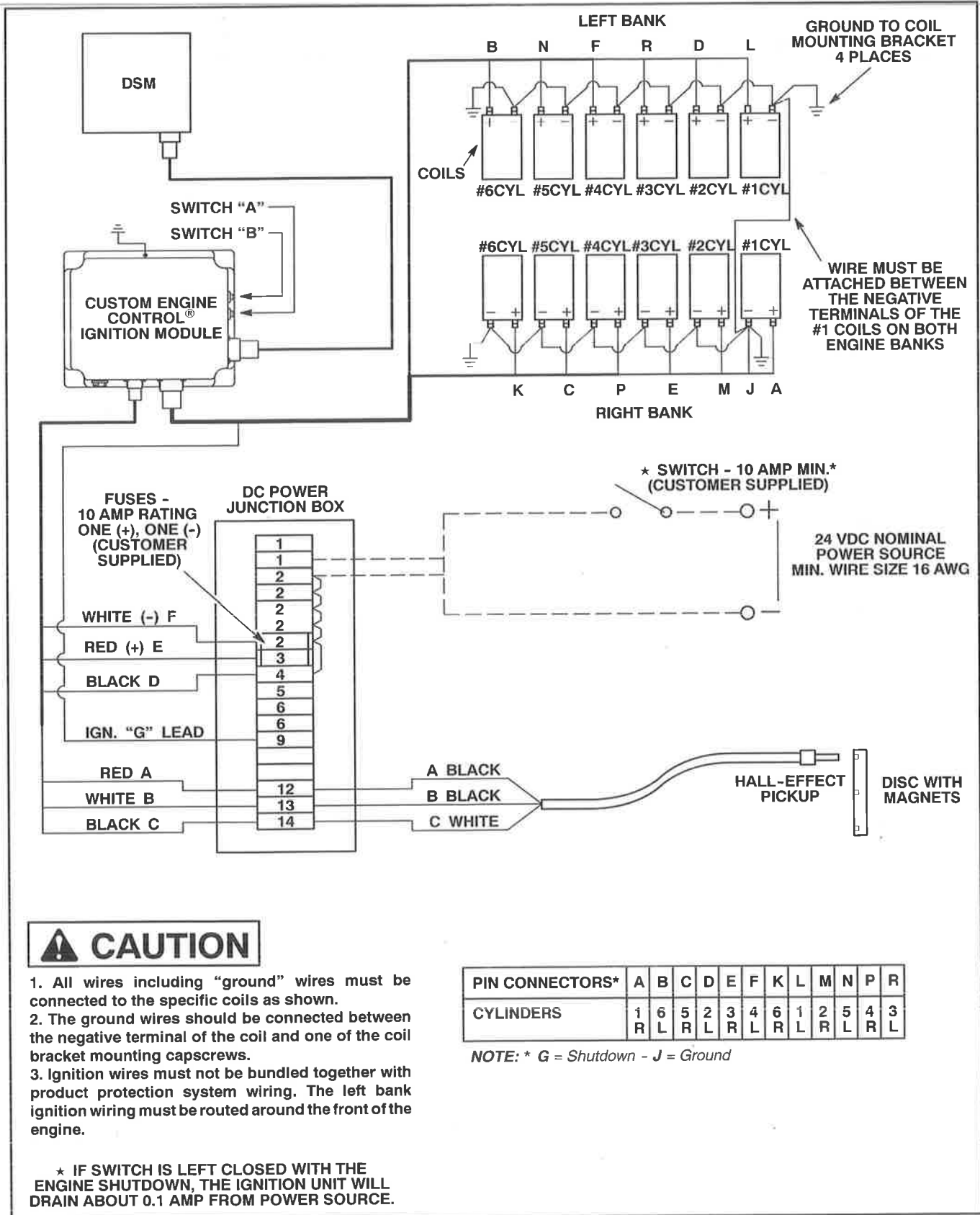


Figure 2.05-8. VHP 12 Cylinder (Without Murphy Gas Valves) Ignition Module Wiring Diagram

VHP IGNITION MODULE ELECTRICAL CONNECTIONS



CAUTION

1. All wires including "ground" wires must be connected to the specific coils as shown.
2. The ground wires should be connected between the negative terminal of the coil and one of the coil bracket mounting capscrews.
3. Ignition wires must not be bundled together with product protection system wiring. The left bank ignition wiring must be routed around the front of the engine.

* IF SWITCH IS LEFT CLOSED WITH THE ENGINE SHUTDOWN, THE IGNITION UNIT WILL DRAIN ABOUT 0.1 AMP FROM POWER SOURCE.

PIN CONNECTORS*	A	B	C	D	E	F	K	L	M	N	P	R
CYLINDERS	1	6	5	2	3	4	6	1	2	5	4	3
	R	L	R	L	R	L	R	L	R	L	R	L

NOTE: * G = Shutdown - J = Ground

Figure 2.05-9. VHP 5115GL Ignition Module Wiring Diagram

VHP IGNITION MODULE ELECTRICAL CONNECTIONS

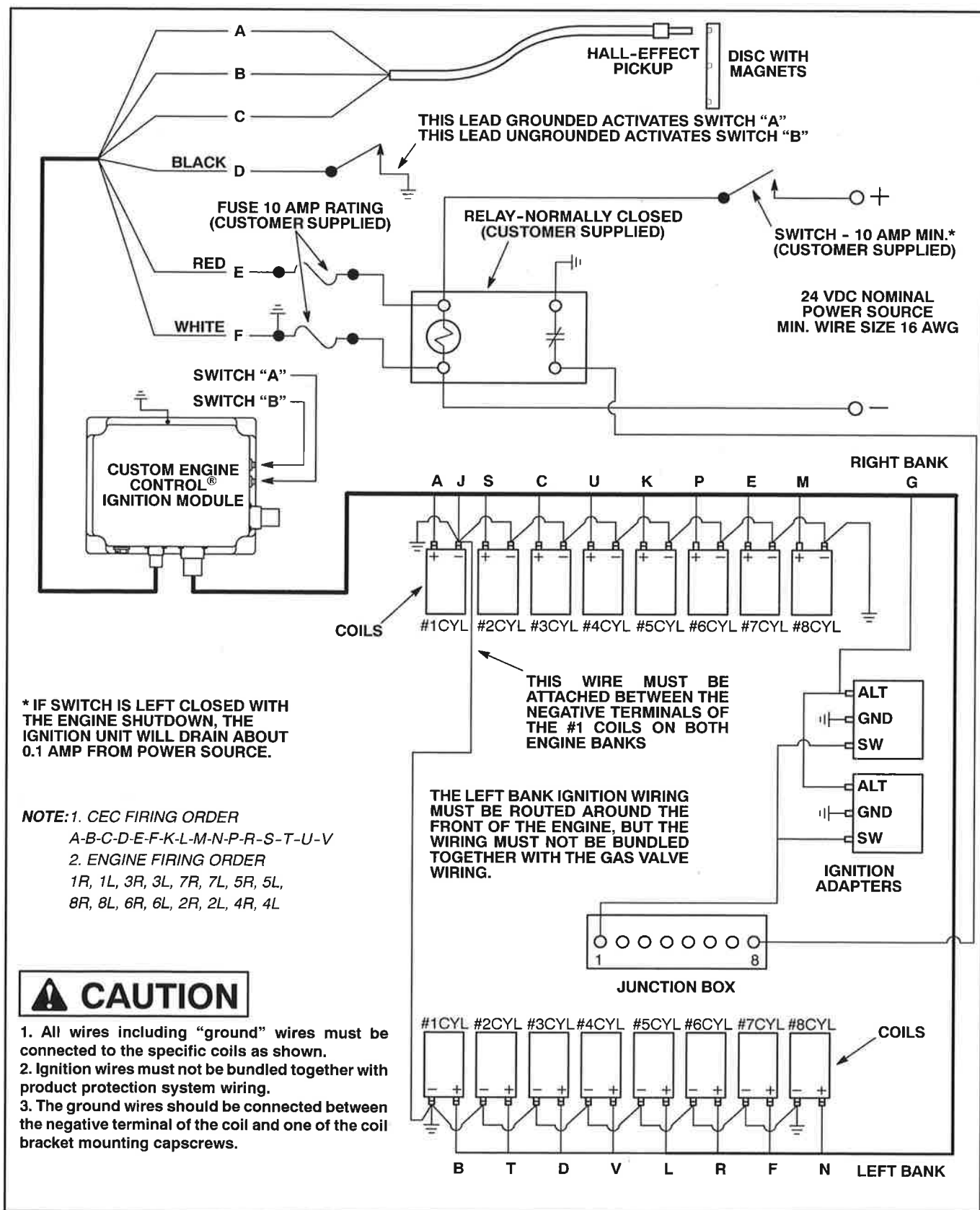


Figure 2.05-10. VHP 16 Cylinder (With Murphy Gas Valves) Ignition Module Wiring Diagram

VHP IGNITION MODULE ELECTRICAL CONNECTIONS

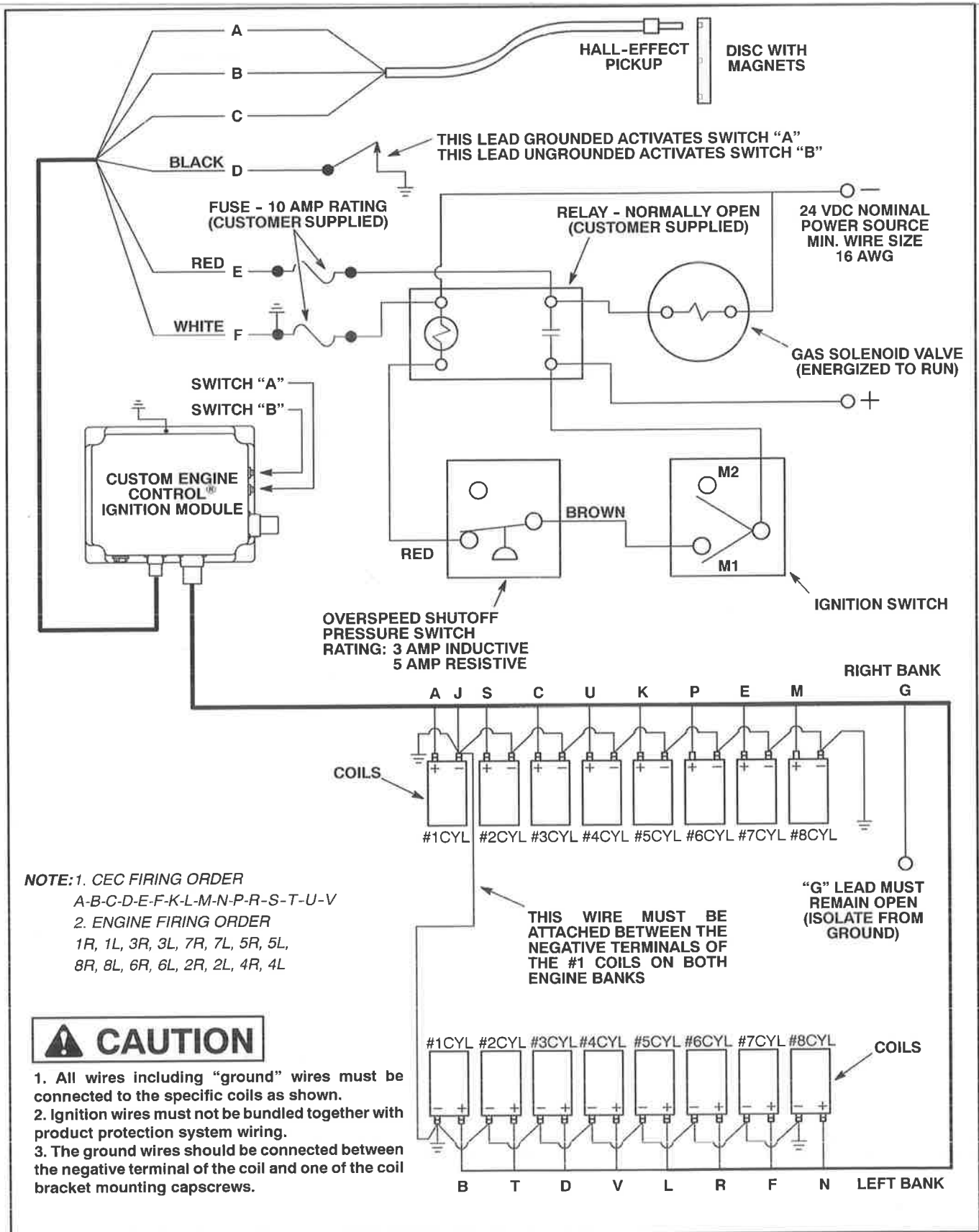


Figure 2.05-11. VHP 16 Cylinder (Without Murphy Gas Valves) Ignition Module Wiring Diagram

SECTION 2.10

VHP IGNITION MODULE TIMING ADJUSTMENTS

PRESTART CHECKLIST

Before applying power to the IM (engine not running):

- A. Visually inspect the installation to be sure that all wiring conforms to the requirements of this manual, local codes, and regulatory bodies.
- B. Verify all grounding requirements. Refer to Section 2.00, *VHP Ignition Module Electrical Connections*, "Electrical Connections," for wiring diagrams.
- C. Leave the IM unpowered. Verify that the power supply is within specification. Refer to Section 2.00, *VHP Ignition Module Electrical Connections*, "Electrical Connections," for power specifications.

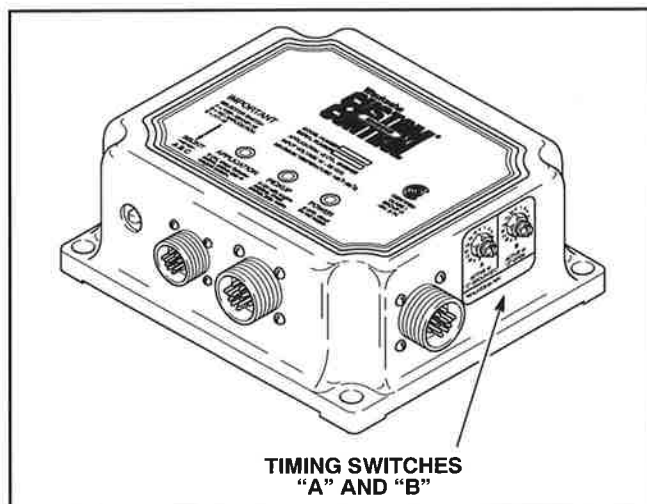


Figure 2.10-1. Ignition Module Timing Switches

VHP IGNITION TIMING SET

Timing is changed with two 16 position (0 - 15) timing switches located on the IM (see Figure 2.10-1). Each switch can be set to separate ignition timing settings for different applications. Timing switch position 15 gives the most advanced timing on the active timing switch, either switch "A" or "B." Switch "A" has a more advanced timing range than switch "B." Switch position 0 (zero) is full retard. The timing advances/retards 1.0 degree between each switch position. Grounding lead "D" in the Power Pickup Harness (7 pin connector) activates the timing selected by switch "A." Ungrounded lead "D" will activate the timing selected by switch "B."

For 6 and 12 cylinder engines, a 6 degree overlap between timing switch "A" and timing switch "B" gives the IM a combined timing range of 25 degrees.

For 16 cylinder engines, a 7 degree overlap between timing switch "A" and timing switch "B" gives the IM a combined timing range of 24 degrees.

Table 2.10-1 lists the IM firing order for 6 cylinder VHP engines. Table 2.10-2 lists the IM firing order for 12 cylinder VHP engines. Table 2.10-3 lists the IM firing order for 16 cylinder VHP engines.

Table 2.10-1. Firing Order For VHP 6 Cylinder Engines

PIN CONNECTORS*	A	B	C	D	E	F
CYLINDERS	1	5	3	6	2	4

Table 2.10-2. Firing Order For VHP 12 Cylinder Engines

PIN CONNECTORS*	A	B	C	D	E	F	K	L	M	N	P	R
CYLINDERS	1 R	6 L	5 R	2 L	3 R	4 L	6 R	1 L	2 R	5 L	4 R	3 L

NOTE: * G=Shutdown - J=Ground

Table 2.10-3. Firing Order For VHP 16 Cylinder Engines

PIN CONNECTORS*	A	B	C	D	E	F	K	L
CYLINDERS	1R	1L	3R	3L	7R	7L	5R	5L
PIN CONNECTORS*	M	N	P	R	S	T	U	V
CYLINDERS	8R	8L	6R	6L	2R	2L	4R	4L

NOTE: * G=Shutdown - J=Ground

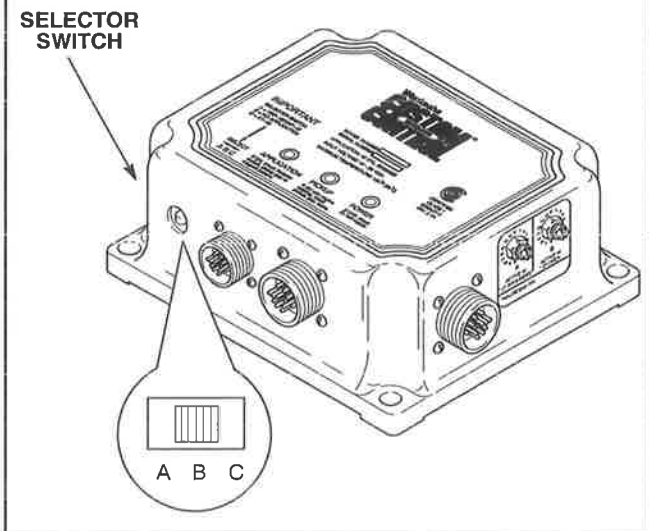
VHP IGNITION MODULE TIMING ADJUSTMENTS

STEPS REQUIRED TO ADJUST IGNITION MODULE TIMING

1. Complete the Prestart Checklist before running engine and adjusting timing.
2. Remove the cap from the Selector Switch access hole.
3. Set the appropriate timing application by adjusting the Selector Switch (see Table 2.10-4). The Selector Switch is a three position switch (A, B, and C). Use your finger or a screwdriver to switch to the proper application.
4. Replace the cover on the Selector Switch access hole.

Table 2.10-4. Ignition Module Selector Switch Settings

SELECTOR SWITCH SETTING	IGNITION MODULE MODELS		
	Model 811 for 6 & 8 Cylinder Engines	Model 1211 for All 12 Cylinder Engines	Model 1611 for All 16 Cylinder Engines
A	VHP/VGF 6 Cylinder Engines	VHP/VGF 12 Cylinder Engines	VHP/VGF 16 Cylinder Engines
B	No Application	No Application	No Application
C	ATGL/VGF 8 Cylinder Engines	ATGL 12 Cylinder Engines	ATGL 16 Cylinder Engines



5. Remove the white caps from the timing switches "A" and "B" on the side of the IM (see Figure 2.10-2).

6. Using a screwdriver, set both timing switches on the side of the IM to 10. Timing selection is made by the dot on the switch, not the screwdriver slot.

NOTE: If the IM being adjusted is replacing another IM, set the timing switches to the same positions as the IM being replaced.

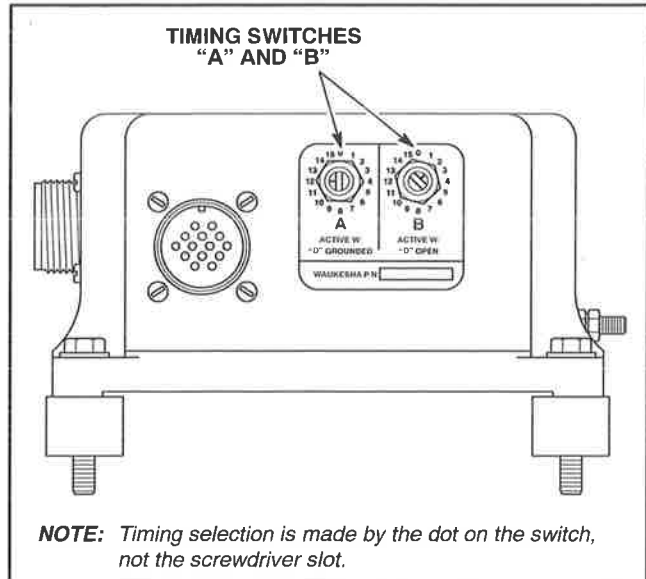


Figure 2.10-2. Timing Switches "A" And "B"

7. Check the engine's nameplate to determine the exact timing (or most advanced) of the primary and secondary (if equipped) fuels.

8. Apply power to IM. Refer to Section 2.05, VHP Ignition Module Electrical Connections, "Electrical Connections," for power specifications.

⚠ WARNING

If a gas engine has been cranked excessively without starting, shut off the gas fuel supply and ignition, and then crank the engine to purge the cylinders and exhaust system of accumulated unburned gas. If this is not done a spark could ignite the gas and cause an exhaust explosion. Failure to comply could cause severe personal injury or death.

9. Start engine. Run engine at idle speed and with NO load.

10. Run the engine on primary fuel with the "D" lead (found in the 7 pin connector from the IM) **grounded** to the engine block and the CEC Detonation Sensing Module (DSM) deactivated (14 pin DSM harness disconnected from IM).

11. Check engine timing at the flywheel using a timing light (see Figure 2.10-3).

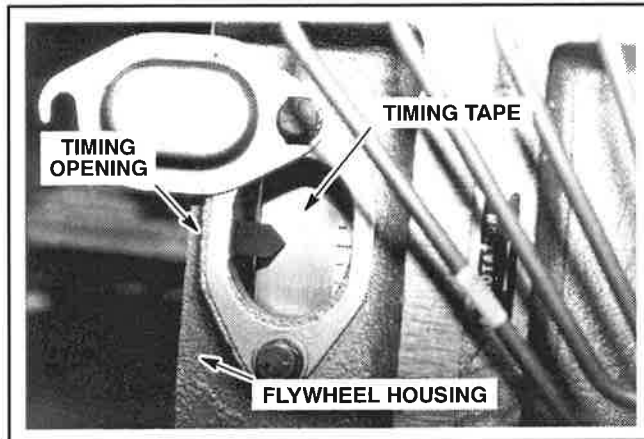


Figure 2.10-3. Flywheel Timing Opening

CAUTION Do not switch from position 15 to 0, 0 to 15 or make other large timing changes quickly while the engine is running. The large timing change may cause engine damage or shutdown.

NOTE: Increasing the timing switch position by one will advance the timing one degree. Decreasing the timing switch position by one will retard the timing one degree.

12. Adjust the "A" timing switch as required to achieve correct timing (see Figure 2.10-2). Single fuel ignition adjustments are now complete. If you have a single fuel application, continue with Step 16. If you have a dual fuel application, continue with Step 13.

13. Run the engine on secondary fuel with the "D" lead (found in the 7 pin connector from IM) **open** and the CEC Detonation Sensing Module (DSM) deactivated (14 pin DSM harness disconnected from IM).

14. Check engine timing at the flywheel using a timing light (see Figure 2.10-3).

NOTE: Increasing the timing switch position by one will advance the timing one degree. Decreasing the timing switch position by one will retard the timing one degree.

15. Adjust the "B" timing switch as required to achieve correct timing (see Figure 2.10-2). Dual fuel ignition adjustments are now complete.

CAUTION To prevent the timing from being altered, always replace the white caps over the timing switches once the desired setting has been selected. Disregarding this information could result in product damage and/or personal injury.

16. When timing adjustments are complete, replace the white caps on the timing switches "A" and "B."

17. If applicable, reconnect the DSM harness to the 14 pin connector on the IM. Activate the DSM. Refer to *Custom Engine Control® Detonation Sensing Module (DSM) Installation, Operation, And Maintenance Manual* (Form 6268) for programming information.

CAUTION It is the sole responsibility of the customer to ensure that all product protection devices effectively shut off both the ignition and gas simultaneously in the event of any malfunctions. Disregarding this information could result in product damage and/or personal injury.

18. Verify shutdown switches and load carrying ability.

DISCHARGING THE STORAGE CAPACITOR

WARNING

If the ignition switch is left in the ON position when an Ignition Module is disconnected, then the spark plugs may fire when the ignition system harness is reconnected, and could cause severe personal injury or death.

Before connecting the ignition harness (to the coils) to the IM, discharge the storage capacitors to ground. Attach one end of a wire lead to the crankcase and then touch the other end to the harness connector pins on the IM, one at a time. A snap may be heard when a capacitor discharges.

WARNING

As a safety measure, ground all the pins. Some breakerless ignition systems have more than one storage capacitor. Severe personal injury or death could result.

VHP IGNITION MODULE TIMING ADJUSTMENTS

CHAPTER 3 - ATGL IGNITION MODULE INSTALLATION AND OPERATION

CONTENTS

**SECTION 3.00 - IGNITION MODULE OPERATION ON
ATGL ENGINES**

**SECTION 3.05 - ATGL IGNITION MODULE
ELECTRICAL CONNECTIONS**

SECTION 3.10 - ATGL IGNITION MODULE TIMING ADJUSTMENTS

SECTION 3.00

IGNITION MODULE OPERATION ON ATGL ENGINES

IGNITION MODULE OPERATION ON ATGL ENGINES

The purpose of this section is to describe IM operation on ATGL engines and to describe the location of Hall-effect pickup(s).

8L-AT27GL ENGINES

Location Of Hall-effect Pickups

The IM system consists of the following components: module, timing disc, two Hall-effect pickups, pickup cable assembly, and a magnet-embedded flywheel.

The 8L-AT27GL has a two pickup, crankshaft-fired ignition system. The 8L-AT27GL has an index disc mounted on the rear end of the camshaft and a camshaft Hall-effect pickup mounted on the rear plate of the engine (see Figure 3.00-1). The index disc has one magnet—the index magnet.

The 8L-AT27GL has a second Hall-effect pickup mounted at the flywheel (see Figure 3.00-2). The flywheel Hall-effect pickup senses the passing of four magnets on the rear of the flywheel and sends a signal to the IM which fires the appropriate cylinders. (Since there is one camshaft revolution for every two flywheel revolutions, the four flywheel magnets are sensed *twice* for every one revolution of the camshaft.) The center of the Hall-effect pickup face lines up with the center of each magnet embedded in the face of the timing disc as it rotates on the camshaft. The camshaft Hall-effect pickup, in conjunction with the index magnet, signals the IM that another camshaft revolution is about to begin.

The advantage of the two pickup system on the 8L-AT27GL is that it allows for increased accuracy in timing by eliminating the effects of camshaft gear lash from information relayed to the IM.

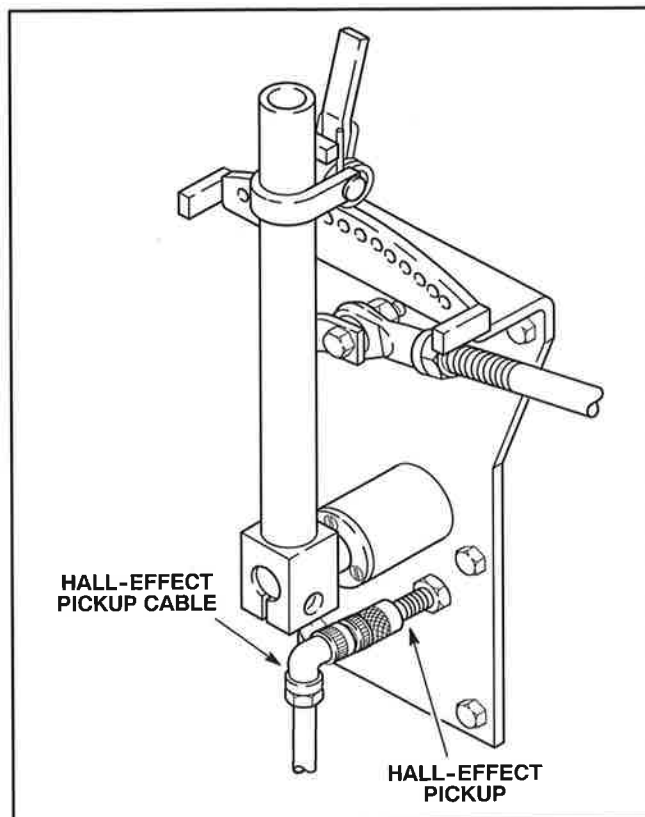


Figure 3.00-1. AT27GL Hall-effect Pickup

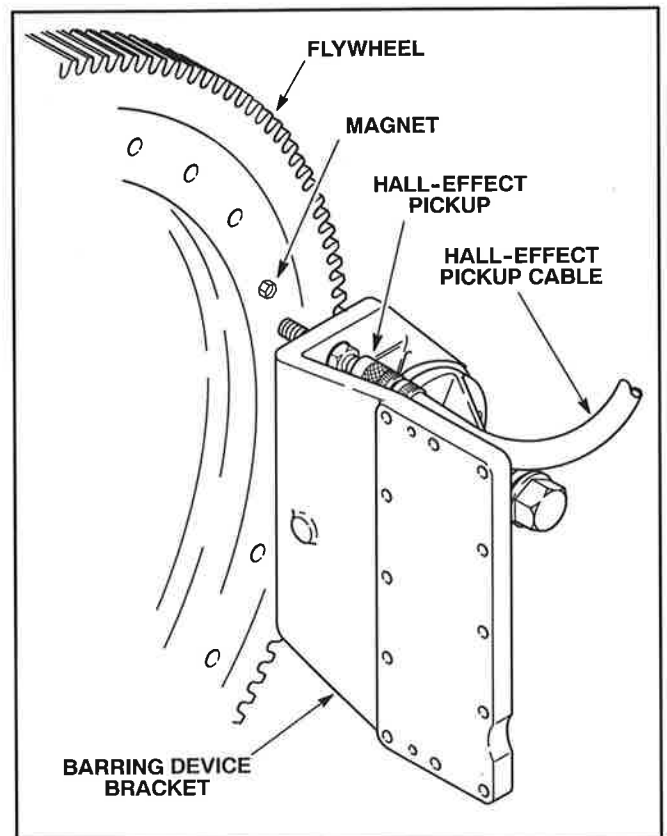


Figure 3.00-2. AT27GL Hall-effect Pickup

IGNITION MODULE OPERATION ON ATGL ENGINES

Setting The Air Gap

To set the air gap specification, complete the following steps.

1. Thread the Hall-effect pickup into the engine rear plate until the pickup comes in contact with the timing disc.
2. Scribe a reference mark on the Hall-effect pickup and at the same point mark the mounting bracket.
3. Using the reference mark on the pickup as the starting point, rotate the Hall-effect pickup **one (1)** full turn (+0, -1/16 of a turn) counterclockwise to set the pickup to timing disc clearance.
4. After the clearance is set, snug the locking nut.

12V-AT27GL ENGINES

Location Of Hall-effect Pickups

The 12V-AT27GL IM system consists of the following components: module, aluminum disc mounted on the camshaft gear, two Hall-effect pickups, pickup cable assembly, magnet imbedded flywheel, and flywheel Hall-effect pickup.

The 12V-AT27GL has a two pickup, crankshaft-fired ignition system with an index disc mounted on the rear end of the right bank camshaft and a camshaft Hall-effect pickup mounted on the right bank side of the rear plate (see Figure 3.00-3 and Figure 3.00-4). The index disc has one magnet—the index magnet.

The 12V-AT27GL engine also has a second Hall-effect pickup mounted at the flywheel (see Figure 3.00-5). This flywheel Hall-effect pickup senses the passing of six magnets on the rear of the flywheel and sends a signal to the IM which fires the appropriate cylinders. (Since there is one camshaft revolution for every two flywheel revolutions, the six flywheel magnets are sensed *twice* for every one revolution of the camshaft.) The camshaft Hall-effect pickup, in conjunction with the index magnet, signals the IM that another camshaft revolution is about to begin.

The advantage of the two pickup system on the 12V-AT27GL is that it allows for increased accuracy in timing by eliminating the effects of camshaft gear lash from information relayed to the IM.

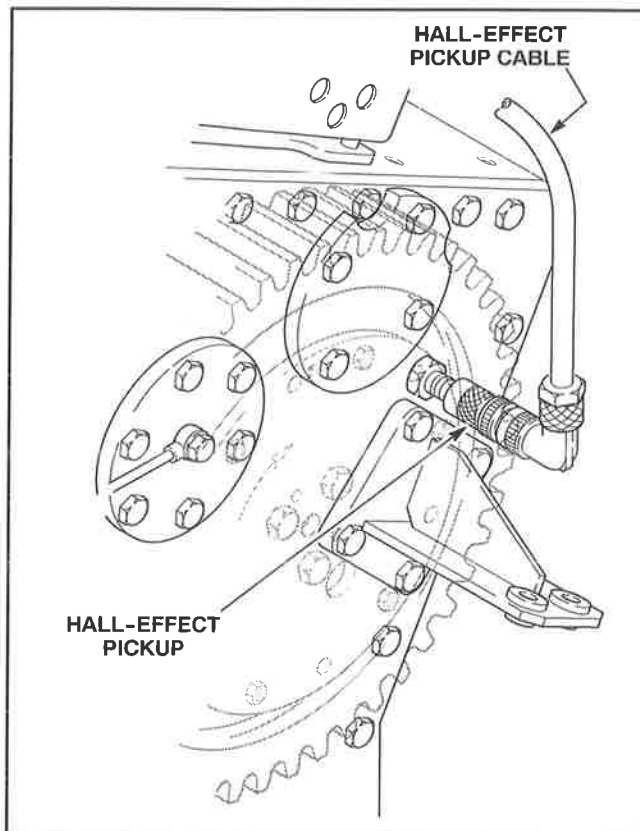


Figure 3.00-3. Camshaft Hall-effect Pickup

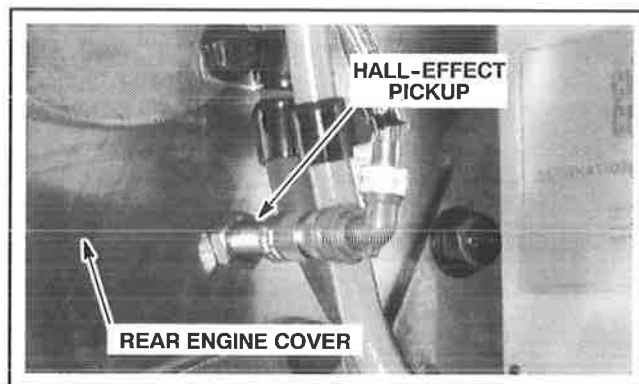


Figure 3.00-4. Hall-effect Pickup Installed

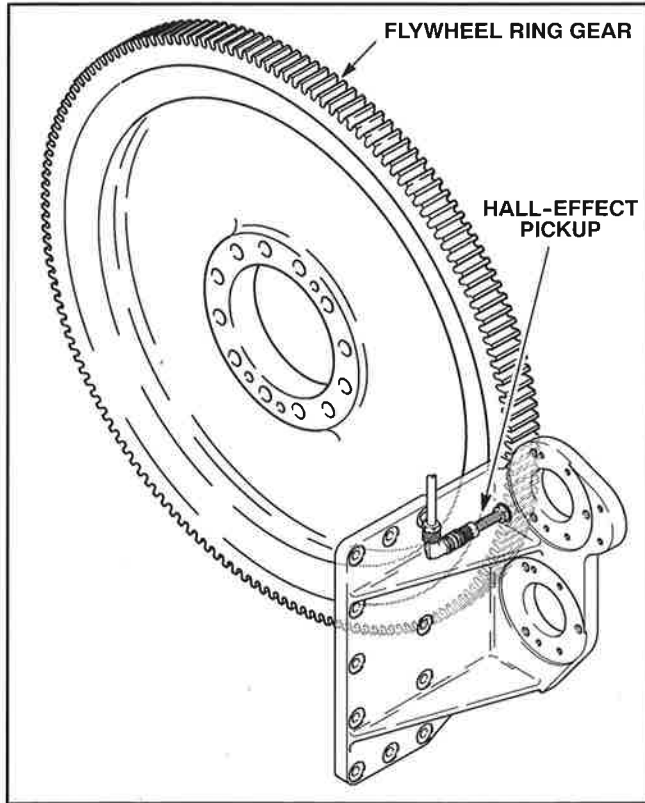


Figure 3.00-5. AT27GL Flywheel Hall-effect Pickup

Setting The Air Gap

To set the air gap specification, complete the following steps.

1. Thread the Hall-effect pickup into the engine rear plate until the pickup comes in contact with the timing disc.
2. Scribe a reference mark on the Hall-effect pickup and at the same point mark the mounting bracket.
3. Using the reference mark on the pickup as the starting point, rotate the Hall-effect pickup **one (1)** full turn (+0, -1/16 of a turn) counterclockwise to set the pickup to timing disc clearance.
4. After the clearance is set, snug the locking nut.

12V-AT25GL ENGINES

Location Of Hall-effect Pickup

The 12V-AT25GL IM system consists of the following components: module, aluminum disc mounted on the camshaft gear, one Hall-effect pickup, and pickup cable assembly.

The 12V-AT25GL has a one pickup, camshaft-fired ignition system. A timing disc is mounted on the rear end of the right bank camshaft (see Figure 3.00-6). The timing disc has thirteen magnets. Twelve of the magnets are for firing the appropriate cylinder. Trailing 15 degrees after the last magnet is an index magnet that signals the IM that another camshaft revolution is about to begin. The camshaft Hall-effect pickup, mounted on the right bank side of the rear plate, senses the passing of these magnets and sends a signal to the IM which fires the appropriate cylinders (see Figure 3.00-3).

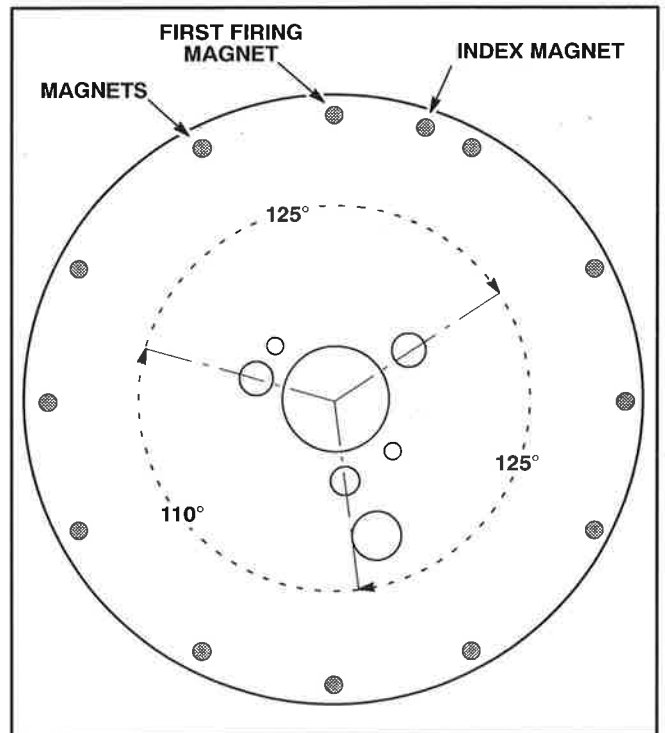


Figure 3.00-6. 12V-AT25GL Timing Disc

IGNITION MODULE OPERATION ON ATGL ENGINES

Setting The Air Gap

To set the air gap specification, complete the following steps.

1. Thread the Hall-effect pickup into the engine rear plate until the pickup comes in contact with the timing disc.
2. Scribe a reference mark on the Hall-effect pickup and at the same point mark the mounting bracket.
3. Using the reference mark on the pickup as the starting point, rotate the Hall-effect pickup $\frac{3}{4}$ of a turn ($\pm \frac{1}{16}$ of a turn) counterclockwise to set the pickup to timing disc clearance.
4. After the clearance is set, snug the locking nut.

SECTION 3.05

ATGL IGNITION MODULE ELECTRICAL CONNECTIONS

MOUNTING THE IGNITION MODULE

Mount the IM using the vibration isolators supplied with the IM (see Figure 3.05-1). Note the following:

- When the IM is being mounted on an earlier rear plate in a retrofit situation, the IM is mounted in the manner shown in Figure 3.05-1 (see asterisked components).

- The outside temperature of IM casing should not exceed 150° F (65° C) in operation.

CAUTION Do not weld on or around engine unless the Ignition Module has been unplugged. Failure to do so may damage the Ignition Module.

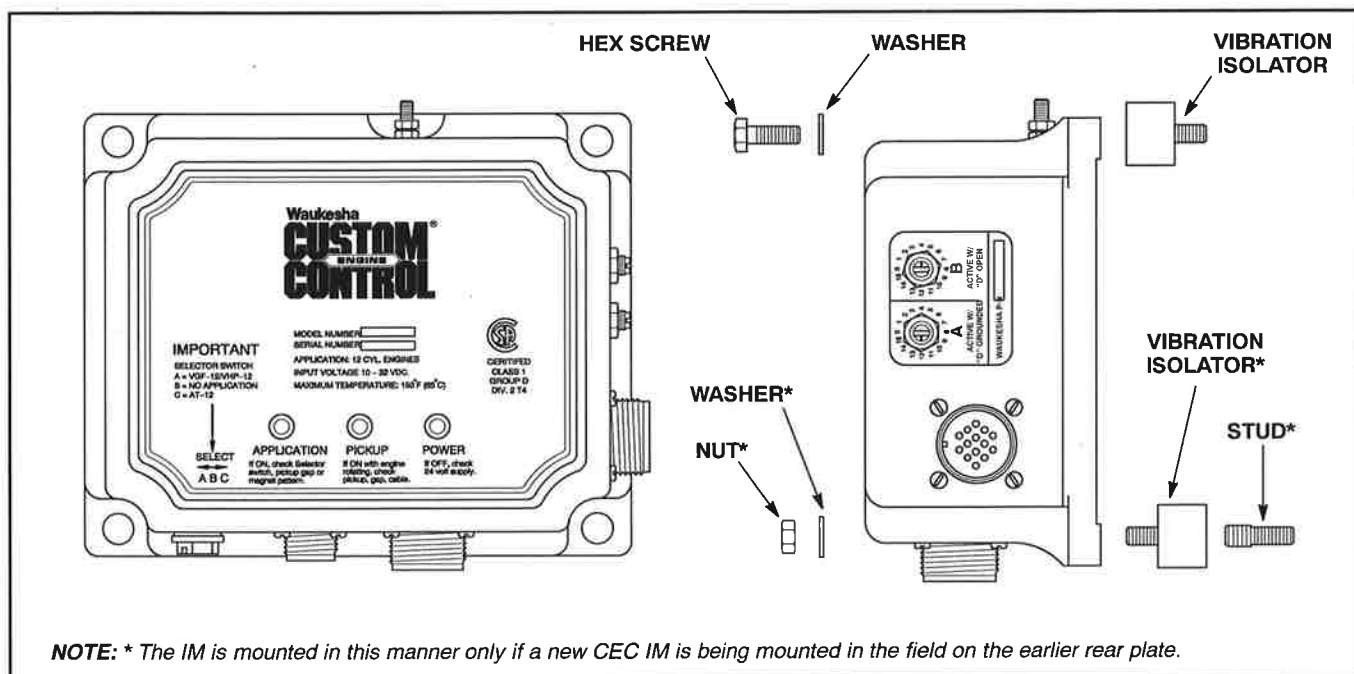


Figure 3.05-1. Mounting The Ignition Module - AT Engines

ATGL IGNITION MODULE ELECTRICAL CONNECTIONS

ELECTRICAL CONNECTIONS

IGNITION MODULE POWER REQUIREMENTS

The power connections made for the IM must be in accordance with the applicable local electrical codes. The IM is suitable for installation in Canadian Standards Association (CSA) Class I, Group D, Division 2 locations. All power sizing must be in accordance with Figure 3.05-3, "Waukesha CEC Products Power Wiring Requirements."

See Table 3.05-1 for IM power requirements.

NOTE: An AC to DC power supply is not preferred unless care is taken to eliminate the possibility of a momentary loss of AC power which will result in an engine shutdown. A DC voltage filter (battery) is recommended to eliminate voltage fluctuations.

NOTE: For compatibility with other CEC products, a nominal supply of 24 VDC with less than a 2 volt peak-to-peak ripple is recommended to power the IM.

NOTE: Refer to Section 1.05, General Information, "Power Requirements for Custom Engine Control® Products," for the power requirements of all Waukesha Engine CEC products.

POWER SOURCE WIRING SIZING AND GROUNDING

The IM, a capacitive discharge (CD) ignition system, requires an external power source which presents special wiring requirements. The IM will function properly with a power source as defined in Table 3.05-1. However, if the supply is capable of providing a pulse current (higher current level for a shorter period of time such that the average current is the same), the IM will utilize that pulse capability. In this case, the voltage fluctuations on the supply wiring, including the ground return to the power source, may interfere with the operation of other electrical devices. For this reason, it is recommended that the IM power source wiring, specifically the ground return, be sized for at least 30 amps even though the average current will be less than 2 amps (typical).

In addition, the grounding, particularly where the ground is "referenced," is critical. It is necessary to reference all of the grounds to the same point. The engine crankcase has been chosen as THE GROUND reference to minimize interference with sensor signals. By following the recommended wiring and grounding procedures, the concerns associated with the ignition power supply wiring voltage drops can be greatly reduced or eliminated.

NOTE: For additional information on capacitive discharge and grounding, see Section 1.05, General Information, "Capacitive Discharge And Grounding."

AT ENGINE WIRING HARNESS CONNECTIONS

The IM has three external wiring harness connectors (see Figure 3.05-2). The Power Pickup Harness which includes leads for DC power, the Hall-effect pickup, and the "D" lead connects to the Main J-box and the 7 pin connector on the IM. The Primary Coil Harness which includes leads to the ignition coils connects to the Ignition J-Box and the IM. The 14 pin connector is used to interface with the CEC Detonation Sensing Module (DSM). The 14 pin connector is only used when the DSM is installed on the engine.

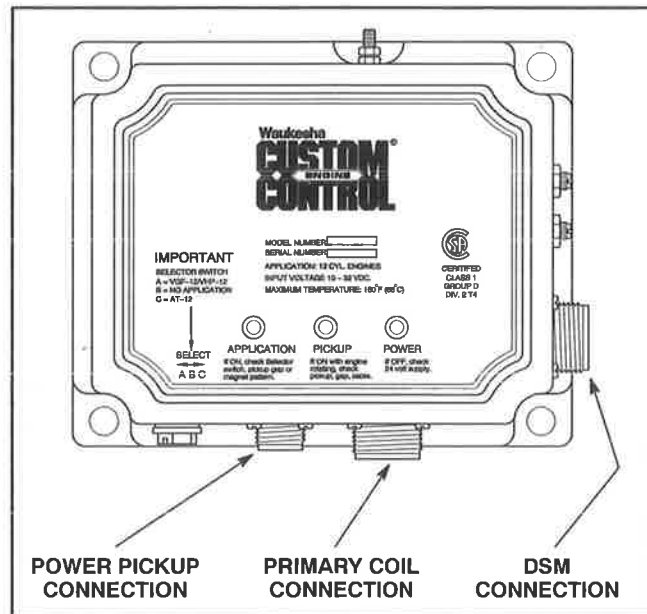


Figure 3.05-2. Ignition Module Wiring Harness Connections

ATGL IGNITION MODULE ELECTRICAL CONNECTIONS

Table 3.05-1. Power Requirements For The Ignition Module

CEC PRODUCT	NOMINAL VOLTAGE (volts DC)	TOLERANCE	OPERATING RANGE (volts DC)	PEAK-TO-PEAK RIPPLE (volts AC)	OPERATING CURRENT (amps)
Ignition Module	24	+33%, -58%	10.0 - 32.0*	less than 2*	2 (typical)

NOTE: *For compatibility with other CEC products, a nominal supply of 24 VDC with less than a 2 volt peak-to-peak ripple is recommended to power the IM.

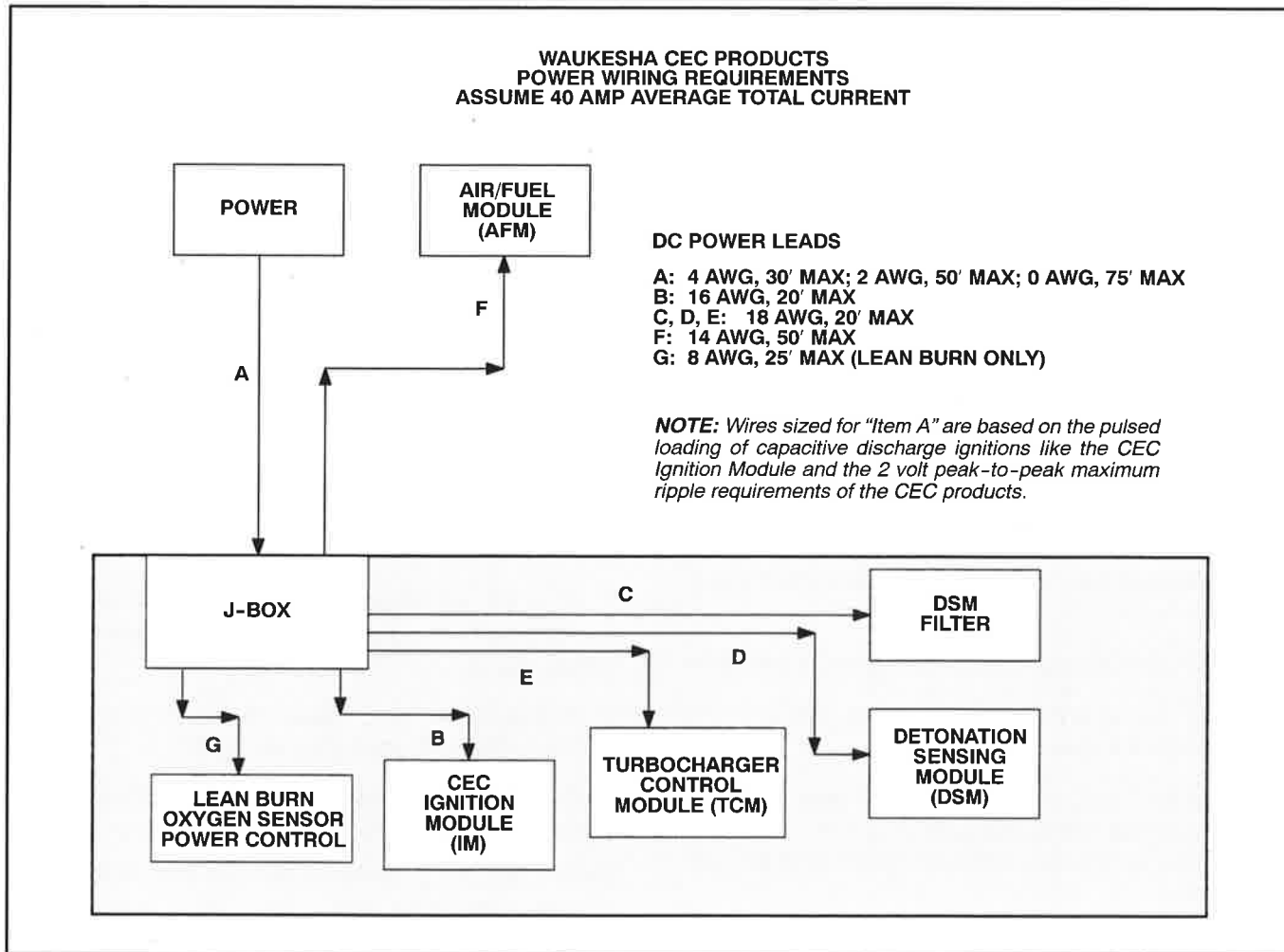


Figure 3.05-3. Waukesha CEC Products Power Wiring Requirements

ATGL IGNITION MODULE ELECTRICAL CONNECTIONS

COMPLETING IGNITION MODULE WIRING

Complete IM electrical connections by following the steps below. Refer to Figure 3.05-8 through Figure 3.05-10 for IM wiring diagrams. Table 3.05-2 lists the page numbers of the wiring diagrams for each AT wiring diagram.

NOTE: The wiring diagrams included in this manual are to be used as a reference only. Refer to the wiring diagrams received with the IM when making electrical connections.

Table 3.05-2. Page Locations Of AT Wiring Diagrams

WIRING DIAGRAM	PAGE NUMBER
Figure 3.05-8. 8L-AT27GL IM Wiring Diagram	3.05-9
Figure 3.05-9. 12V-AT27GL IM Wiring Diagram	3.05-10
Figure 3.05-10. 12V-AT25GL IM Wiring Diagram	3.05-11

WARNING

Do not install, set up, maintain or operate any electrical components unless you are a technically qualified individual who is familiar with the electrical elements involved. Electrical shock can cause severe personal injury or death.

1. Connect a ground lead from the engine crankcase to the ground stud on the IM.
2. Connect the Primary Coil Harness to the IM connector.
3. Route the specified leads of the Primary Coil Harness into the Ignition J-box.
4. Attach the leads of the Primary Coil Harness to the proper terminals inside the Ignition J-box. Install new spark plugs to achieve optimum ignition system performance.
5. Complete wiring connections to ignition coils from the Ignition J-box.
6. Route the harness(es) from the Hall-effect pickup(s) to the Main J-box (see Figure 3.05-5, Figure 3.05-6, and Figure 3.05-7). AT27GL engines have two Hall-effect pickups and harnesses.

WARNING

Disconnect all electrical power supplies before making any power connections to the Ignition Module. Electrical shock can cause severe personal injury or death.

CAUTION

Engines that use TWO Murphy fuel shutoff valves for emergency fuel shutdowns must use an additional capacitor in parallel with the existing adapter. The additional capacitor is required to supply sufficient voltage to close both Murphy fuel shutdowns during emergency shutdowns. Disregarding this information could result in product damage and/or personal injury.

CAUTION

Do not bundle the Ignition Module wiring and Hall-effect pickup wiring together. Maintain a minimum separation of at least six inches. Disregarding this information could result in product damage and/or personal injury.

NOTE: All wiring and IM setup must be completed BEFORE the power supply is turned on.

7. Wire the IM power supply to the Main J-box. All wiring must be completed BEFORE the power supply is turned on.
8. Connect the Power Pickup Harness from the Main J-Box to the 7 pin connector on the IM.
9. Continue with Section 3.10, *ATGL Ignition Module Timing Adjustments*, to adjust engine timing.

Before applying power to the IM and starting the engine, complete the "Prestart Checklist" in Section 3.10, *ATGL Ignition Module Timing Adjustments*.

NOTE: Refer to Custom Engine Control[®] Detonation Sensing Module (DSM) Installation, Operation, And Maintenance Manual (*Form 6268*), for information on completing wiring connections between the DSM system and the IM.

ATGL IGNITION MODULE ELECTRICAL CONNECTIONS

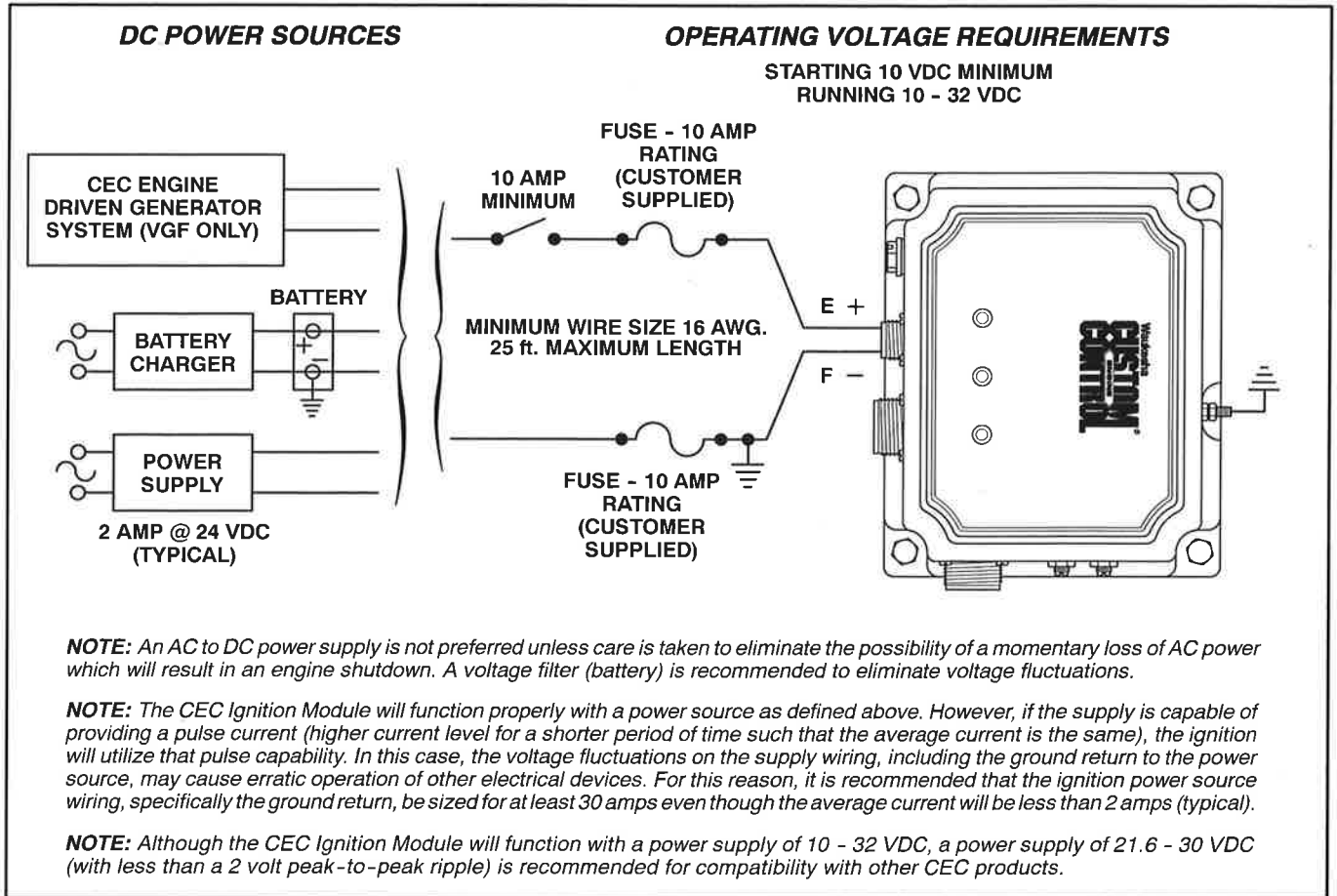


Figure 3.05-4. CEC Ignition Module Power Supply

ATGL IGNITION MODULE ELECTRICAL CONNECTIONS

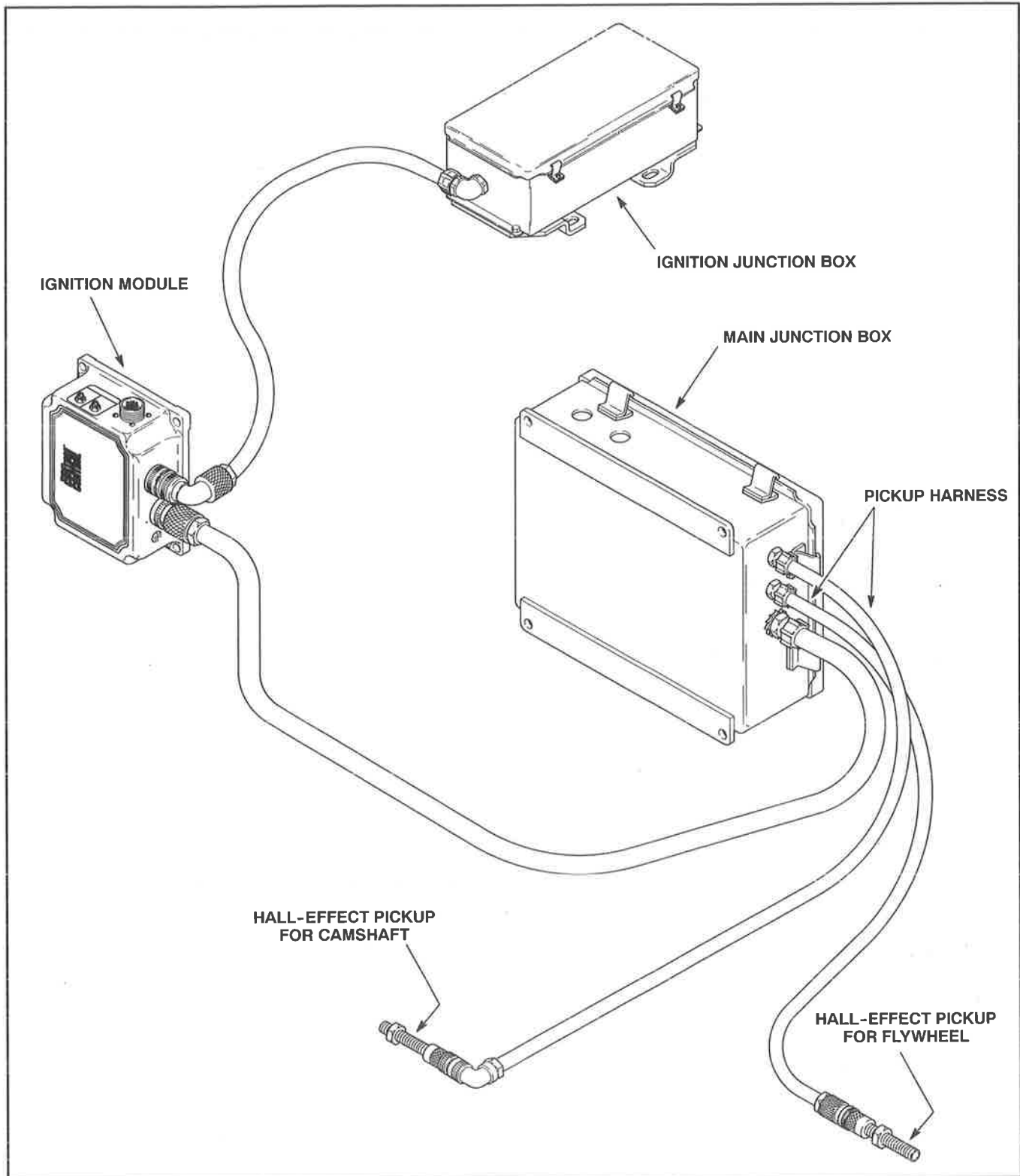


Figure 3.05-5. 8L-AT27GL Hall-effect Pickups And Harness Connections

ATGL IGNITION MODULE ELECTRICAL CONNECTIONS

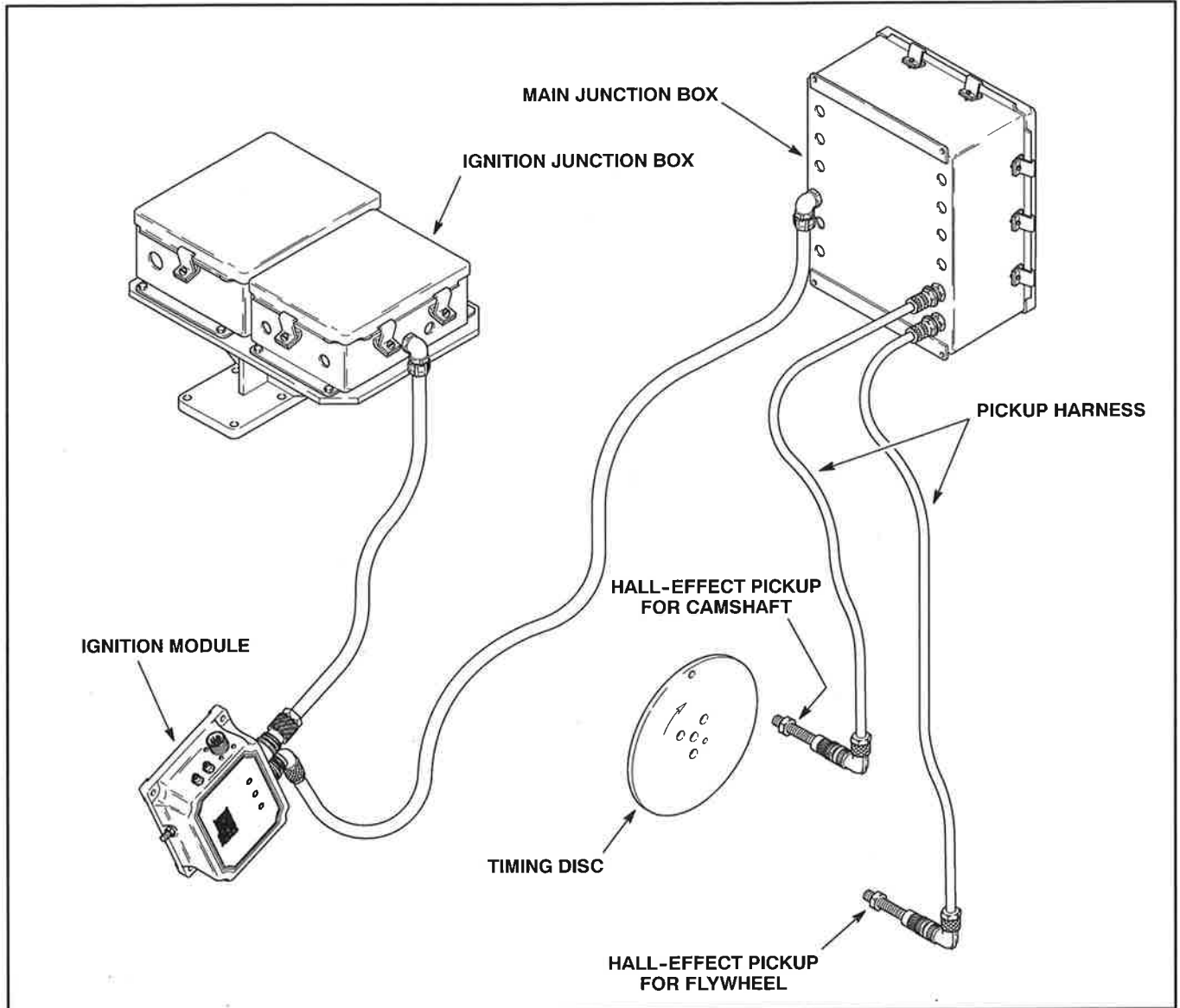


Figure 3.05-6. 12V-AT27GL Hall-effect Pickups And Harness Connections

ATGL IGNITION MODULE ELECTRICAL CONNECTIONS

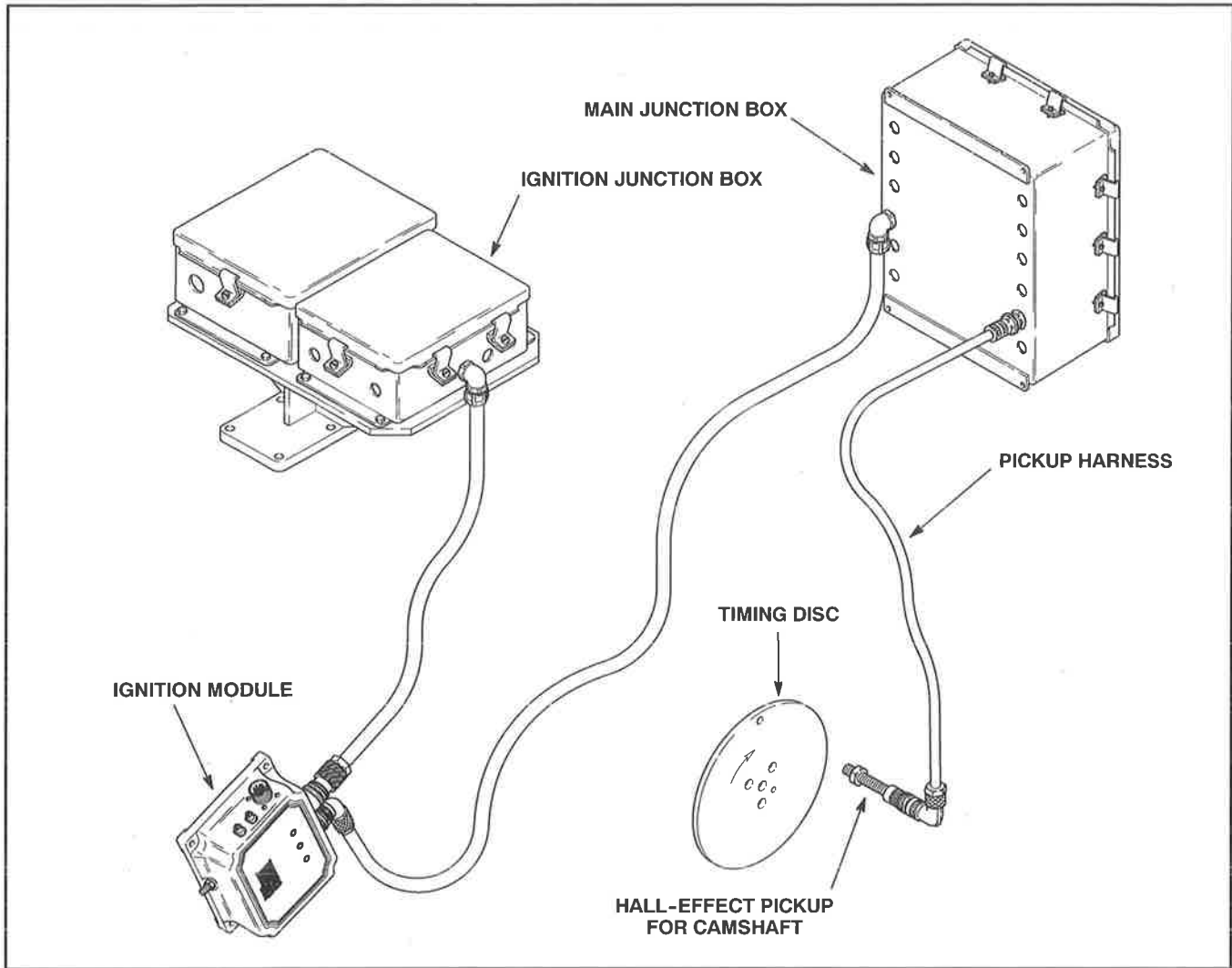


Figure 3.05-7. 12V-AT25GL Hall-effect Pickup And Harness Connections

ATGL IGNITION MODULE ELECTRICAL CONNECTIONS

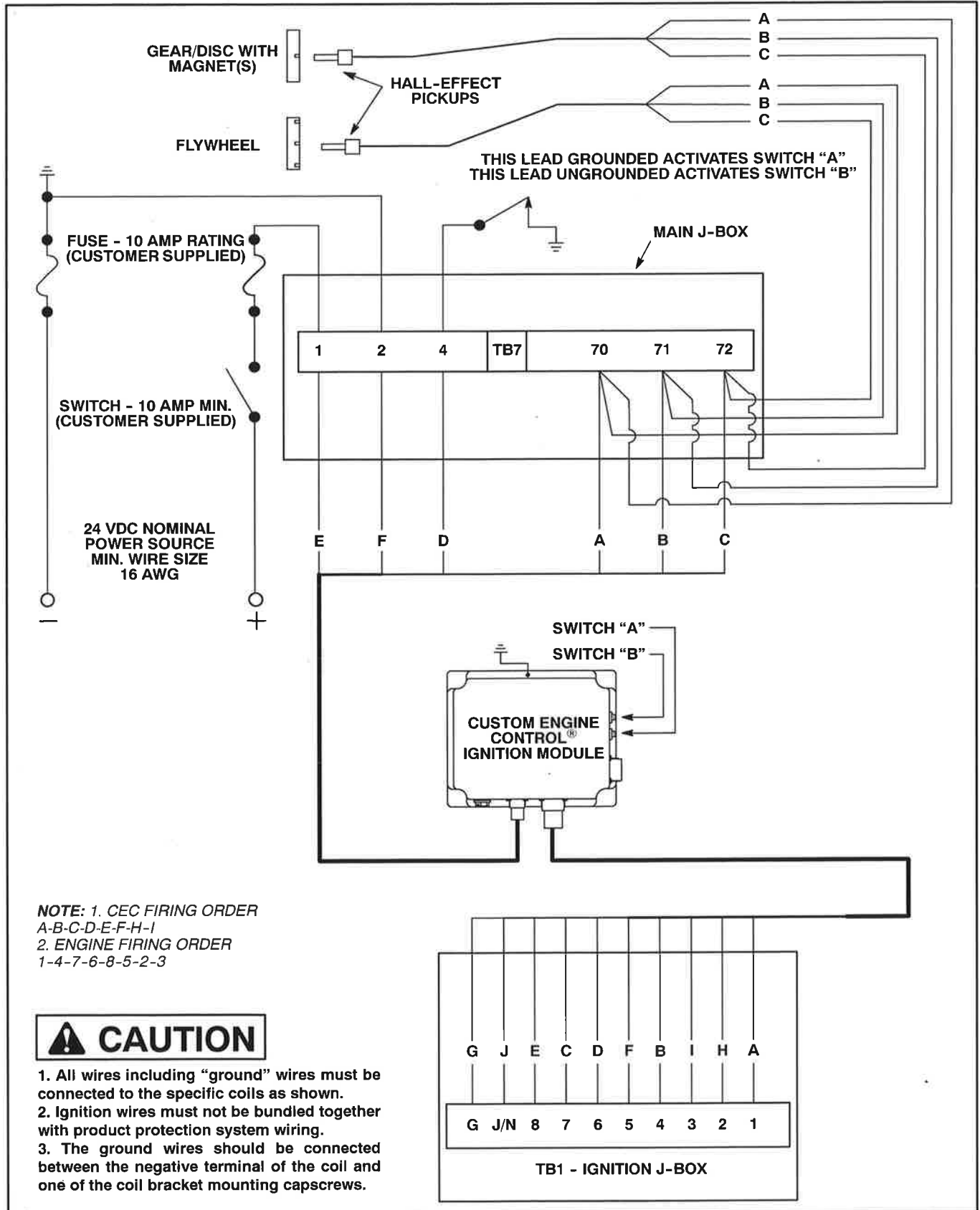


Figure 3.05-8. 8L-AT27GL IM Wiring Diagram

ATGL IGNITION MODULE ELECTRICAL CONNECTIONS

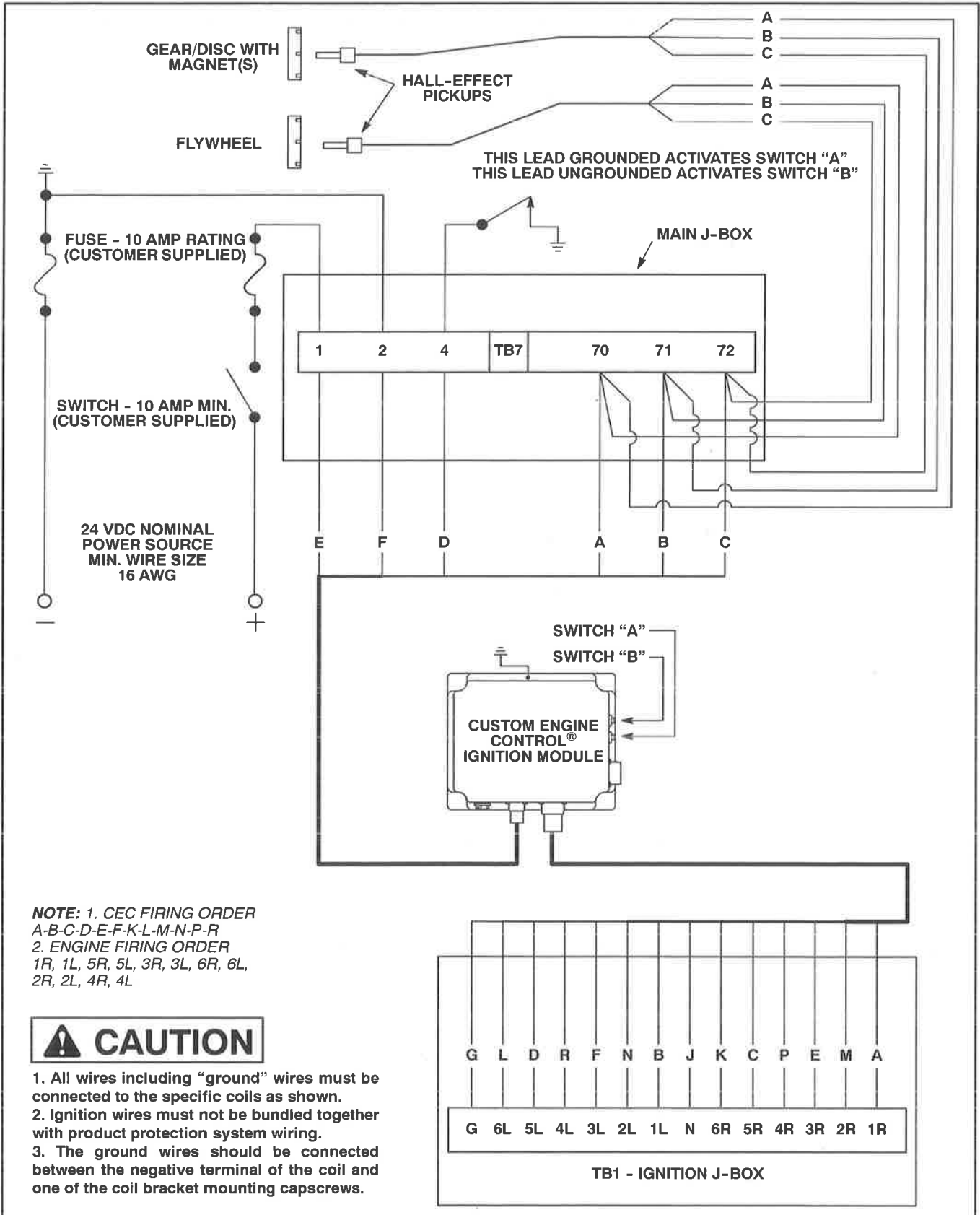


Figure 3.05-9. 12V-AT27GL IM Wiring Diagram

ATGL IGNITION MODULE ELECTRICAL CONNECTIONS

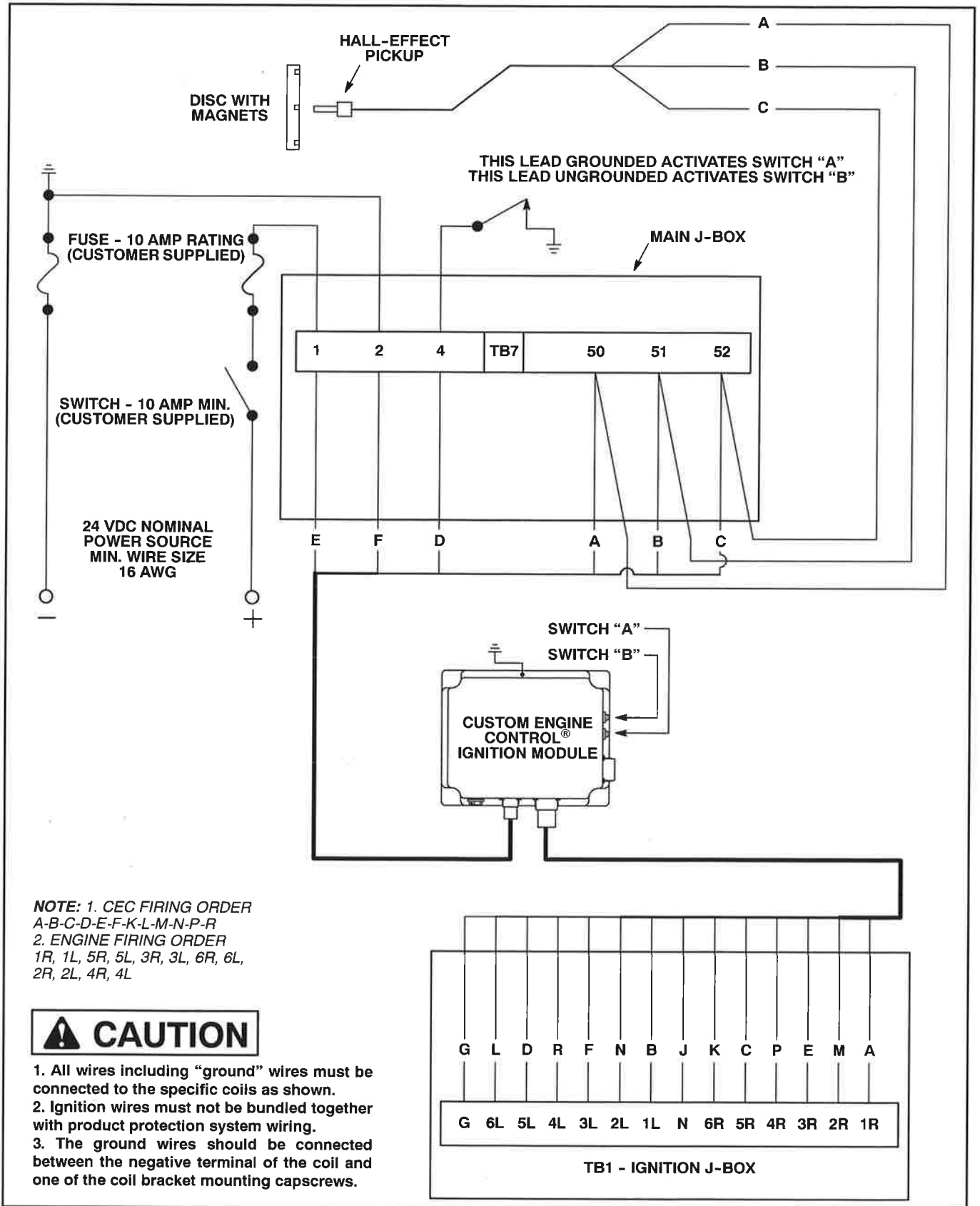


Figure 3.05-10. 12V-AT25GL IM Wiring Diagram

ATGL IGNITION MODULE ELECTRICAL CONNECTIONS

SECTION 3.10

ATGL IGNITION MODULE TIMING ADJUSTMENTS

PRESTART CHECKLIST

Before applying power to the IM (engine not running):

- A. Visually inspect the installation to be sure that all wiring conforms to the requirements of this manual, local codes, and regulatory bodies.
- B. Verify all grounding requirements. Refer to Section 3.00, *ATGL Ignition Module Electrical Connections*, "Electrical Connections," for wiring diagrams.
- C. Leave the IM unpowered. Verify that the power supply is within specification. Refer to Section 3.00, *ATGL Ignition Module Electrical Connections*, "Electrical Connections," for power specifications.

ATGL IGNITION TIMING SET

Timing is changed with two 16 position (0 - 15) timing switches located on the IM (see Figure 3.10-1). Each switch can be set to separate ignition timing settings for different applications. Timing switch position 15 gives the most advanced timing on the active timing switch, either switch "A" or "B." Switch "A" has a more advanced timing range than switch "B." Switch position 0 (zero) is full retard. The timing advances/retards 1.0 degree between each switch position. Grounding lead "D" in the Power Pickup Harness (7 pin connector) activates the timing selected by switch "A." Ungrounded lead "D" will activate the timing selected by switch "B."

For 8 and 12 cylinder ATGL engines, a 6 degree overlap between timing switch "A" and timing switch "B" gives the IM a combined timing range of 25 degrees.

For 16 cylinder ATGL engines, an 8 degree overlap between timing switch "A" and timing switch "B" gives the IM a combined timing range of 23 degrees.

Table 3.10-1 lists the IM firing order for 8L-ATGL engines. Table 3.10-2 lists the IM firing order for 12V-ATGL engines. Table 3.10-3 lists the IM firing order for 16V-ATGL engines.

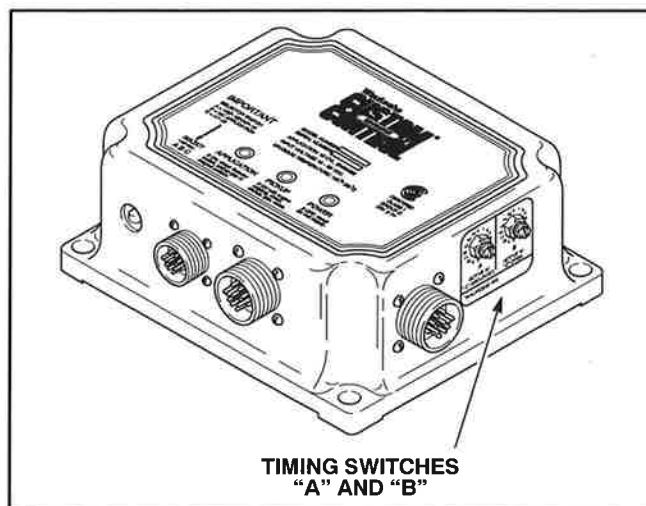


Figure 3.10-1. Ignition Module Timing Switches

Table 3.10-1. Firing Order For 8L-ATGL Cylinder Engines

PIN CONNECTORS*	A	B	C	D	E	F	H	I
CYLINDERS	1	4	7	6	8	5	2	3

Table 3.10-2. Firing Order For 12V-ATGL Cylinder Engines

PIN CONNECTORS*	A	B	C	D	E	F	K	L	M	N	P	R
CYLINDERS	1 R	1 L	5 R	5 L	3 R	3 L	6 R	6 L	2 R	2 L	4 R	4 L

NOTE: * G=Shutdown - J=Ground

Table 3.10-3. Firing Order For VGF 16 Cylinder Engines

PIN CONNECTORS*	A	B	C	D	E	F	K	L
CYLINDERS	1R	1L	4R	4L	7R	7L	6R	6L
PIN CONNECTORS*	M	N	P	R	S	T	U	V
CYLINDERS	8R	8L	5R	5L	2R	2L	3R	3L

NOTE: * G=Shutdown - J=Ground

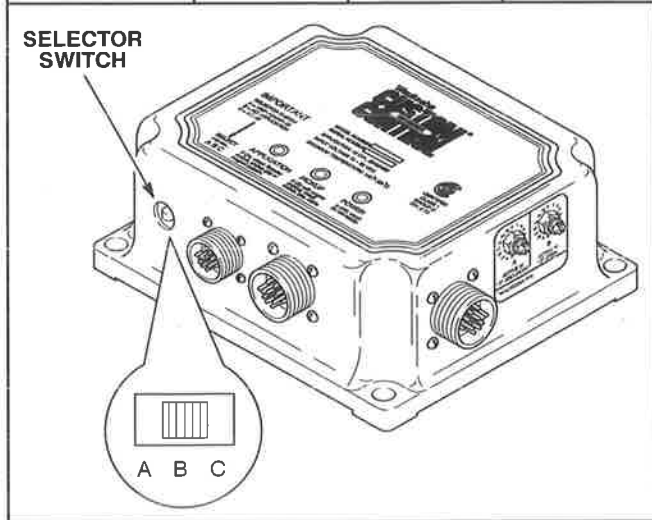
ATGL IGNITION MODULE TIMING ADJUSTMENTS

STEPS REQUIRED TO ADJUST IGNITION MODULE TIMING

1. Complete the Prestart Checklist before running engine and adjusting timing.
2. Remove the cap from the Selector Switch access hole.
3. Set the appropriate timing application by adjusting the Selector Switch (see Table 3.10-4). The Selector Switch is a three position switch (A, B, and C). Use your finger or a screwdriver to switch to the proper application.
4. Replace the cover on the Selector Switch access hole.

Table 3.10-4. Ignition Module Selector Switch Settings

SELECTOR SWITCH SETTING	IGNITION MODULE MODELS		
	Model 811 for 6 & 8 Cylinder Engines	Model 1211 for All 12 Cylinder Engines	Model 1611 for All 16 Cylinder Engines
A	VHP/VGF 6 Cylinder Engines	VHP/VGF 12 Cylinder Engines	VHP/VGF 16 Cylinder Engines
B	No Application	No Application	No Application
C	ATGL/VGF 8 Cylinder Engines	ATGL 12 Cylinder Engines	ATGL 16 Cylinder Engines



5. Remove the white caps from the timing switches "A" and "B" on the side of the IM (see Figure 3.10-2).
6. Using a screwdriver, set both timing switches on the side of the IM to 10. Timing selection is made by the dot on the switch, not the screwdriver slot.

NOTE: If the IM being adjusted is replacing another IM, set the timing switches to the same positions as the IM being replaced.

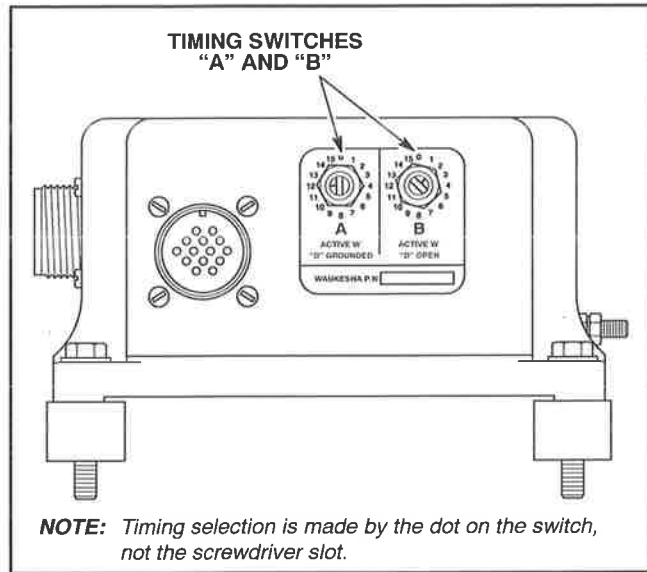


Figure 3.10-2. Timing Switches "A" And "B"

7. Check the engine's nameplate to determine the exact timing (or most advanced) of the primary and secondary (if equipped) fuels.
8. Apply power to IM. Refer to Section 3.05, *ATGL Ignition Module Electrical Connections*, "Electrical Connections," for power specifications.

⚠ WARNING

If a gas engine has been cranked excessively without starting, shut off the gas fuel supply and ignition, and then crank the engine to purge the cylinders and exhaust system of accumulated unburned gas. If this is not done a spark could ignite the gas and cause an exhaust explosion. Failure to comply could cause severe personal injury or death.

9. Start engine. Run engine at idle speed and with NO load.

ATGL IGNITION MODULE TIMING ADJUSTMENTS

10. Run the engine on primary fuel with the "D" lead (found in the 7 pin connector from the IM) **grounded** to the engine block and the CEC Detonation Sensing Module (DSM) deactivated (14 pin DSM harness disconnected from IM).

NOTE: The actual ignition timing will depend on the particular engine that the IM is installed. Actual timing may be off a few degrees; therefore, timing should be reset as required.

11. Check engine timing at the flywheel using a timing light.

CAUTION Do not switch from position 15 to 0, 0 to 15 or make other large timing changes quickly while the engine is running. The large timing change may cause engine damage or shutdown.

NOTE: Increasing the timing switch position by one will advance the timing one degree. Decreasing the timing switch position by one will retard the timing one degree.

12. Adjust the "A" timing switch as required to achieve correct timing (see Figure 3.10-2). Single fuel ignition adjustments are now complete. If you have a single fuel application, continue with Step 16. If you have a dual fuel application, continue with Step 13.

13. Run the engine on secondary fuel with the "D" lead (found in the 7 pin connector from IM) **open** and the CEC Detonation Sensing Module deactivated.

14. Check engine timing at the flywheel using a timing light.

NOTE: Increasing the timing switch position by one will advance the timing one degree. Decreasing the timing switch position by one will retard the timing one degree.

15. Adjust the "B" timing switch as required to achieve correct timing (see Figure 3.10-2). Dual fuel ignition adjustments are now complete.

CAUTION To prevent the timing from being altered, always replace the white caps over the timing switches once the desired setting has been selected. Disregarding this information could result in product damage and/or personal injury.

16. When timing adjustments are complete, replace the white caps on the timing switches "A" and "B."

17. If applicable, reconnect the DSM harness to the 14 pin connector on the IM. Activate the DSM. Refer to *Custom Engine Control® Detonation Sensing Module (DSM) Installation, Operation, And Maintenance Manual* (Form 6268) for programming information.

CAUTION It is the sole responsibility of the customer to ensure that all product protection devices effectively shut off both the ignition and gas simultaneously in the event of any malfunctions. Disregarding this information could result in product damage and/or personal injury.

18. Verify shutdown switches and load carrying ability.

DISCHARGING THE STORAGE CAPACITOR

WARNING

If the ignition switch is left in the ON position when a Ignition Module is disconnected, then the spark plugs may fire when the ignition system harness is reconnected, and could cause severe personal injury or death.

Before connecting the ignition harness (to the coils) to the IM, discharge the storage capacitors to ground. Attach one end of a wire lead to the crankcase and then touch the other end to the harness connector pins on the IM, one at a time. A snap may be heard when a capacitor discharges.

WARNING

As a safety measure, ground all the pins. Some breakerless ignition systems have more than one storage capacitor. Severe personal injury or death could result.

ATGL IGNITION MODULE TIMING ADJUSTMENTS

CONTENTS

**SECTION 4.00 - IGNITION MODULE OPERATION ON
VGF ENGINES**

**SECTION 4.05 - VGF IGNITION MODULE
ELECTRICAL CONNECTIONS**

SECTION 4.10 - VGF IGNITION MODULE TIMING ADJUSTMENTS

SECTION 4.00

IGNITION MODULE OPERATION ON VGF ENGINES

IGNITION MODULE OPERATION ON VGF ENGINES

The purpose of this section is to describe IM operation on VGF engines and describe the location of the Hall-effect pickup.

VGF 6 AND 8 CYLINDER ENGINES

The IM uses a Hall-effect pickup, a magnetic switching device, to read magnetic reference marks on a disc attached to the front of the cam gear. This method of timing determines the exact position of the crankshaft. The microcircuit-based, digital IM interprets the pickup's impulses to set the optimum ignition timing. The IM then directs a precisely timed voltage to the appropriate coil.

Location Of Hall-effect Pickup

The Hall-effect pickup is located on the front gear cover. The pickup senses each magnet as it passes and trips the logic circuit of the IM to fire (see Figure 4.00-1).

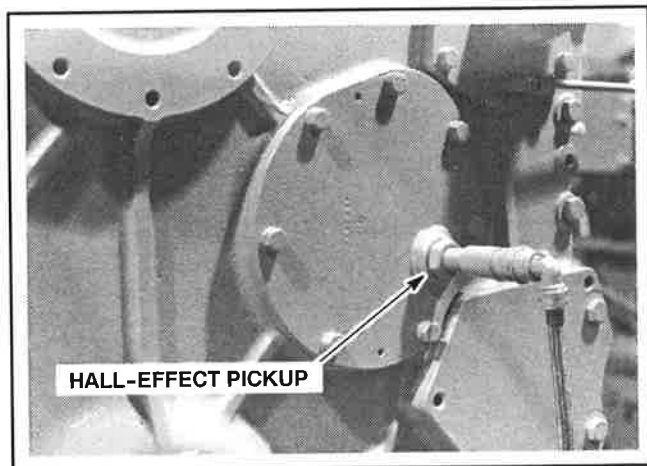


Figure 4.00-1. Hall-effect Pickup Location

Setting The Air Gap

To set the air gap specification, complete the following steps.

1. Install the Hall-effect pickup into the front gear cover.
2. Thread the Hall-effect pickup clockwise until the pickup touches the timing disc.
3. Scribe a reference mark on the Hall-effect pickup and at the same point mark the front gear cover.
4. Using the reference mark on the pickup as the starting point, rotate the Hall-effect pickup $\frac{3}{4}$ of a turn ($\pm 1/16$ of a turn) counterclockwise to set the pickup to timing disc clearance.
5. After the clearance is set, snug the locking nut.

VGF 12 AND 16 CYLINDER ENGINES

The IM uses a Hall-effect pickup, a magnetic switching device, to read reference magnets installed in the left bank cam gear. This method of timing determines the exact position of the crankshaft. The microcircuit-based, digital IM interprets the pickup's impulses to set the optimum ignition timing. The IM then directs a precisely timed voltage to the appropriate coil.

IGNITION MODULE OPERATION ON VGF ENGINES

Location Of Hall-effect Pickup

The Hall-effect pickup is located on the front surface of the rear gear housing, above the barring device (see Figure 4.00-2). The pickup senses each magnet as it passes and trips the logic circuit of the IM to fire (see Figure 4.00-3).

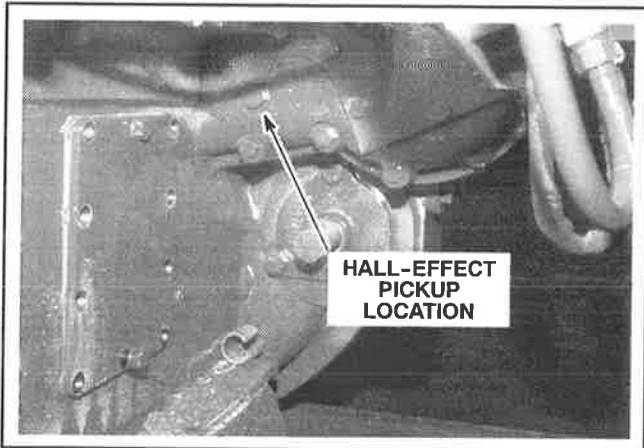


Figure 4.00-2. Hall-effect Pickup

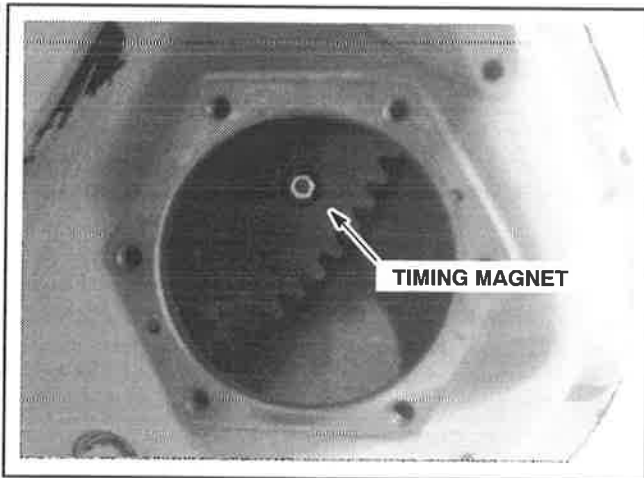


Figure 4.00-3. CEC Ignition Timing Magnets

Setting The Air Gap

To set the air gap specification, complete the following steps.

1. Install the Hall-effect pickup into the rear gear housing.
2. Thread the Hall-effect pickup clockwise until the pickup touches the timing disc.
3. Scribe a reference mark on the Hall-effect pickup and at the same point mark the rear gear housing.
4. Using the reference mark on the pickup as the starting point, rotate the Hall-effect pickup $\frac{3}{4}$ of a turn ($\pm \frac{1}{16}$ of a turn) counterclockwise to set the pickup to timing disc clearance.
5. After the clearance is set, snug the locking nut.

SECTION 4.05

VGF IGNITION MODULE ELECTRICAL CONNECTIONS

MOUNTING THE IGNITION MODULE

Mount the IM using the vibration isolators supplied with the IM (see Figure 4.05-1). Note the following:

- The outside temperature of IM casing should not exceed 150° F (65° C) in operation.

CAUTION Do not weld on or around engine unless the Ignition Module has been unplugged. Failure to do so may damage the Ignition Module.

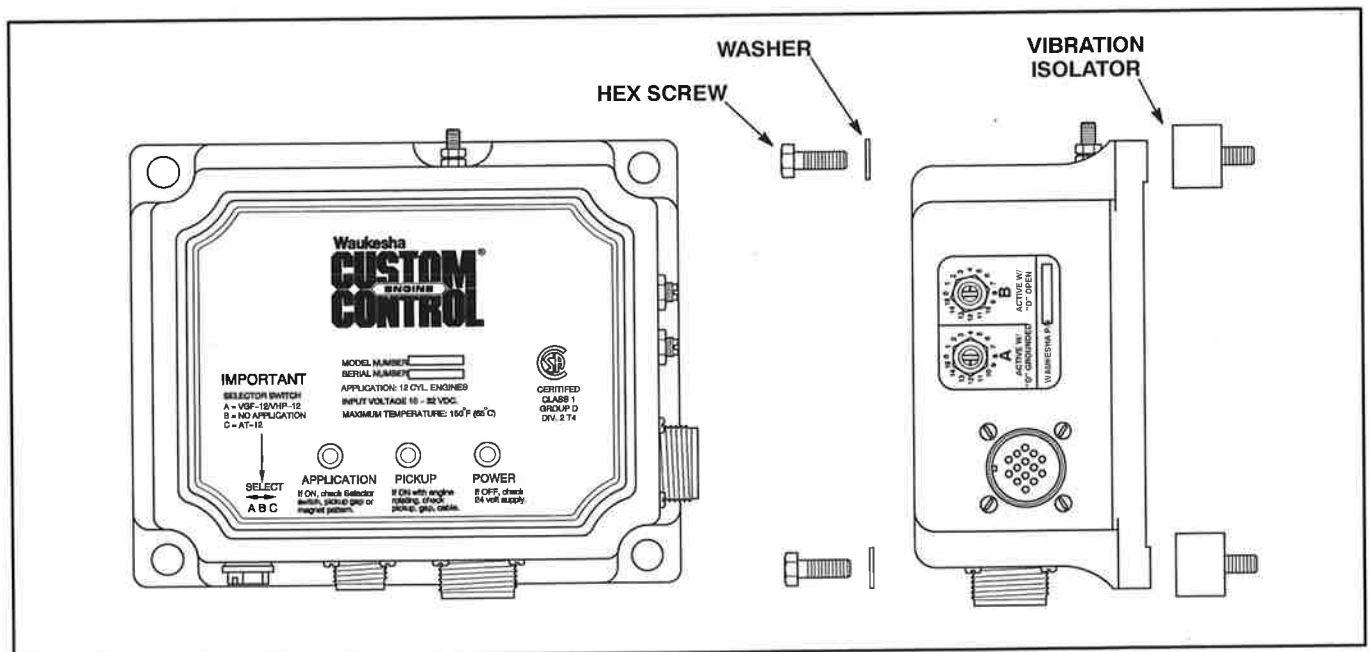


Figure 4.05-1. Mounting The Ignition Module - VGF Engines

VGF IGNITION MODULE ELECTRICAL CONNECTIONS

ELECTRICAL CONNECTIONS

IGNITION MODULE POWER REQUIREMENTS

The power connections made for the IM must be in accordance with the applicable local electrical codes. The IM is suitable for installation in Canadian Standards Association (CSA) Class I, Group D, Division 2 locations. All power sizing must be in accordance with Figure 4.05-3, "Waukesha CEC Products Power Wiring Requirements."

See Table 4.05-1 for IM power requirements.

NOTE: An AC to DC power supply is not preferred unless care is taken to eliminate the possibility of a momentary loss of AC power which will result in an engine shutdown. A DC voltage filter (battery) is recommended to eliminate voltage fluctuations.

NOTE: For compatibility with other CEC products, a nominal supply of 24 VDC with less than a 2 volt peak-to-peak ripple is recommended to power the IM.

NOTE: Refer to Section 1.05, General Information, "Power Requirements for Custom Engine Control® Products," for the power requirements of all Waukesha Engine CEC products.

POWER SOURCE WIRING SIZING AND GROUNDING

The IM, a capacitive discharge (CD) ignition system, requires an external power source which presents special wiring requirements. The IM will function properly with a power source as defined in Table 4.05-1. However, if the supply is capable of providing a pulse current (higher current level for a shorter period of time such that the average current is the same), the IM will utilize that pulse capability. In this case, the voltage fluctuations on the supply wiring, including the ground return to the power source, may interfere with the operation of other electrical devices. For this reason, it is recommended that the IM power source wiring, specifically the ground return, be sized for at least 30 amps even though the average current will be less than 2 amps (typical).

In addition, the grounding, particularly where the ground is "referenced," is critical. It is necessary to reference all of the grounds to the same point. The engine crankcase has been chosen as THE GROUND reference to minimize interference with sensor signals. By following the recommended wiring and grounding procedures, the concerns associated with the ignition power supply voltage drops can be greatly reduced or eliminated.

NOTE: For additional information on capacitive discharge and grounding, see Section 1.05, General Information, "Capacitive Discharge And Grounding."

WIRING HARNESS CONNECTIONS

The IM has three external wiring harness connectors (see Figure 4.05-2). The Power Pickup Harness connects to the 7 pin connector on the IM and includes leads for DC power, the Hall-effect pickup, and the "D" lead which determines which timing switch is used. The Primary Coil Harness connects to the IM and includes leads to the ignition coils. The 14 pin connector is used to interface with the CEC Detonation Sensing Module (DSM). The 14 pin connector is only used when the DSM is installed on the engine.

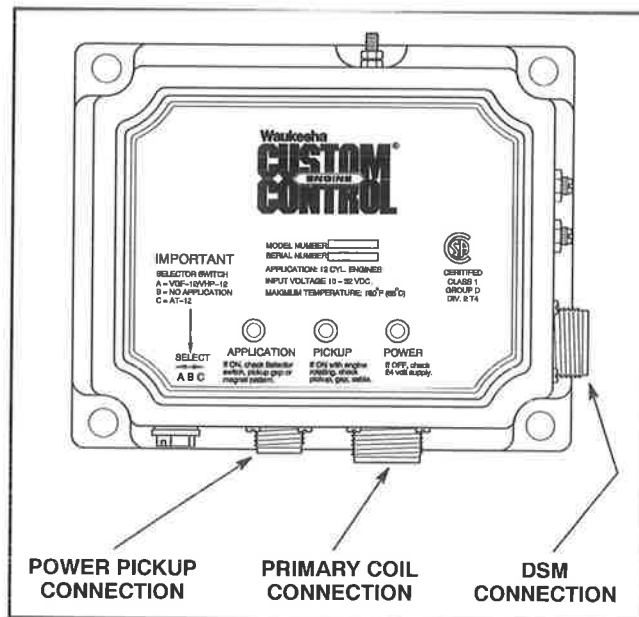


Figure 4.05-2. Ignition Module Wiring Harness Connections

VGF IGNITION MODULE ELECTRICAL CONNECTIONS

Table 4.05-1. Power Requirements For The Ignition Module

CEC PRODUCT	NOMINAL VOLTAGE (volts DC)	TOLERANCE	OPERATING RANGE (volts DC)	PEAK-TO-PEAK RIPPLE (volts AC)	OPERATING CURRENT (amps)
Ignition Module	24	+33%, -58%	10.0 - 32.0*	less than 2*	2 (typical)

*NOTE: *For compatibility with other CEC products, a nominal supply of 24 VDC with less than a 2 volt peak-to-peak ripple is recommended to power the IM.*

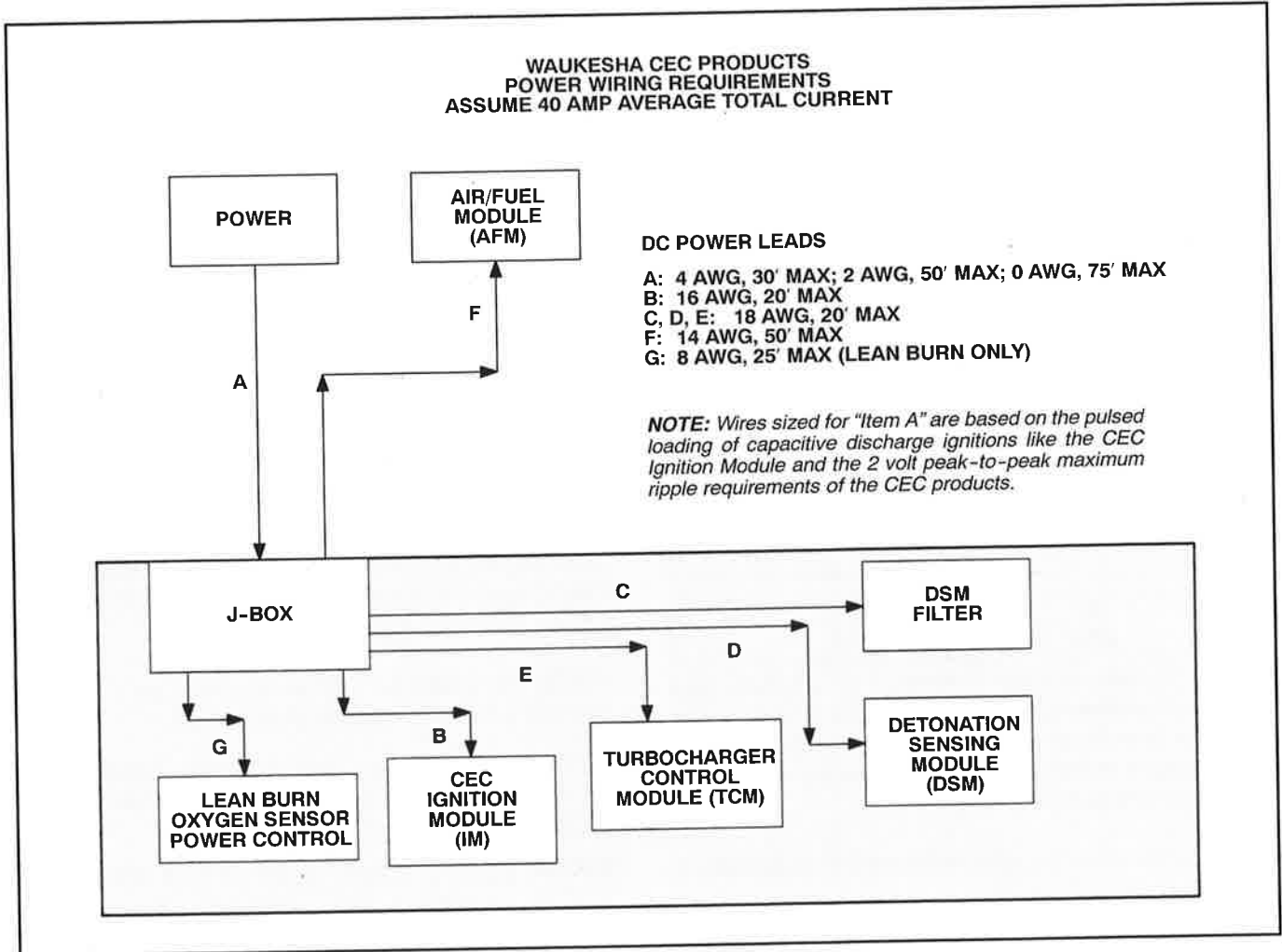


Figure 4.05-3. Waukesha CEC Products Power Wiring Requirements

VGF IGNITION MODULE ELECTRICAL CONNECTIONS

COMPLETING IGNITION MODULE WIRING

Complete IM electrical connections by following the steps below. Refer to Figure 4.05-5 through Figure 4.05-11 for IM wiring diagrams. Table 4.05-2 lists the page numbers of the wiring diagrams for each VGF wiring diagram.

NOTE: The wiring diagrams included in this manual are to be used as a reference only. Refer to the wiring diagrams received with the IM when making electrical connections.

Table 4.05-2. Page Locations Of VGF Wiring Diagrams

WIRING DIAGRAM	PAGE NUMBER
Figure 4.05-5. VGF 6 Cylinder (With Murphy Gas Valves - Retrofit Only) IM Wiring Diagram	4.05-6
Figure 4.05-6. VGF 6 Cylinder (Without Murphy Gas Valves - Retrofit Or Production) IM Wiring Diagram	4.05-7
Figure 4.05-7. VGF 8 Cylinder (With Murphy Gas Valves - Retrofit Only) IM Wiring Diagram	4.05-8
Figure 4.05-8. VGF 8 Cylinder (Without Murphy Gas Valves - Retrofit Or Production) IM Wiring Diagram	4.05-9
Figure 4.05-9. VGF 12 Cylinder (Without Murphy Gas Valves) IM Wiring Diagram	4.05-10
Figure 4.05-10. VGF 12 Cylinder IM Wiring Diagram	4.05-11
Figure 4.05-11. VGF 16 Cylinder IM Wiring Diagram	4.05-12

WARNING

Do not install, set up, maintain or operate any electrical components unless you are a technically qualified individual who is familiar with the electrical elements involved. Electrical shock can cause severe personal injury or death.


1. Connect a ground lead from the engine crankcase to the ground stud on the IM.
2. Connect the Primary Coil Harness to the IM connector.
3. Route the specified leads of the Primary Coil Harness to the ignition coils and cut to length (see applicable wiring diagram). Proper installation requires that the two end coils on 6 and 8 cylinder engines or the four corner coils on 12 and 16 cylinder engines are grounded to the engine. Install flashover protectors and new spark plugs to achieve optimum IM performance.


4. Connect the Power Pickup Harness to the Hall-effect pickup.

5. Connect the Power Pickup Harness from the Hall-effect pickup to the IM's 7 pin connector.

WARNING

Disconnect all electrical power supplies before making any power connections to the Ignition Module. Electrical shock can cause severe personal injury or death.

 **CAUTION** Engines that use TWO Murphy fuel shutoff valves for emergency fuel shutdowns must use an additional capacitor in parallel with the existing adapter. The additional capacitor is required to supply sufficient voltage to close both Murphy fuel shutdowns during emergency shutdowns. Disregarding this information could result in product damage and/or personal injury.

 **CAUTION** Do not bundle the Ignition Module wiring and Hall-effect pickup wiring together. Maintain a minimum separation of at least six inches. Disregarding this information could result in product damage and/or personal injury.

NOTE: All wiring and IM setup must be completed BEFORE the power supply is turned on.

6. Connect the power lead from the Power Pickup Harness to the DC power supply (see applicable wiring diagram and Figure 4.05-4).

Before applying power to the IM and starting the engine, complete the "Prestart Checklist" in Section 4.10, VGF Ignition Module Timing Adjustments.

NOTE: Refer to Custom Engine Control® Detonation Sensing Module (DSM) Installation, Operation, And Maintenance Manual (Form 6268) for information on completing wiring connections between the DSM system and the IM.

VGF IGNITION MODULE ELECTRICAL CONNECTIONS

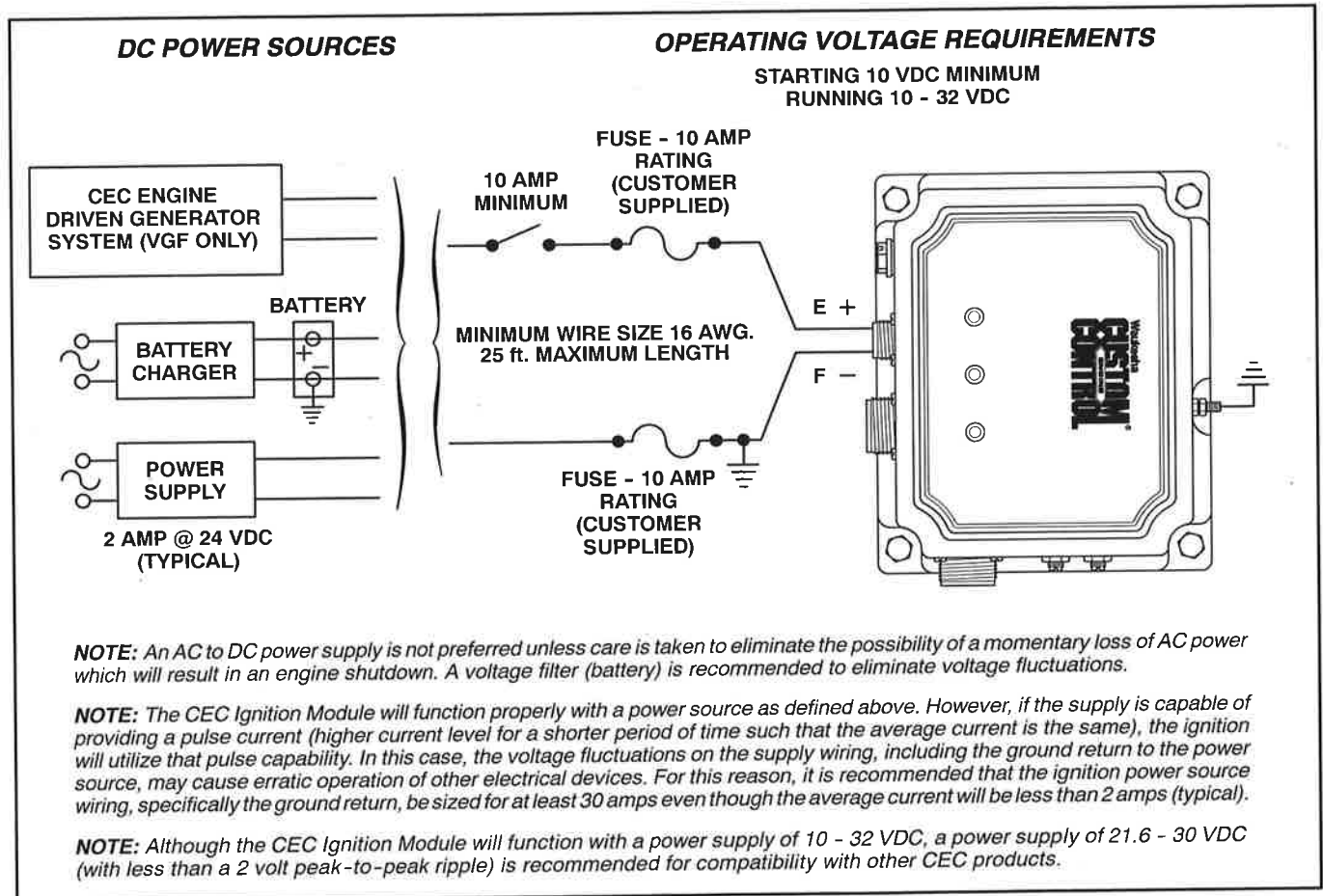


Figure 4.05-4. CEC Ignition Module Power Supply

VGF IGNITION MODULE ELECTRICAL CONNECTIONS

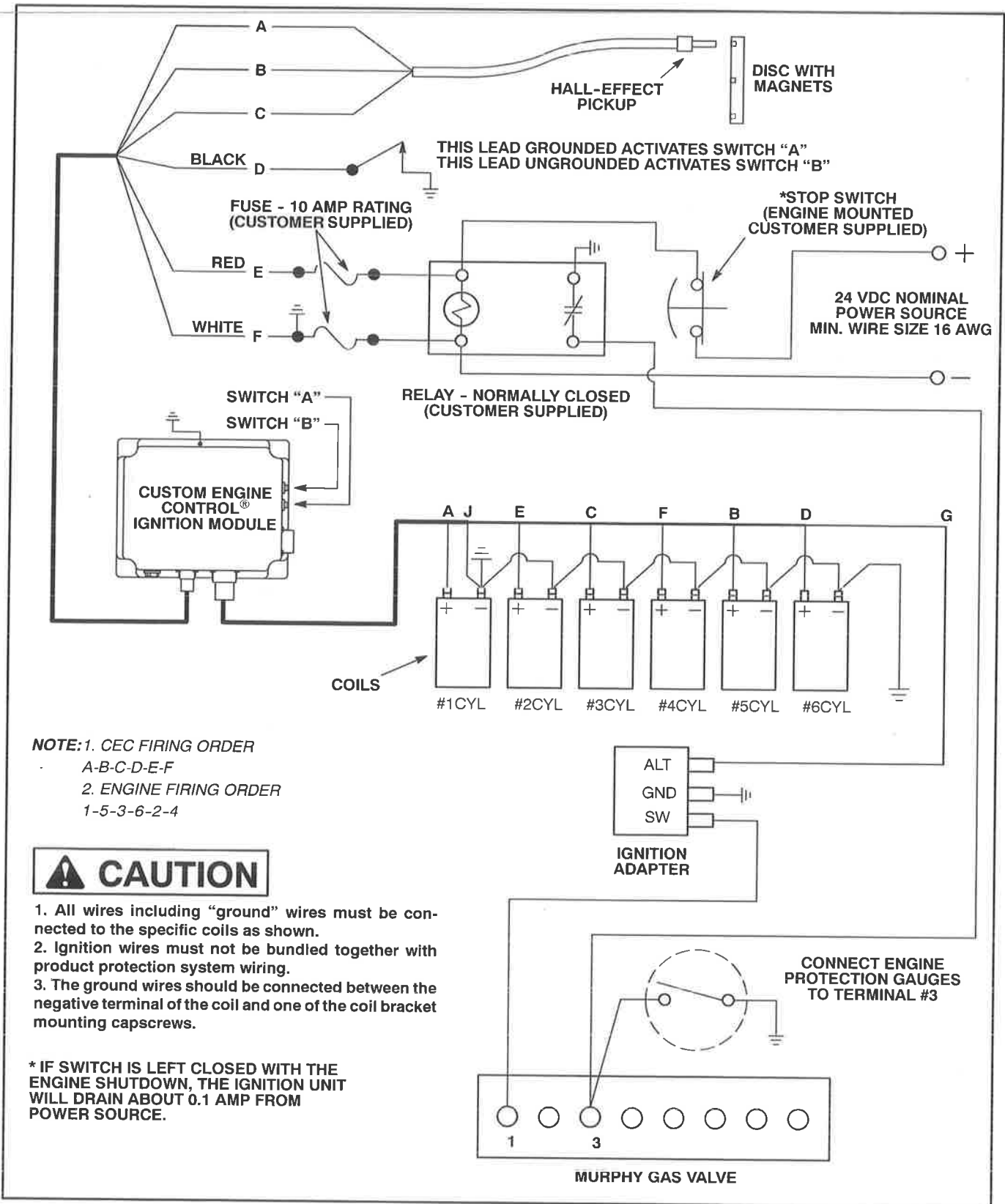


Figure 4.05-5. VGF 6 Cylinder (With Murphy Gas Valves-Retrofit Only) Ignition Module Wiring Diagram

VGF IGNITION MODULE ELECTRICAL CONNECTIONS

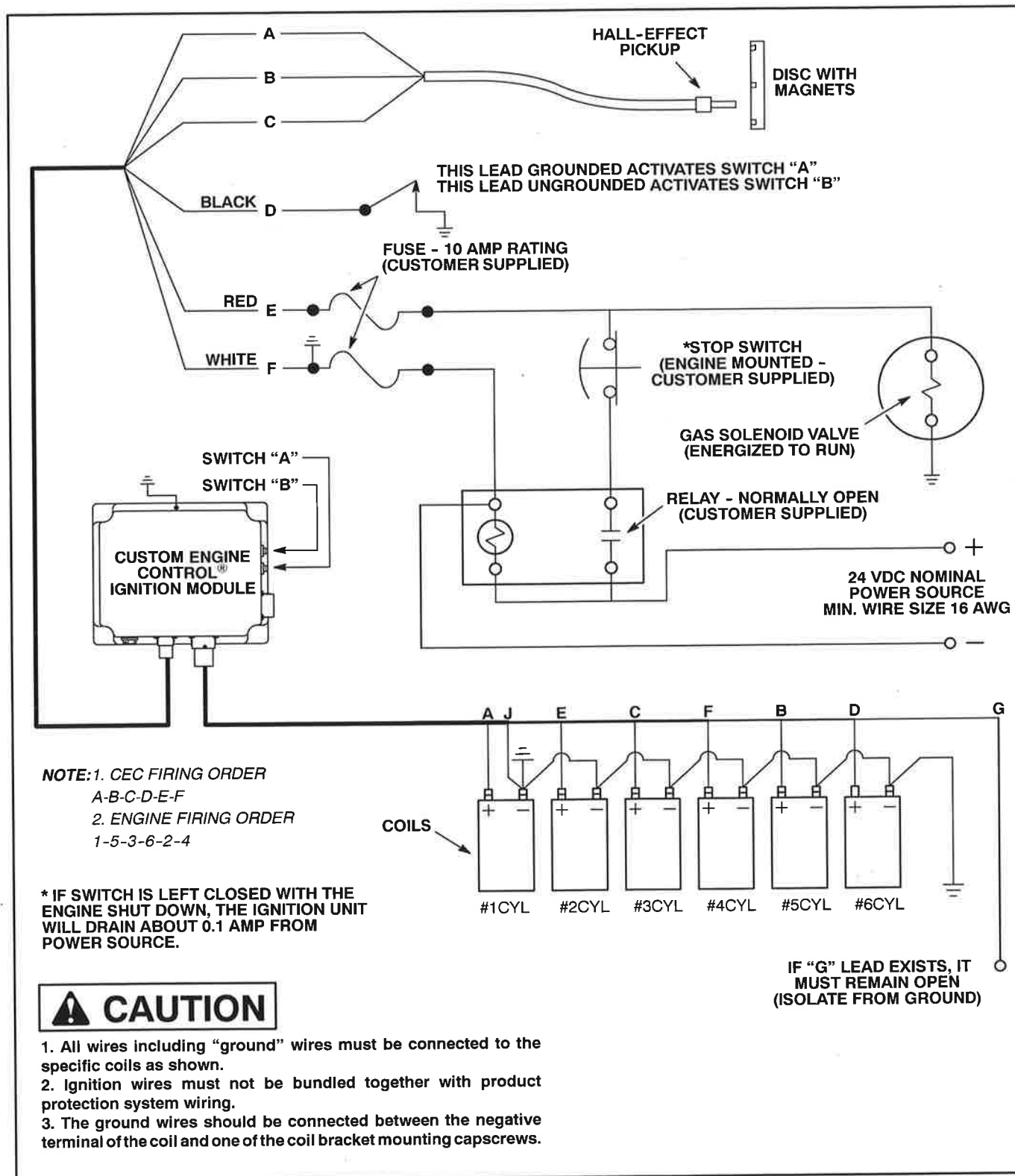


Figure 4.05-6. VGF 6 Cylinder (Without Murphy Gas Valves-Retrofit Or Production) Ignition Module Wiring Diagram

VGF IGNITION MODULE ELECTRICAL CONNECTIONS

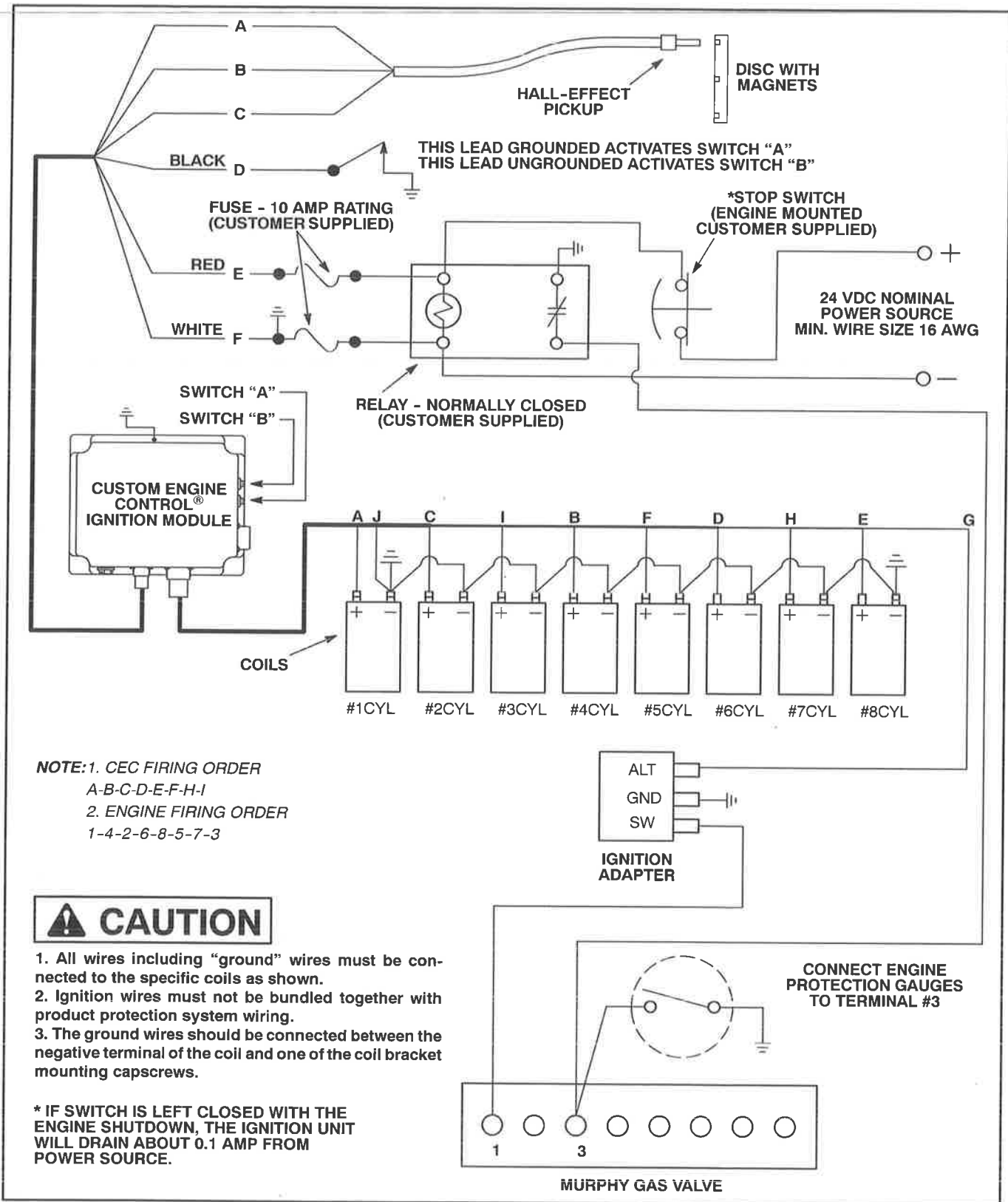


Figure 4.05-7. VGF 8 Cylinder (With Murphy Gas Valves-Retrofit Only) Ignition Module Wiring Diagram

VGF IGNITION MODULE ELECTRICAL CONNECTIONS

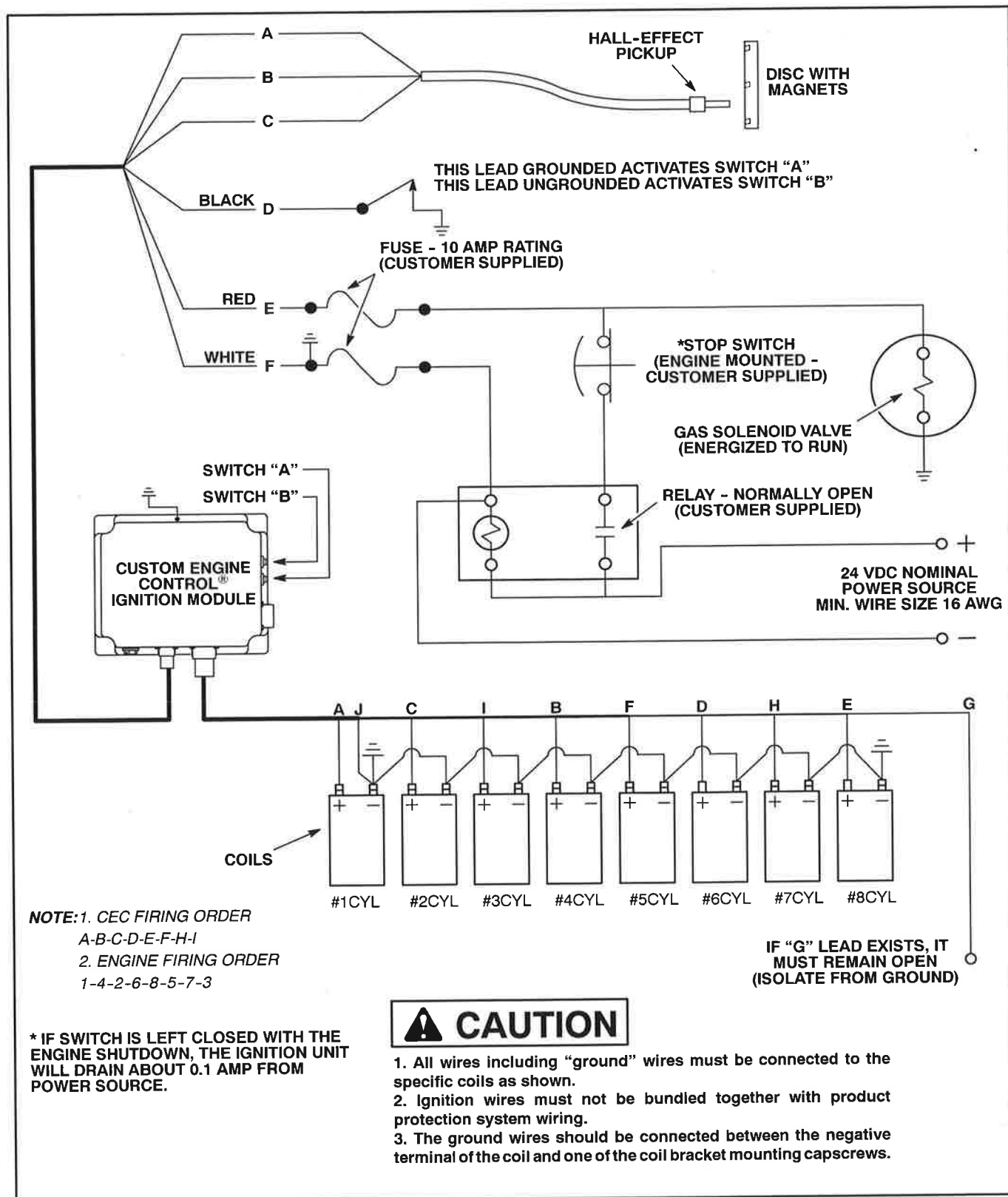


Figure 4.05-8. VGF 8 Cylinder (Without Murphy Gas Valves-Retrofit or Production) Ignition Module Wiring Diagram

VGf IGNITION MODULE ELECTRICAL CONNECTIONS

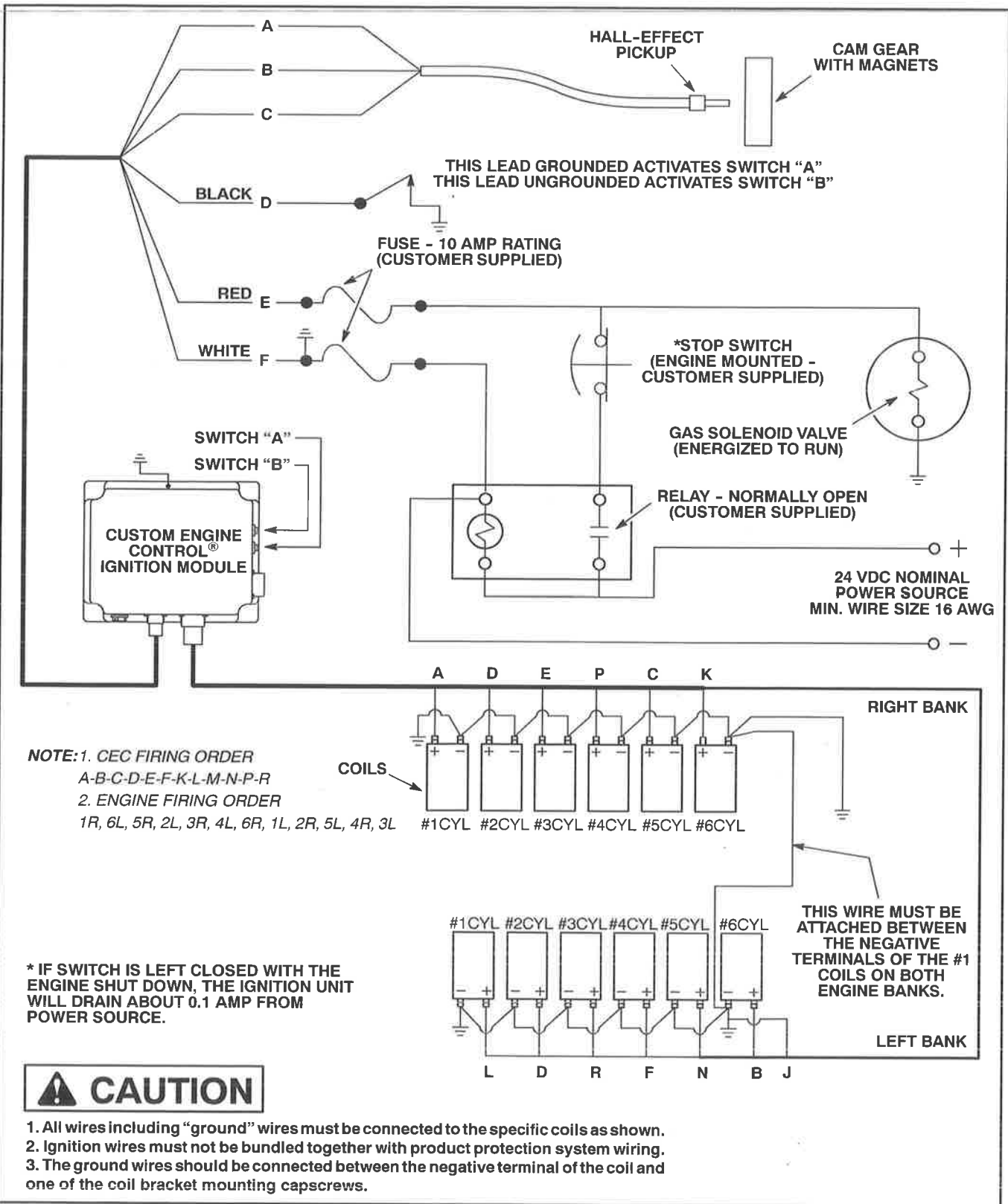


Figure 4.05-9. VGf 12 Cylinder (Without Murphy Gas Valves) Ignition Module Wiring Diagram

VGF IGNITION MODULE ELECTRICAL CONNECTIONS

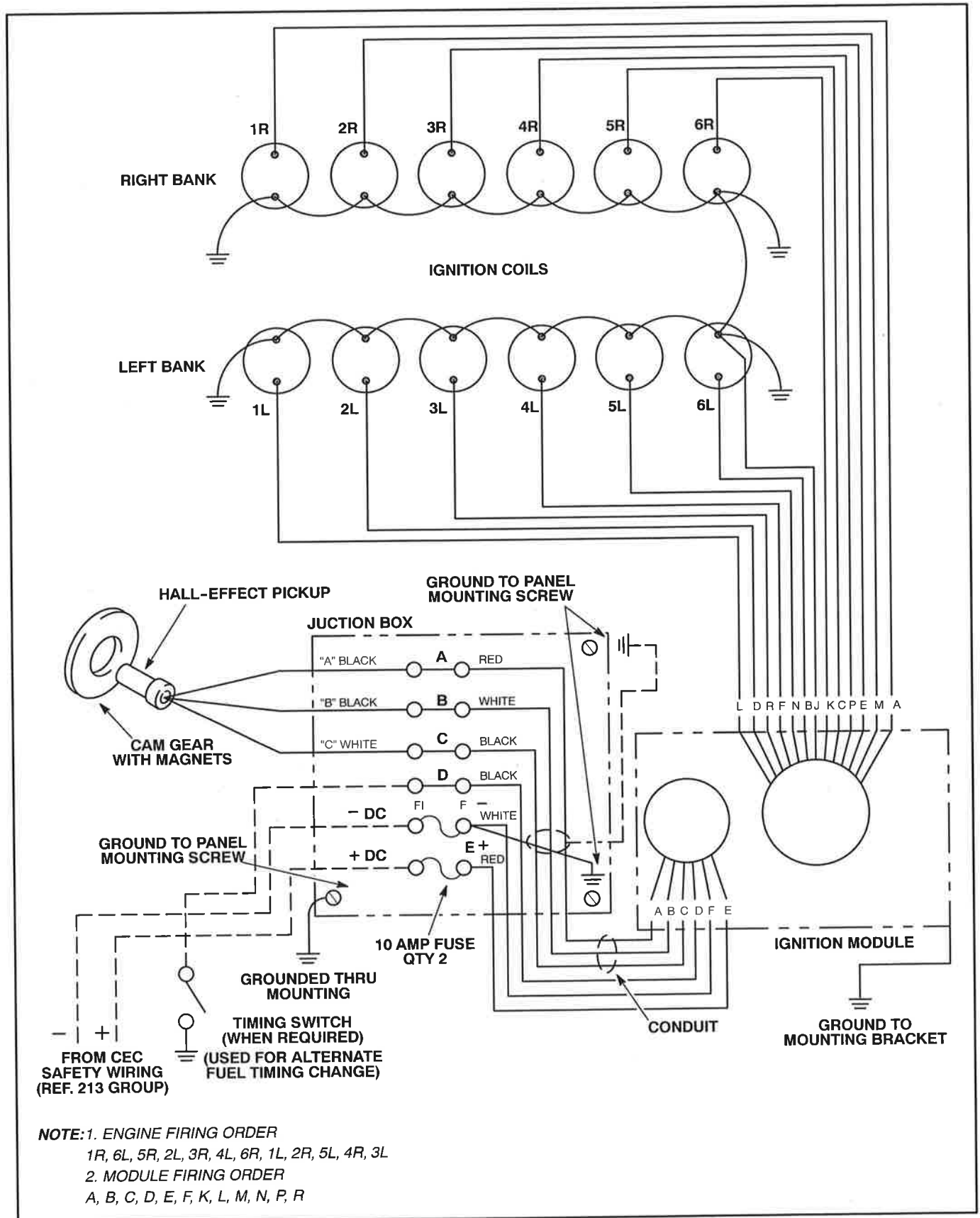


Figure 4.05-10. VGF 12 Cylinder Ignition Module Wiring Diagram

VGF IGNITION MODULE ELECTRICAL CONNECTIONS

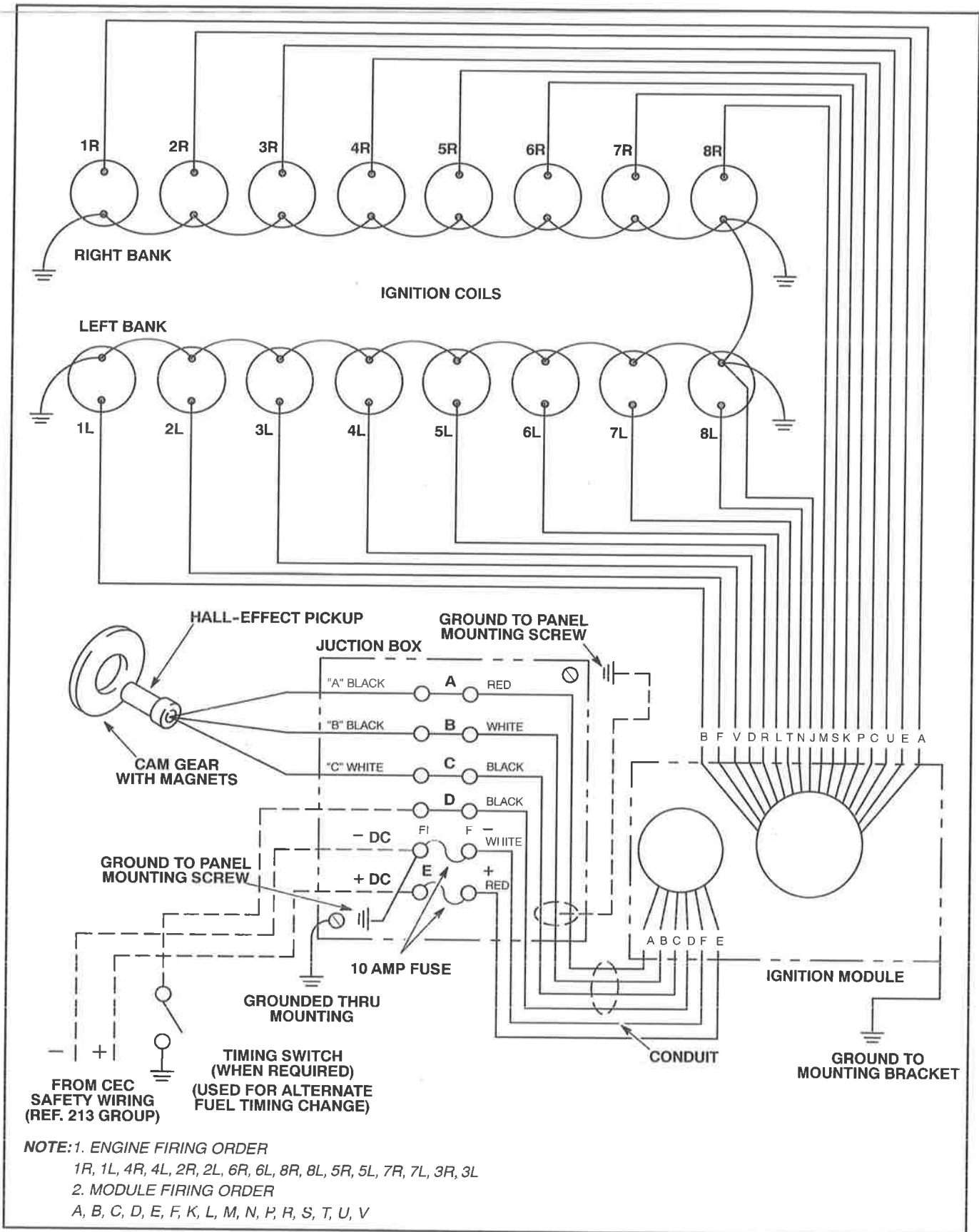


Figure 4.05-11. VGF 16 Cylinder Ignition Module Wiring Diagram

SECTION 4.10

VGF IGNITION MODULE TIMING ADJUSTMENTS

PRESTART CHECKLIST

Before applying power to the IM (engine not running):

- A. Visually inspect the installation to be sure that all wiring conforms to the requirements of this manual, local codes, and regulatory bodies.
- B. Verify all grounding requirements. Refer to Section 4.00, *VGF Ignition Module Electrical Connections*, "Electrical Connections," for wiring diagrams.
- C. Leave the IM unpowered. Verify that the power supply is within specification. Refer to Section 4.00, *VGF Ignition Module Electrical Connections*, "Electrical Connections," for power specifications.

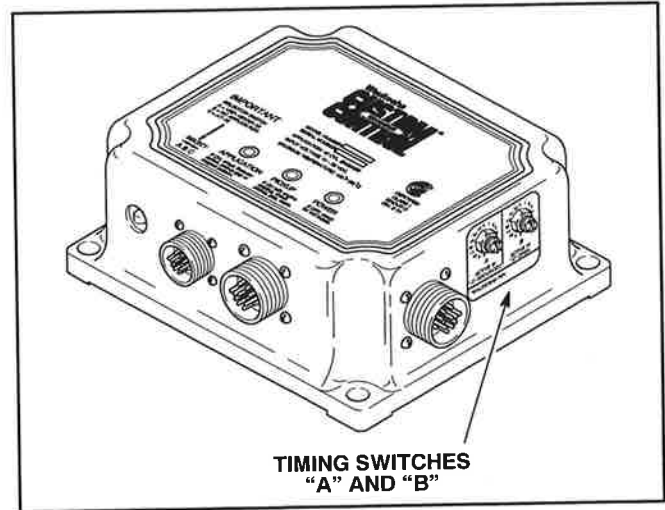


Figure 4.10-1. Ignition Module Timing Switches

VGF IGNITION TIMING SET

Timing is changed with two 16 position (0 - 15) timing switches located on the IM (see Figure 4.10-1). Each switch can be set to separate ignition timing settings for different applications. Timing switch position 15 gives the most advanced timing on the active timing switch, either switch "A" or "B." Switch "A" has a more advanced timing range than switch "B." Switch position 0 (zero) is full retard. The timing advances/retards 1.0 degree between each switch position. Grounding lead "D" in the Power Pickup Harness (7 pin connector) activates the timing selected by switch "A." Ungrounded lead "D" will activate the timing selected by switch "B."

For 6, 8, and 12 cylinder engines, a 6 degree overlap between timing switch "A" and timing switch "B" gives the IM a combined timing range of 25 degrees.

For 16 cylinder engines, a 7 degree overlap between timing switch "A" and timing switch "B" gives the IM a combined timing range of 24 degrees.

Table 4.10-1 lists the IM firing order for 6 cylinder VGF engines. Table 4.10-2 lists the IM firing order for 8 cylinder VGF engines. Table 4.10-3 lists the IM firing order for 12 cylinder VGF engines. Table 4.10-4 lists the IM firing order for 16 cylinder VGF engines.

Table 4.10-1. Firing Order For VGF 6 Cylinder Engines

PIN CONNECTORS*	A	B	C	D	E	F
CYLINDERS	1	5	3	6	2	4

Table 4.10-2. Firing Order For VGF 8 Cylinder Engines

PIN CONNECTORS*	A	B	C	D	E	F	H	I
CYLINDERS	1	4	2	6	8	5	7	3

NOTE: * G=Shutdown

Table 4.10-3. Firing Order For VGF 12 Cylinder Engines

PIN CONNECTORS*	A	B	C	D	E	F	K	L	M	N	P	R
CYLINDERS	1 R	6 L	5 R	2 L	3 R	4 L	6 R	1 L	2 R	5 L	4 R	3 L

NOTE: * G=Shutdown - J=Ground

Table 4.10-4. Firing Order For VGF 16 Cylinder Engines

PIN CONNECTORS*	A	B	C	D	E	F	K	L
CYLINDERS	1R	1L	4R	4L	2R	2L	6R	6L
PIN CONNECTORS*	M	N	P	R	S	T	U	V
CYLINDERS	8R	8L	5R	5L	7R	7L	3R	3L

NOTE: * G=Shutdown - J=Ground

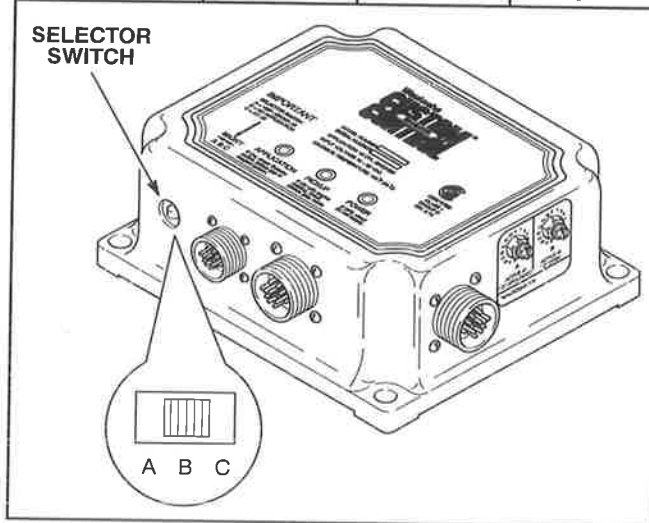
VGf IGNITION MODULE TIMING ADJUSTMENTS

STEPS REQUIRED TO ADJUST IGNITION MODULE TIMING

1. Complete the Prestart Checklist before running engine and adjusting timing.
2. Remove the cap from the Selector Switch access hole.
3. Set the appropriate timing application by adjusting the Selector Switch (see Table 4.10-5). The Selector Switch is a three position switch (A, B, and C). Use your finger or a screwdriver to switch to the proper application.
4. Replace the cover on the Selector Switch access hole.

Table 4.10-5. Ignition Module Selector Switch Settings

SELECTOR SWITCH SETTING	IGNITION MODULE MODELS		
	Model 811 for 6 & 8 Cylinder Engines	Model 1211 for All 12 Cylinder Engines	Model 1611 for All 16 Cylinder Engines
A	VHP/VGF 6 Cylinder Engines	VHP/VGF 12 Cylinder Engines	VHP/VGF 16 Cylinder Engines
B	No Application	No Application	No Application
C	ATGL/VGF 8 Cylinder Engines	AT 12 Cylinder Engines	AT 16 Cylinder Engines



5. Remove the white caps from the timing switches "A" and "B" on the side of the IM (see Figure 4.10-2).
6. Using a screwdriver, set both timing switches on the side of the IM to 10. Timing selection is made by the dot on the switch, not the screwdriver slot.

NOTE: If the IM being adjusted is replacing another IM, set the timing switches to the same positions as the IM being replaced.

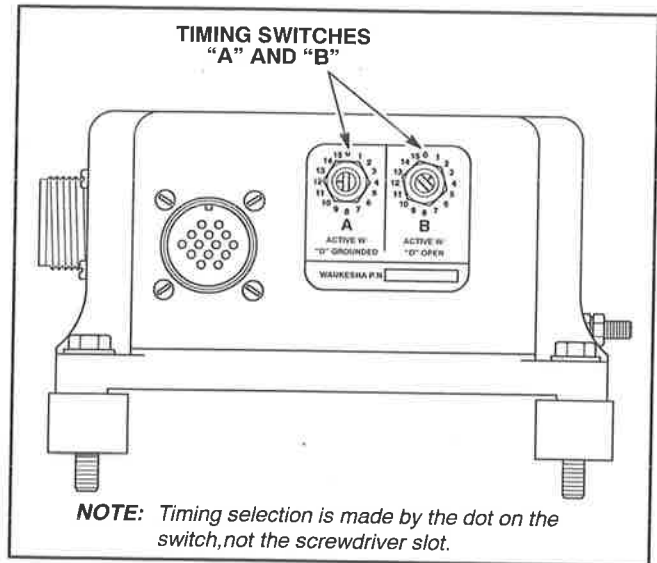


Figure 4.10-2. Timing Switches "A" And "B"

7. Check the engine's nameplate to determine the exact timing (or most advanced) of the primary and secondary (if equipped) fuels.
8. Apply power to IM. Refer to Section 2.05, VGF Ignition Module Electrical Connections, "Electrical Connections," for power specifications.

WARNING

If a gas engine has been cranked excessively without starting, shut off the gas fuel supply and ignition, and then crank the engine to purge the cylinders and exhaust system of accumulated unburned gas. If this is not done a spark could ignite the gas and cause an exhaust explosion. Failure to comply could cause severe personal injury or death.

9. Start engine. Run engine at idle speed and with NO load.

10. Run the engine on primary fuel with the "D" lead (found in the 7 pin connector from the IM) **grounded** to the engine block and the CEC Detonation Sensing Module (DSM) deactivated (14 pin DSM harness disconnected from IM).

11. Check engine timing at the flywheel using a timing light.

CAUTION Do not switch from position 15 to 0, 0 to 15 or make other large timing changes quickly while the engine is running. The large timing change may cause engine damage or shutdown.

NOTE: Increasing the timing switch position by one will advance the timing one degree. Decreasing the timing switch position by one will retard the timing one degree.

12. Adjust the "A" timing switch as required to achieve correct timing (see Figure 4.10-2). Single fuel ignition adjustments are now complete. If you have a single fuel application, continue with Step 16. If you have a dual fuel application, continue with Step 13.

13. Run the engine on secondary fuel with the "D" lead (found in the 7 pin connector from IM) **open** and the CEC Detonation Sensing Module deactivated (14 pin DSM harness disconnected from IM).

14. Check engine timing at the flywheel using a timing light.

NOTE: Increasing the timing switch position by one will advance the timing one degree. Decreasing the timing switch position by one will retard the timing one degree.

15. Adjust the "B" timing switch as required to achieve correct timing (see Figure 4.10-2). Dual fuel ignition adjustments are now complete.

CAUTION To prevent the timing from being altered, always replace the white caps over the timing switches once the desired setting has been selected. Disregarding this information could result in product damage and/or personal injury.

16. When timing adjustments are complete, replace the white caps on the timing switches "A" and "B."

17. If applicable, reconnect the DSM harness to the 14 pin connector on the IM. Activate the DSM. Refer to *Custom Engine Control® Detonation Sensing Module (DSM) Installation, Operation, And Maintenance Manual* (Form 6268) for programming information.

CAUTION It is the sole responsibility of the customer to ensure that all product protection devices effectively shut off both the ignition and gas simultaneously in the event of any malfunctions. Disregarding this information could result in product damage and/or personal injury.

18. Verify shutdown switches and load carrying ability.

DISCHARGING THE STORAGE CAPACITOR

WARNING

If the ignition switch is left in the ON position when a CEC Ignition Module is disconnected, then the spark plugs may fire when the ignition system harness is reconnected, and could cause severe personal injury or death.

Before connecting the ignition harness (to the coils) to the IM, discharge the storage capacitors to ground. Attach one end of a wire lead to the crankcase and then touch the other end to the harness connector pins on the IM, one at a time. A snap may be heard when a capacitor discharges.

WARNING

As a safety measure, ground all the pins. Some breakerless ignition systems have more than one storage capacitor. Severe personal injury or death could result.

VGF IGNITION MODULE TIMING ADJUSTMENTS

CONTENTS

**SECTION 5.00 - IGNITION MODULE DIAGNOSTICS
AND TROUBLESHOOTING**

SECTION 5.00

IGNITION MODULE DIAGNOSTICS AND TROUBLESHOOTING

IGNITION MODULE DIAGNOSTICS AND TROUBLESHOOTING

DIAGNOSTICS CHART

The IM is equipped with three diagnostic LEDs on front of the IM housing: "Power," "Pickup," and "Application" (see Figure 5.00-1). These LEDs give operators visual confirmation on (1) incoming power, (2) Hall-effect pickup signal, and (3) proper application settings.

During normal operation with the engine running the "Power" LED is on, the "Pickup" LED is off, and the "Application" LED is off. When the engine is not running and power is applied to IM the "Power" LED is on, the "Pickup" LED is on, and the "Application" LED is off. If a different condition exists, refer to Table 5.00-1.

Table 5.00-1 describes what an inerrant LED indicates and provides troubleshooting suggestions to remedy the situation if required.



Figure 5.00-1. Ignition Module Diagnostic LEDs

TROUBLESHOOTING CHART

Table 5.00-2 is provided to assist the user in determining the possible causes of unsatisfactory IM operation, as well as point out the corrective action that may be taken to remedy the problem.

If problems persist, contact your local Waukesha Engine Distributor or Waukesha Engine Product Support for assistance.

Troubleshooting the IM can involve some disassembly of circuit board assemblies and other work of similar nature. Only "qualified technicians" should undertake these activities. Improper handling of circuit boards and electronic components can cause damage that may render them unusable.

NOTE: Table 5.00-2 is only provided as a service to our customers. The table should not be viewed as a reflection of Waukesha Engine's actual experience with this product.

WARNING

Allow the engine to cool to room temperature before cleaning, servicing, or repairing the unit. Hot components or fluids can cause severe personal injury or death.

WARNING

Always wear OSHA approved body, sight, hearing, and respiratory system protection. Never wear loose clothing, jewelry, or long hair around an engine. The use of improper attire may result in severe personal injury or death.

WARNING

Do not install, set up, maintain, or operate any electrical components unless you are a technically qualified individual who is familiar with the electrical elements involved. Electrical shock can cause severe personal injury or death.

IGNITION MODULE DIAGNOSTICS AND TROUBLESHOOTING

Table 5.00-1. Ignition Module Diagnostics Chart

LED	IF LED IS ...	THEN
"Power" LED (Green)	OFF*	<ul style="list-style-type: none"> • IM does not have power (10 - 32 VDC). <ol style="list-style-type: none"> a. Check to see if power source is within specification. Refer to "IM Power Requirements" in Section 2.05 (VHP), Section 3.05 (AT), or Section 4.05 (VGF) for power supply requirements. b. Check wiring for proper connections. Refer to "IM Power Requirements" in Section 2.05 (VHP), Section 3.05 (AT), or Section 4.05 (VGF). c. Perform diagnostic test on IM circuit board assemblies by completing the steps in "Ignition Module Testing" in this section. Replace power board assembly if required and retest IM.
"Pickup" LED (Red)	ON* (ENGINE NOT RUNNING)	<ul style="list-style-type: none"> • Normal operation.
	ON* (ENGINE RUNNING)	<ul style="list-style-type: none"> • Engine is at rest. • No Hall-effect pickup signal is being sensed by the IM. <ol style="list-style-type: none"> a. Reset air gap between timing disc/gear and Hall-effect pickup. Refer to "Hall-effect Pickup Testing On Engine With Ohmmeter" and Table 5.00-14 for instructions on resetting the air gap. b. Check wiring for proper connections. Refer to "IM Power Requirements" in Section 2.05 (VHP), Section 3.05 (AT), or Section 4.05 (VGF). c. Check the Hall-effect pickup for proper operation. Refer to "Hall-effect Pickup Testing" in this section. Replace Hall-effect pickup if necessary. d. Check the magnetism of the magnets in the timing disc/gear. To check magnetism, take a small steel object like a stiff feeler gauge approximately 0.040 (1.0 mm) thick, and pass the gauge over the top of one of the magnets. The relative pull on the gauge should then be compared with the pull of the other magnets. The pull on the feeler gauge should be about the same for all the magnets. Replace magnet(s) or timing disc if necessary.
"Application" LED (Red)	ON*	<ul style="list-style-type: none"> • Magnet pattern does not match the application for which the IM Selector Switch is set (for example: 6 versus 8 cylinder) OR the Selector Switch is in the B position (No Application). <ol style="list-style-type: none"> a. Check the Selector Switch setting on IM. Refer to Table 5.00-7 for Selector Switch settings. b. Check IM part number. If part number of IM is not correct for the application, replace IM. Refer to Table 5.00-3 for IM part numbers. c. Check P/N of timing disc installed versus engine application. If part number of timing disc is not correct for the application, replace timing disc. Refer to Table 5.00-3 for timing disc part numbers. • Timing disc magnet is lost or is very weak. <ol style="list-style-type: none"> a. Reset air gap between timing disc/gear and Hall-effect pickup. Refer to "Hall-effect Pickup Testing On Engine With Ohmmeter" and Table 5.00-14 for instructions on resetting the air gap. b. Check the magnetism of the magnets in the timing disc/gear. To check magnetism, take a small steel object like a stiff feeler gauge approximately 0.040 (1.0 mm) thick, and pass the gauge over the top of one of the magnets. The relative pull on the gauge should then be compared with the pull of the other magnets. The pull on the feeler gauge should be about the same for all the magnets. Replace magnet(s) or timing disc if necessary. • Hall-effect pickup is lost (disconnected or failed) on a two pickup system (AT engines). <ol style="list-style-type: none"> a. Determine which timing disc is not being sensed. b. Reset air gap between timing disc/gear and Hall-effect pickup. Refer to "Hall-effect Pickup Testing On Engine With Ohmmeter" and Table 5.00-14 for instructions on resetting the air gap. c. Check wiring for proper connections. Refer to "IM Power Requirements" in Section 2.05 (VHP), Section 3.05 (AT), or Section 4.05 (VGF).

NOTE: * During normal operation with the engine running the "Power" LED is on, the "Pickup" LED is off, and the "Application" LED is off. When the engine is not running and power is applied to IM the "Power" LED is on, the "Pickup" LED is on, and the "Application" LED is off. If a different condition exists, refer to the diagnostics provided in the table.

IGNITION MODULE DIAGNOSTICS AND TROUBLESHOOTING

Before referring to the troubleshooting procedures in Table 5.00-2, check IM LEDs. During normal operation with the engine running the "Power" LED is on, the "Pickup" LED is off, and the "Application" LED is off. When the engine is not running and power is applied to IM the "Power" LED is on, the "Pickup" LED is on, and the "Application" LED is off.

- If a different condition exists, refer to the IM diagnostics in Table 5.00-1.

- If the LEDs are displaying normal LED operation and IM operation is unsatisfactory, use Table 5.00-2 to troubleshoot the IM system.

NOTE: If you completed the diagnostics in Table 5.00-1, some of the troubleshooting checks listed in Table 5.00-2 have already been completed.

Table 5.00-2. Ignition Module Troubleshooting Chart

SYMPTOM	TEST OR CHECK DESCRIPTION	IF CHECK IS OK	IF CHECK IS NOT OK
No Spark	1A. Verify 10 - 32 VDC is available to IM.	Go to 1B	Supply 10 - 32 VDC to IM.
	1B. Verify Hall-effect pickup gap is within specification (see section "Hall-effect Pickup Testing" and Table 5.00-14).	Go to 1C	Reset air gap.
	1C. Verify that IM installed on engine is correct model for engine application (see Table 5.00-3).	Go to 1D	Install correct IM for application.
	1D. Verify no short exists in wiring connected to "G" lead. Disconnect "G" lead from on/off switch, safety switches, etc.	Go to 1E	Find and correct short in wiring connected to "G" lead.
	1E. Visually check Power Pickup Harness for damage and check harness with ohmmeter for continuity.	Go to 1F	Replace Power Pickup Harness.
	1F. Verify proper operation of Hall-effect pickup using CEC Ignition Tester (see "Hall-effect Pickup Testing").	Go to 1G	Replace Hall-effect pickup.
	1G. Verify ground wire is securely attached to ground stud on IM and engine crankcase.	Go to 1H	Secure ground wire.
	1H. Test IM to determine problem circuit board following testing procedures in "Ignition Module Testing."	---	Replace problem circuit board assembly.
One Output Does not Fire	2A. Check spark plug and spark plug lead.	Go to 2B	Replace faulty part.
	2B. Check Primary Coil Harness from IM to ignition coils.	Go to 2C	Repair connection or replace harness.
	2C. Check ignition coils.	Go to 2D	Replace faulty ignition coil(s).
	2D. Replace IM's power board assembly following the procedure in "Ignition Module Repair."	---	If problems persist, contact your local Waukesha Engine Distributor or Waukesha Engine Product Support.
One Output Fires Continuously	3A. Replace IM's power board assembly.	---	If problems persist, contact your local Waukesha Engine Distributor or Waukesha Engine Product Support.
Timing is Not Correct	4A. Verify Selector Switch setting is correct for application (see Table 5.00-7).	Go to 4B	Select correct application setting on Selector Switch.
	4B. Adjust engine timing with timing switch "A" or "B" on IM.	Go to 4C	Adjust timing switch to desired timing.
	4C. Check if "D" lead of 7 pin harness is grounded ("A" switch active) or open ("B" switch active).	Go to 4D	Adjust corresponding timing switch according to connection of "D" lead.
	4D. Check timing disc reference position to #1 cylinder position.	Go to 4E	Correct timing disc mount to #1 cylinder position.
	4E. Replace IM's logic board assembly.	---	If problems persist, contact your local Waukesha Engine Distributor or Waukesha Engine Product Support.

IGNITION MODULE DIAGNOSTICS AND TROUBLESHOOTING

TESTING IGNITION MODULE COMPONENTS

This section includes troubleshooting information for IM components. Testing of the components may be performed on the engine or using a test bench. Both of these testing methods are included in this section. The purpose of these tests is to determine the condition of the IM and which circuit boards inside the IM need to be replaced.

NOTE: The test bench required will be very similar to ones used for testing magnetos. These bench tests should only be performed by those individuals who have the appropriate equipment (test bench) and prior knowledge required to test magnetos.

The IM is an electronic, digital-circuit ignition system for Waukesha spark-ignited engines (see Figure 5.00-2 and Figure 5.00-3). The system has no wearing parts and uses the capacitor discharge principle providing high energy, precision timed sparks for maximum engine performance.

- Table 5.00-3 lists the Waukesha Engine part numbers for the various IM components.
- Table 5.00-4 lists the Waukesha Engine part numbers for the wiring harnesses used in the IM system.
- Table 5.00-5 lists the internal parts of the IM.
- Table 5.00-6 lists IM specifications.
- Table 5.00-7 lists the Selector Switch settings used to set the IM for the engine application.
- Table 5.00-8 and Table 5.00-9 lists the part numbers of the triggering magnets and Hall-effect pickup(s).

In operation, the IM steps up the DC supply voltage to charge an energy storage capacitor. SCR (silicon controlled rectifiers) switching devices release this stored energy in response to signals from the IM's logic circuitry which processes signals from the rotating trigger magnets. Six, eight, and twelve cylinder engines employ one magnet for every firing cylinder of the engine. Each firing occurs at a programmed number of degrees after the magnet signal is received (see Table 5.00-6). Units for the 16 cylinder engines use one magnet for every two firing cylinders with the odd firing angle electronically synthesized by the IM circuitry. All IMs use one additional index magnet that trails the last firing magnet by 9 degrees or 15 degrees (depending on application). This indicates that another firing cycle is beginning.

The 8L-AT27GL, 12V-AT27GL, and 16V-AT27GL use a slightly different system of components than the standard IM found on all other Waukesha Engine products. These engines use two Hall-effect pickups, a timing disc, and a flywheel with magnets. The timing disc, containing one magnet, is mounted on the cam gear and signals the IM that another firing cycle is beginning. The flywheel contains four (on 8L-AT27GL and 16V-AT27GL) or six (on 12V-AT27GL) trigger magnets which accurately signal the engine's crankshaft timing to the IM.

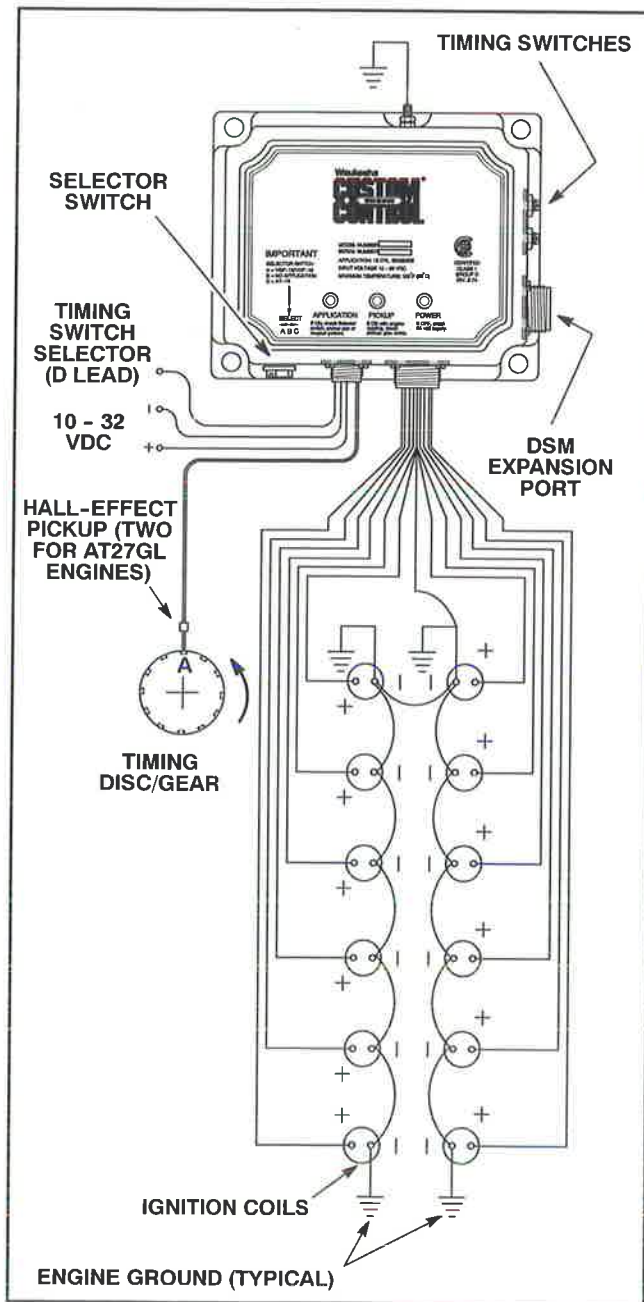


Figure 5.00-2. Ignition Module System

IGNITION MODULE DIAGNOSTICS AND TROUBLESHOOTING

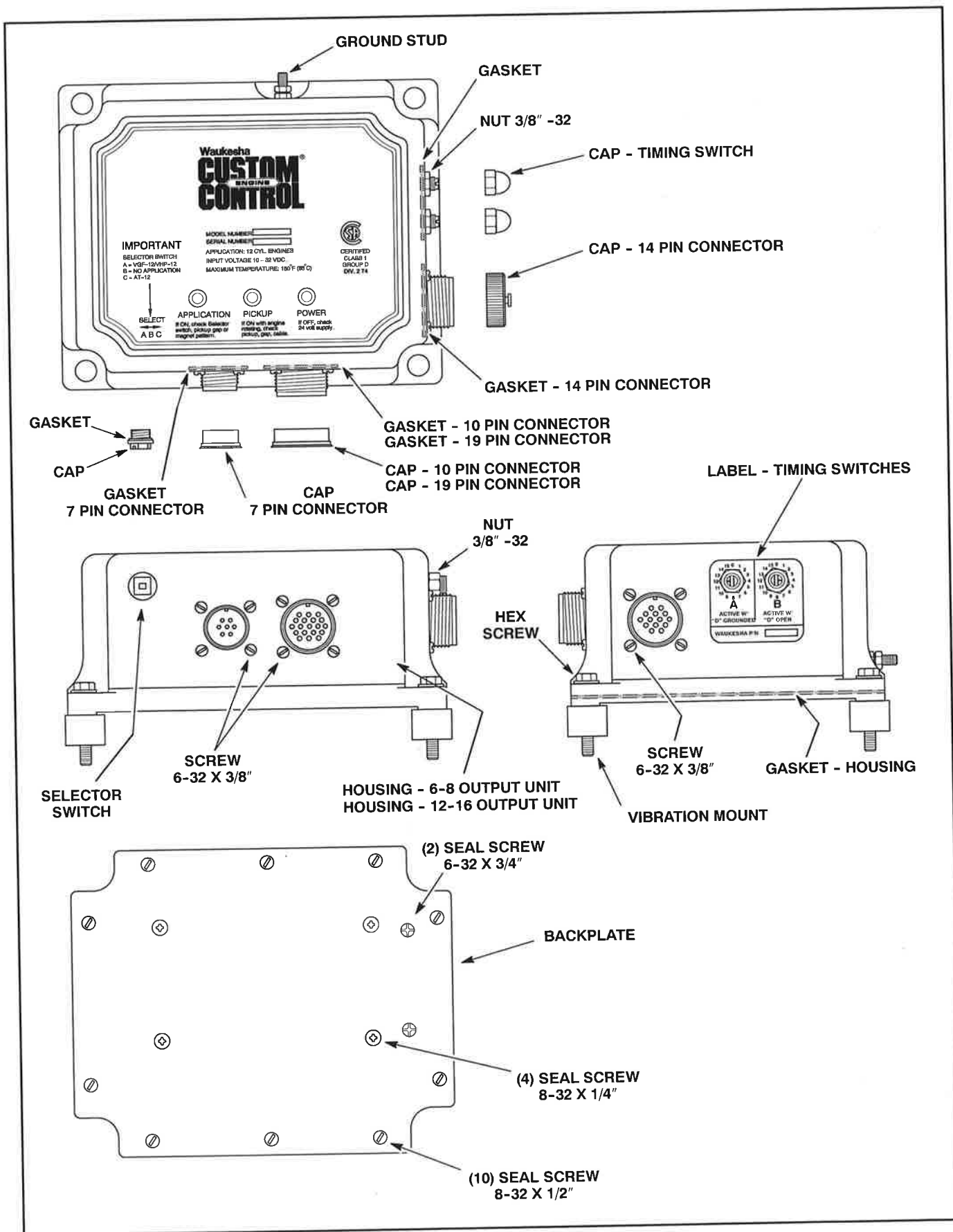


Figure 5.00-3. Ignition Module Components

IGNITION MODULE DIAGNOSTICS AND TROUBLESHOOTING

Table 5.00-3. Ignition Module Components Part Numbers

ENGINE MODEL	TIMING DISC	HALL-EFFECT PICKUP	IGNITION MODULE	POWER BOARD ASSEMBLY	LOGIC BOARD ASSEMBLY
VGf 6	305805	295844A	740608	A740819	A740816
VGf 8	305805A	295844A			
VHP 6	305805R	295844A			
8L-AT27GL	305805L and 280513C (Flywheel) with 305509 (Magnets)	295844B 295844			
VGf 12	302226B (Left Bank Cam Gear) and 305509 (Trigger Magnets)	295844	740609	A740820	A740817
VHP 12	305805P	295844A			
VHP 5115GL	305805S	295844A			
12V-AT25GL	305805E	295844			
12V-AT27GL	305805K and 280513C (Flywheel) with 305509 (Magnets)	295844 (Qty. 2)	740610	A740821	A740818
VGf 16	303026 (Left Bank Cam Gear) and 305509 (Trigger Magnets)	295844			
VHP 16	305805N	295844A			
16V-AT27GL	305805K and 280013M (Flywheel) with 305509 (Magnets)	295844 (Qty. 2)			

Table 5.00-4. Wiring Harnesses Part Numbers

ENGINE	UNSHIELDED PICKUP AND INPUT HARNESS	SHIELDED INPUT HARNESS	SHIELDED PICKUP HARNESS	UNSHIELDED PRIMARY HARNESS	SHIELDED PRIMARY HARNESS
VGf 6	69796	295841J	295495A	69792 (or) G305628A	H208497
VGf 8	69796	295841J	295495A	69793 (or) V305628	CA208497D
VGf 12	69796	295841B	295495	69794 (or) F305628	V208497D (R.H.) W208497D (L.H.)
VHP 6	69796	485065	485066	69792 (or) C295497B	485064
VHP 12	69796	485065	485066	F69692J	295497
VHP 16	69796	295841N	295495B	69795A (or) 69692V	485073
8L-AT27GL	---	295841A	295495A (or) 295495B	---	295497B
12V-AT25GL	---	295841A	295495	---	295497
12V-AT27GL	---	295841A	295495A (or) 295495D	---	295497
16V-AT27GL	---	295841A	295495B and 295495D	---	295497M

IGNITION MODULE DIAGNOSTICS AND TROUBLESHOOTING

Table 5.00-5. Ignition Module Internal Parts List

P/N	QUANTITY	DESCRIPTION
See Table 5.00-3	1	Logic Board Assembly (see Table 5.00-3) (Each Board Assembly Also Contains an IM Gasket/Hardware Kit)
See Table 5.00-3	1	Power Board Assembly (See Table 5.00-3) (Each Board Assembly Also Contains an IM Gasket/Hardware Kit)
A740815 (Ignition Module Gasket/Hardware Kit)	1	Gasket, Timing Potentiometer
	2	Cap, Timing Switch
	1	Gasket, 14 pin connector
	1	Cap, 14 pin connector
	2	Insulators
	1	Cap, 7 pin connector
	1	Cap, 10 pin connector
	1	Cap, 19 pin connector
	1	Gasket, housing
	1	Gasket, 7 pin connector
	1	Gasket, 10 pin connector
	1	Gasket, 19 pin connector
	10	Screw 8-32 x 1/2"
	4	Seal Screw 8-32 x 1/4"
	12	Seal Screw 6-32 x 1/4"
	2	Seal Screw 6-32 x 3/4"
1	Plug	
1	Gasket, Plug	

Table 5.00-6. Ignition Module Specifications

ENGINE MODEL	NUMBER OF MAGNETS	TIMING SWITCH INCREMENT ENGINE°	FIRING PATTERN - DISC DEGREES
			A-B-C-D-E-F (@ 6 CYL) A-B-C-D-E-F-H-I (@ 8 CYL) A-B-C-D-E-F-K-L-M-N-P-R (@ 12 CYL) A-B-C-D-E-F-K-L-M-N-P-R-S-T-U-V (@ 16 CYL)
VGf 6	6 + 1	1°	0-60-120-180-240-300
VGf 8	8 + 1	1°	0-45-90-135-180-225-270-315
VHP 6	6 + 1	1°	0-60-120-180-240-300
8L-AT27GL	4 + 1	1°	0-45-90-135-180-225-270-315
VGf 12	12 + 1	1°	0-30-60-90-120-150-180-210-240-270-300-330
VHP 12	12 + 1	1°	0-30-60-90-120-150-180-210-240-270-300-330
VHP 5115GL	12 + 1	1°	0-30-60-90-120-150-180-210-240-270-300-330
12V-AT25GL	12 + 1	1°	0-27-60-87-120-147-180-207-240-267-300-327
12V-AT27GL	6 + 1	1°	0-27-60-87-120-147-180-207-240-267-300-327
VGf 16	8 + 1	1°	0-30-45-75-90-120-135-165-180-210-225-255-270-300-315-345
VHP 16	8 + 1	1°	0-30-45-75-90-120-135-165-180-210-225-255-270-300-315-345
16V-AT27GL	4 + 1	1°	0-27-45-72-90-117-135-162-180-207-225-252-270-297-315-342

IGNITION MODULE DIAGNOSTICS AND TROUBLESHOOTING

The IM has a three position Selector Switch for setting the engine model (see Table 5.00-7). The Selector Switch is a three position switch (A, B, and C). The Selector Switch must be set during IM timing adjustments. Use your finger or a screwdriver to switch to the proper application.

NOTE: The IM is shipped from Waukesha Engine with the Selector Switch in the B (No Application) setting. Refer to Table 5.00-7 for Selector Switch settings.

Table 5.00-7. Ignition Module Selector Switch Settings

SELECTOR SWITCH SETTING	IGNITION MODULE MODELS		
	Model 811 for 6 & 8 Cylinder Engines	Model 1211 for All 12 Cylinder Engines	Model 1611 for All 16 Cylinder Engines
A	VHP/VGF 6 Cylinder Engines	VHP/VGF 12 Cylinder Engines	VHP/VGF 16 Cylinder Engines
B	No Application	No Application	No Application
C	ATGL/VGF 8 Cylinder Engines	ATGL 12 Cylinder Engines	ATGL 16 Cylinder Engines

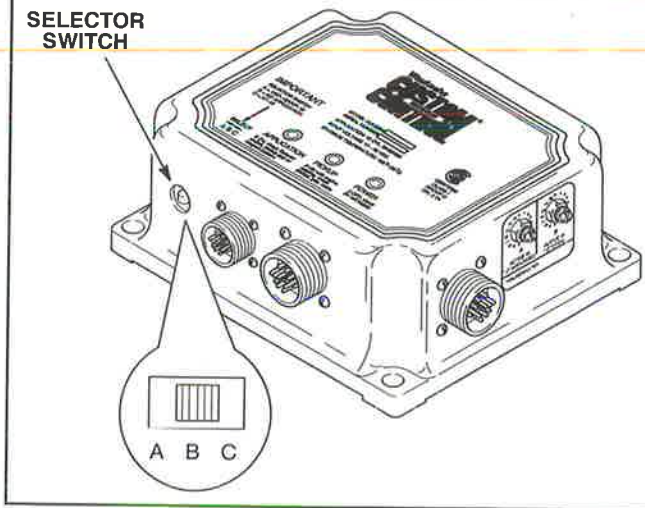


Table 5.00-9. Hall-effect Pickup Part Numbers

P/N	LENGTH "L"
295844	4.5 in.
295844A	2.5 in.
295844B	6.0 in.

IGNITION MODULE TESTING

IGNITION MODULE TESTING - ON ENGINE

Testing The IM With The CEC Ignition Tester

The CEC Ignition Tester (P/N 475032) is designed to quickly troubleshoot the various components of the IM system (see Figure 5.00-4).

The Ignition Tester instructions that follow check operation of the IM, power supplied to the IM, wiring to the ignition coils for the primary circuit, and the secondary circuit from the ignition coils to the spark plugs.

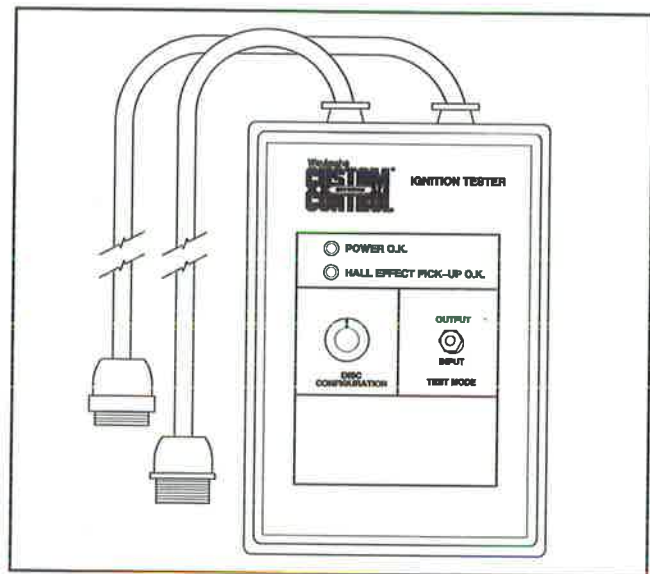


Figure 5.00-4. CEC Ignition Tester

Table 5.00-8. Triggering Magnet


ENGINE	MAGNET	NUMBER OF MAGNETS
VGf 12	305509	12 + 1
VGf 16	305509	8 + 1
8L-AT27GL	305509	4 + 0
12V-AT27GL	305509	6 + 0
16V-AT27GL	305509	4 + 0

WARNING

Verify that the engine is purged of all fuel gas prior to using the test unit. Failure to do so may cause the engine to rotate or start which could cause severe personal injury or engine damage.

WARNING

Do not install, set up, maintain or operate any electrical components unless you are a technically qualified individual who is familiar with the electrical elements involved. Electrical shock can cause severe personal injury or death.

 **CAUTION** Disconnect power supply to Ignition Module before completing test with CEC Ignition Tester. Electrical test equipment may be damaged if the tests are not performed properly.

1. Disconnect power from IM.
2. Disconnect the 7 pin Power Pickup Harness from the IM.
3. Position the "OUTPUT/INPUT" switch on the Ignition Tester to the "INPUT" position.
4. Plug the female cable from the Ignition Tester into the IM 7 pin connector.
5. Plug the male cable from the Ignition Tester into the free end of the 7 pin Power Pickup Harness.
6. Apply 10 - 32 VDC power to the IM. The green "POWER O.K." LED on the Ignition Tester will light indicating power is applied to the IM. The LED does not indicate that the power supply is within specification, but that power is applied.
7. Rotate the "DISC CONFIGURATION" selector switch to the proper magnet arrangement for your application. *For example:* If you have a 12 cylinder engine, the knob should be rotated so that the white indicating line is opposite the "12+1" marking.
8. Verify that the Selector Switch on the IM is set for the proper application. Refer to Table 5.00-7 for Selector Switch settings. Use your finger or a screwdriver to switch to the proper setting.

WARNING

Verify that the engine is purged of all fuel gas prior to using the test unit. Failure to do so may cause the engine to rotate or start which could cause severe personal injury or engine damage.

9. Verify that the engine has been properly purged of fuel since the following steps will cause a functioning unit to output a spark to all engine cylinders.

10. Position the "OUTPUT/INPUT" switch on the Ignition Tester to the "OUTPUT" position.

11. The CEC Ignition Tester will send simulated Hall-effect pickup signals to the IM. If errors are detected during this test, the LEDs on the IM will light (see Table 5.00-1, "Ignition Module Diagnostics Chart"). The IM should fire all outputs in sequence at a rate equivalent to a magnet disc speed of 661 rpm. Use any convenient method, such as a spark plug glow indicator, to check that each ignition coil and spark plug are firing.

12. Position the "OUTPUT/INPUT" switch on the Ignition Tester in the "INPUT" position at the end of the test.

NOTE: The CEC Ignition Tester can also be used to complete a test of the Hall-effect pickup and Power Pickup Harness. Refer to "Hall-effect Pickup Testing On Engine With CEC Ignition Tester" later in this section to perform the test.

13. After testing is complete, disconnect the Ignition Tester and reconnect the Power Pickup Harness to the IM.

Ignition Module Testing With Ohmmeter - On Engine

WARNING

Do not install, set up, operate, or maintain any electrical components unless you are a technically qualified individual who is familiar with electrical elements involved. Electrical shock can cause personal injury or death.

 **CAUTION** Disconnect the power supply from the Ignition Module before attempting the ohmmeter tests. Electrical test equipment may be damaged if the tests are not performed properly.

NOTE: Use Simpson Model 260 or equivalent analog volt-ohmmeter to perform this test. Some ohmmeters use reverse polarity, which will give incorrect results.

IGNITION MODULE DIAGNOSTICS AND TROUBLESHOOTING

1. Connect the ohmmeter positive and negative leads to the corresponding pin locations listed in Table 5.00-10.
2. Record each reading.

3. If the results comply with Table 5.00-10, proceed to the next test. If the results do not comply with Table 5.00-10, replace the IM's power board assembly and retest. Refer to "Ignition Module Repair" to replace power board assembly.

Table 5.00-10. Ohmmeter Tests

TEST	OHMMETER SCALE	POSITIVE LEAD	NEGATIVE LEAD	READING
Ignition Module 10 pin or 19 pin connector	R x 10,000	Pin "G"	Pin "A"	Infinite - replace power board assembly and retest if reading is less than 250,000 ohms. ^{1,2}
		Pin "G"	Pin "B"	
		Pin "G"	Pin "C"	
		Pin "G"	Pin "D"	
		Pin "G"	Pin "E"	
		Pin "G"	Pin "F"	
		Pin "G"	Pin "H"	
		Pin "G"	Pin "I"	
		Pin "G"	Pin "J"	
		Pin "G"	Pin "K"	
		Pin "G"	Pin "L"	
		Pin "G"	Pin "M"	
		Pin "G"	Pin "N"	
		Pin "G"	Pin "P"	
		Pin "G"	Pin "R"	
		Pin "G"	Pin "S"	
		Pin "G"	Pin "T"	
		Pin "G"	Pin "U"	
Pin "G"	Pin "V"			
Pin "G"	Ground Stud			
Ignition Module 7 pin connector	R x 100	Pin "E"	Pin "F"	Infinite - replace power board assembly and retest if reading is less than 1000 ohms. ^{1,2}

NOTE: ¹ The ohmmeter needle will deflect and then move to a final infinite reading within 5 seconds.
² Refer to "Ignition Module Repair" to replace power board assembly.

Ignition Timing Testing - On Engine

NOTE: For the following tests to be performed the engine must be able to operate at rated speed and no load.

1. Verify proper power supply to IM (see Figure 5.00-5). Correct if necessary.

NOTE: The IM system will function properly with a power source as defined in Figure 5.00-5. However, if the supply is capable of providing a pulse current (higher current level for a shorter period of time such that the average current is the same), the ignition will utilize that pulse capability. In this case, the voltage fluctuations on the supply wiring, including the ground return to the power source, may cause erratic operation of other electrical devices. For this reason, it is recommended that the ignition power source wiring, specifically the ground return, be sized for at least 30 amps even though the average current will be less than 6 amps.

⚠ WARNING

Disconnect the power supply to the Ignition Module when servicing the ignition system. Failure to disconnect the power supply can result in electrical shock, causing personal injury or death.

2. Disconnect the power supply to the IM.

⚠ CAUTION Observe correct polarity when connecting power to the Ignition Module. Failure to correctly connect the power supply may damage the Ignition Module.

3. Ground the "D" lead in the Power Pickup Harness to activate timing switch "A" on the IM. Connect the power supply to the IM.
4. Rotate the "A" switch to the "0" position to place the engine in its most retarded setting for this timing switch.

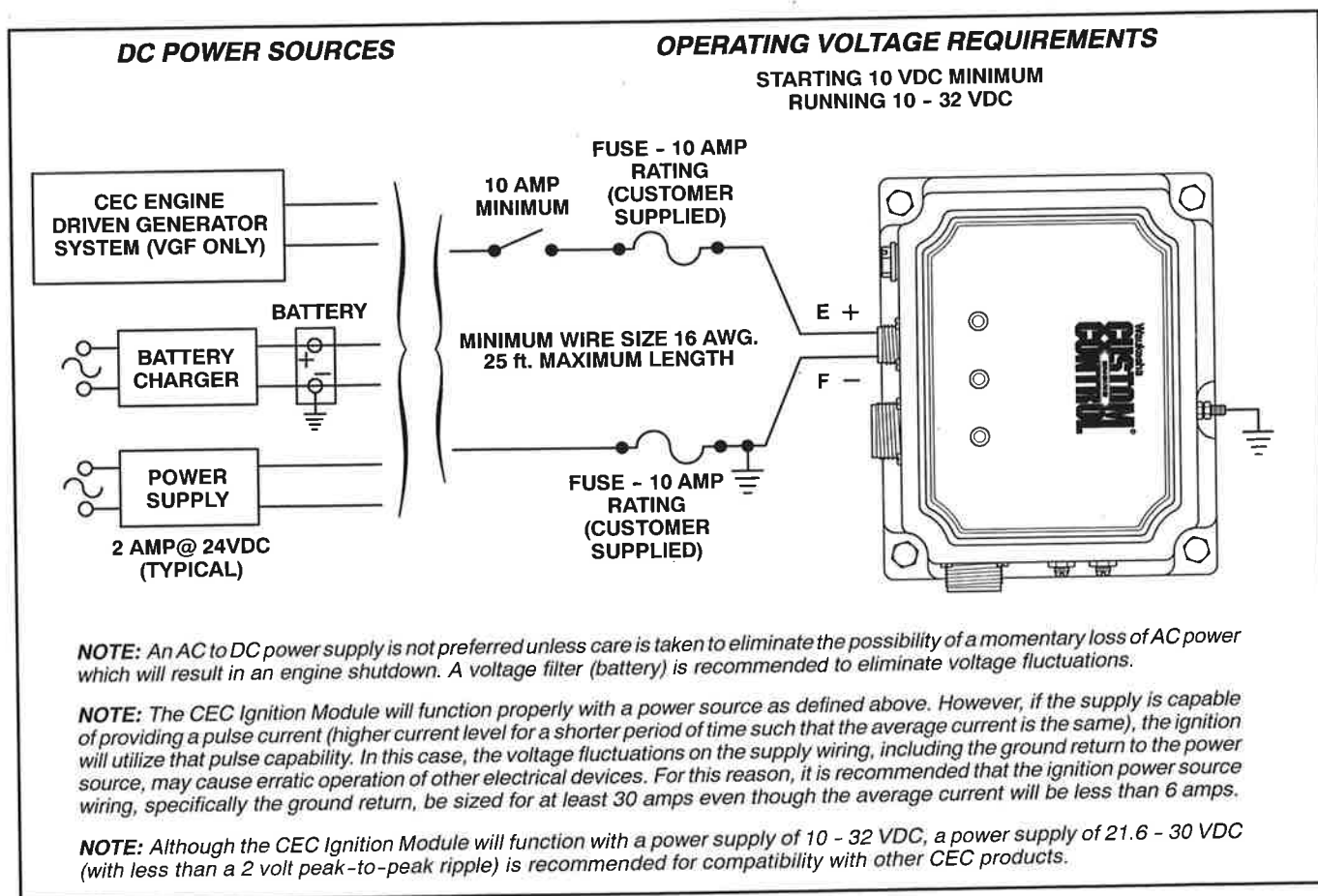


Figure 5.00-5. Ignition Module Power Supply

IGNITION MODULE DIAGNOSTICS AND TROUBLESHOOTING

5. Start the engine. Run the engine at rated speed with no load.
6. Use a timing light to check the ignition timing. Record the ignition timing.
7. Use a screwdriver to slowly rotate switch "A" upwards on the dial (0 - 15). Record the ignition timing at each point. The ignition timing should increase one engine (crankshaft) degree for each upward position change of the timing switch.
8. Shut down engine.
9. Disconnect the power supply to the IM.
10. Unground the "D" lead in the Power Pickup Harness to activate timing switch marked "B" on the IM. Connect the power supply to the IM.
11. Rotate the "B" switch to the "0" position to place the engine in its most retarded setting for this timing switch.
12. Start the engine. Run the engine at rated speed with no load.
13. Use a timing light to check the ignition timing. Record the ignition timing.
14. Use a screwdriver to slowly rotate timing switch "B" upwards on the dial (0 - 15). Record the ignition timing at

each point. The ignition timing should increase one engine (crankshaft) degree for each upward position change of the timing switch.

NOTE: An overlap exists between timing switch "A" and "B."

If the IM's timing switches respond correctly proceed to the next test. If the timing switches do not respond in this manner, replace the logic board assembly (see "Ignition Module Repair" in this section).

7 Pin And 3 Pin Connector Testing - On Engine

NOTE: The following 7 pin and 3 pin tests (see Figure 5.00-6) are performed with the engine running at no load and rated speed. The complete test can only be performed on engines equipped with junction box terminations. Engines without junction boxes will require bench testing or a fabricated test harness to check pins "A," "B," and "C."

1. Connect the voltmeter positive and negative leads to corresponding pin or wire listed in Table 5.00-11.
2. Record each reading.
3. If the results comply with Table 5.00-11, proceed to the next test. Follow the corrective action column of Table 5.00-11 if the readings are out of specification.

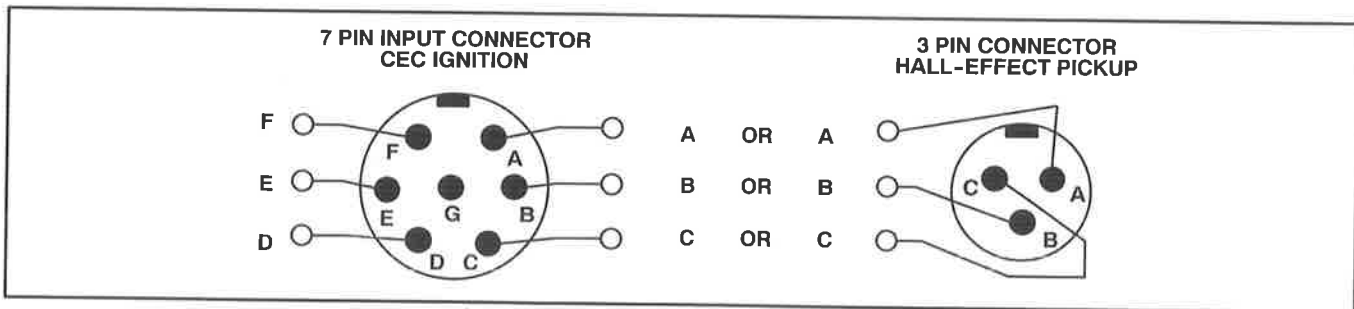


Figure 5.00-6. The 7 Pin And 3 Pin Connectors

Table 5.00-11. Testing The 7 Pin And 3 Pin Connectors

TEST	VOLTMETER SCALE	POSITIVE LEAD	NEGATIVE LEAD	READING	CORRECTIVE ACTION
7 Pin Or 3 Pin Connector	10 VDC	Pin A Or Wire	Ground	4.4 VDC Min. 100 Disc rpm With 10 - 32 VDC Input Voltage	Check Hall-effect Pickup
		Pin B Or Wire	Ground	Approx. 5 VDC	Check Hall-effect Pickup Or Replace IM Power Board Assembly and retest
		Pin C Or Wire	Ground	0 VDC	Correct Ground Lead And/Or Replace Hall-effect Pickup
		Pin D Or Wire	Ground	5 VDC (When Open) 0 VDC (When Grounded)	Replace IM Power Board Assembly and retest
	30 VDC	Pin E Or Wire	Ground	10 - 32 VDC (Positive Input Voltage)	Check Power Supply
	10 VDC	Pin F Or Wire	Ground	0 VDC (Negative Input Voltage)	Check Wire Terminations

Oscilloscope Testing - On Engine

The oscilloscope test checks the voltage pattern at the ignition coil and the firing position of the cylinder. A malfunctioning SCR or a defective coil will affect the voltage pattern and/or its position.

NOTE: An oscilloscope (single channel) and two 10:1 oscilloscope probes are required to perform these tests. The signals being monitored are 150 - 200 VDC, positive polarity. The oscilloscope tests are written for a single channel oscilloscope. The use of dual channel oscilloscope is permitted.

NOTE: The VGF series of engines does not include the "G" lead in the Primary Coil Harness. Special pigtail adaptors are available from Waukesha Engine for use with oscilloscope testing (see Table 5.00-12). The pigtail adaptor is installed between the Primary Coil Harness and the IM. The wire that hangs out is the "G" lead and can be connected to the oscilloscope.

Table 5.00-12. VGF Engine "G" Lead Test Pigtail Adaptors

Engine Model	Test Pigtail P/N
F18 - 6 Cylinder	472059
H24 - 8 Cylinder	472060
L36 - 12 Cylinder	472061
P48 - 16 Cylinder	472062

NOTE: For the following tests to be performed the engine must be able to operate at rated speed and no load.

1. Connect the oscilloscope trigger input to the positive (+) "A" (first firing) coil terminal.
2. Connect the reading probe to the positive (+) coil terminal of each coil being checked and attach the oscilloscope probe ground to an engine ground.
3. Start the engine. Run the engine at rated speed and no load.
4. View the oscilloscope. Compare with the example patterns shown in Figure 5.00-7.

NOTE: The waveform shape displayed on the oscilloscope should be similar in output (140 - 160 VDC) but may differ in the time base because of the timing disc speed, oscilloscope time base setting, or IM model.

5. If the waveforms are not consistent with Figure 5.00-7, replace the IM's power board assembly (see "Ignition Module Repair" in this section).

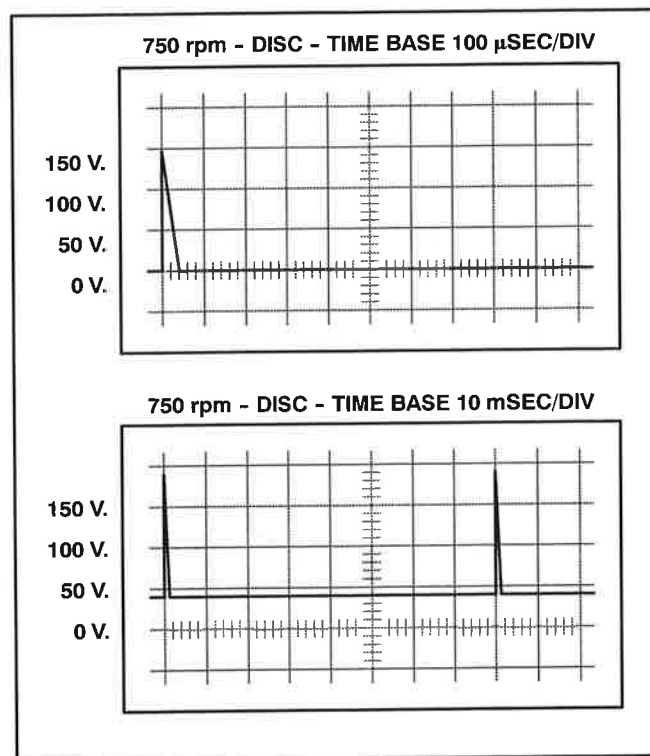


Figure 5.00-7. Oscilloscope Test Pattern (6 Cylinder Shown)

Storage Capacitor Voltage Pattern Testing - On Engine

The storage capacitor voltage pattern test checks the voltage pattern on the storage capacitor which is affected by the SCRs.

NOTE: An oscilloscope (single channel) and two 10:1 oscilloscope probes are required to perform these tests. The signals being monitored are 150 - 200 VDC, positive polarity. The oscilloscope tests are written for a single channel oscilloscope. The use of a dual channel oscilloscope is permitted.

NOTE: Refer to Figure 5.00-8 for the scope pattern pertaining to the particular IM being tested.

NOTE: For the following tests to be performed the engine must be able to operate at rated speed and no load.

IGNITION MODULE DIAGNOSTICS AND TROUBLESHOOTING

1. Connect the trigger input of the oscilloscope to the positive (+) "A" primary coil lead.

2. Connect the oscilloscope reading probe to the "G" lead of the Primary Coil Harness and the oscilloscope probe ground to an engine ground.

NOTE: The "G" lead pattern displays all firings of the unit.

NOTE: With the "G" lead connected **DIRECTLY** to the scope, the oscilloscope or meter should read 140 - 160 VDC. If voltage is low, check power supply (including power supply to ignition wiring and grounds).

NOTE: The VGF series of engines does not include the "G" lead in the Primary Coil Harness. Special pigtail adaptors are available from Waukesha Engine for use with oscilloscope testing.

3. Operate the engine at rated speed and no load. Observe the oscilloscope patterns. The patterns displayed should correspond with those in Figure 5.00-8.

NOTE: The patterns displayed on the oscilloscope should be similar in output (140 - 160 VDC) but may differ in the time base because of the timing disc speed, oscilloscope time base setting, or IM model.

4. If the patterns are not consistent with Figure 5.00-8, replace the IM's power board assembly (see "Ignition Module Repair" in this section).

Firing Pattern Testing - On Engine

NOTE: Refer to Table 5.00-6 for the firing pattern and engine model pertaining to the particular IM being tested. Ensure that the IM's cylinder timing matches that of the engine.

NOTE: In order to complete this test on engine, the flywheel must be marked with timing marks for all cylinders.

NOTE: The engine must be able to operate at rated speed and no load for this test.

1. Start the engine and set to rated speed and no load.

2. Using a timing light, set the ignition timing to zero degrees before top dead center (BTDC) or to the most retarded ignition timing possible.

3. Using the timing light on each cylinder, ensure that the ignition timing is the same for all cylinders. This can be accomplished by using the timing light in conjunction with a fully degreed flywheel. This will check the IM's timing pattern.

4. If the timing pattern does not match the IM and engine combination, replace the IM's logic board assembly (see "Ignition Module Repair" in this section).

IGNITION MODULE DIAGNOSTICS AND TROUBLESHOOTING

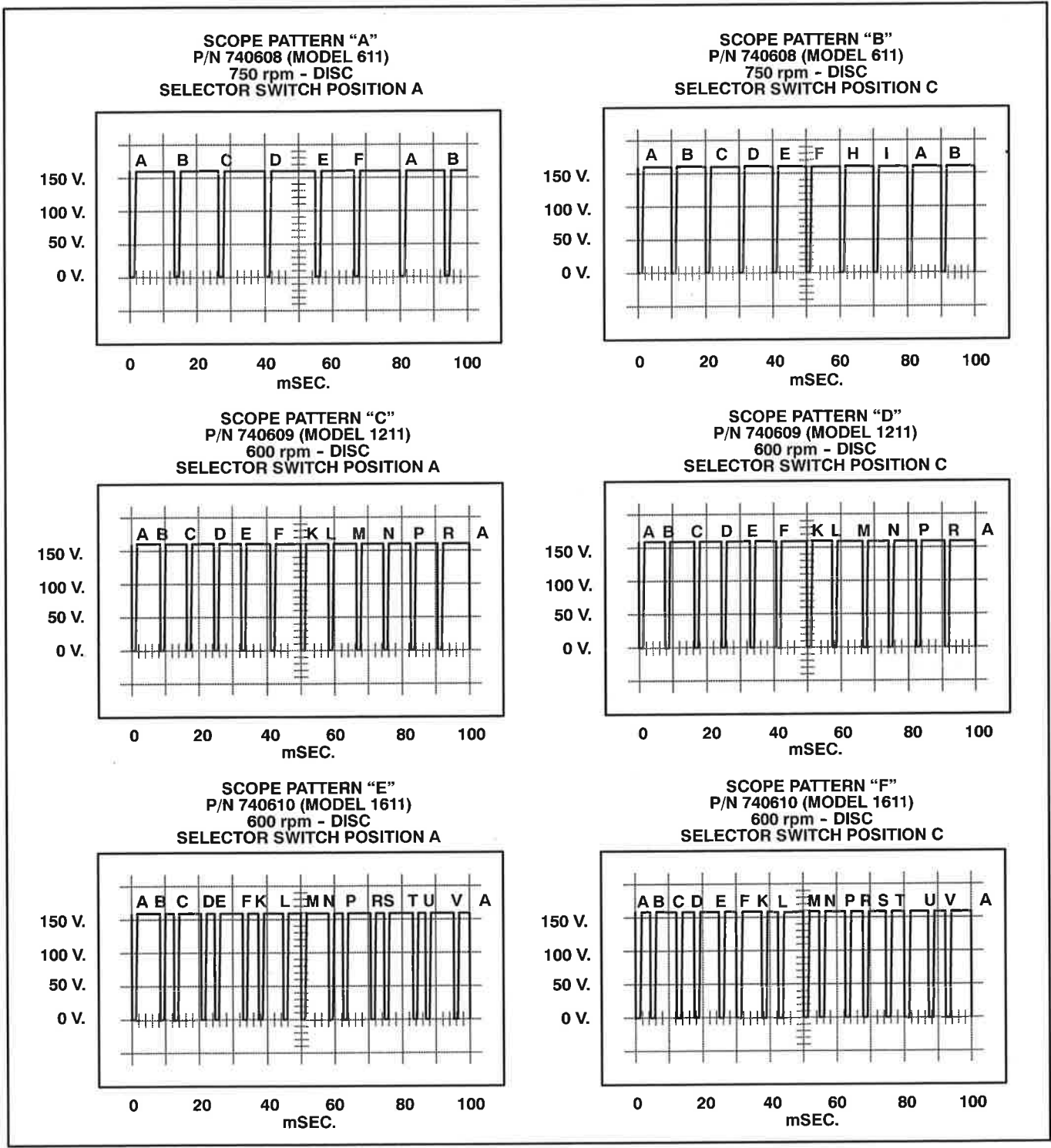


Figure 5.00-8. Oscilloscope Patterns

IGNITION MODULE DIAGNOSTICS AND TROUBLESHOOTING

IGNITION MODULE TESTING - BENCH TEST

The following five tests require the use of a magneto style bench testing apparatus. In order to ensure accuracy of testing, these procedures should be performed only by those individuals having access to and experience with this type of testing equipment. The following is a list of required materials needed in order to construct a test stand:

- A variable speed motor of 0.25 HP or greater, capable of rotating 1000 rpm.
- A spark degree wheel graduated in 360 increments with the indicator attached to the driving shaft.
- An attachment for the timing discs to be mounted to the motor driving shaft.
- A Hall-effect pickup (P/N 295844A) mounted to sense the rotating magnetic disc.
- Sixteen ignition coils connected to suitable, adjustable spark gaps. Additionally, one coil connected to the indicating degree wheel and an arrangement to connect its positive terminal individually to the positive terminals of all other coils.
- A wiring harness connecting the IM to the ignition coils.
- A wiring harness to connect the Hall-effect pickup to the IM.
- A DC power source capable of supplying 10 - 32 VDC, 6 amps.
- A means to elevate and maintain the IM to a controlled temperature of 150° F (65° C).

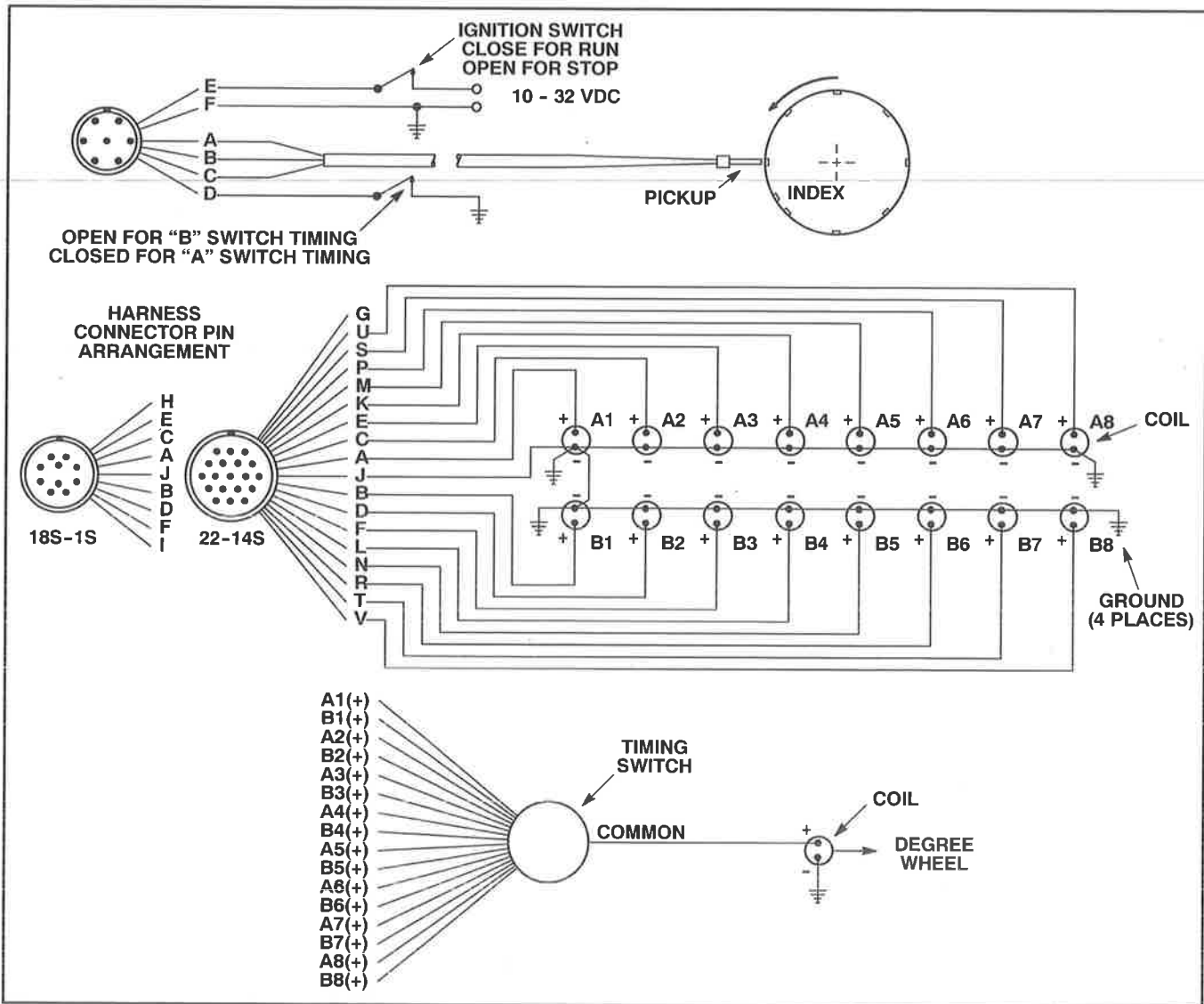


Figure 5.00-9. Ignition System Wiring Diagram For Test Stand

Performance Testing - Bench Test

NOTE: It is required that all bench tests be performed with the IM heated to a temperature of 150° F (65° C).

1. Set each spark gap to 15 mm (0.591").
2. Apply the corresponding input voltage as indicated for each test (see Table 5.00-13). Operate the timing disc at the speed indicated for each test.

Table 5.00-13. Bench Testing Voltage Output

DISC rpm	INPUT VOLTAGE	TEST
25	10 VDC	All outputs fire at 15 mm gap
400	24 VDC	All outputs fire at 15 mm gap
900	24 VDC	All outputs fire at 15 mm gap

3. Check all the spark gaps to ensure the IM is firing each gap.
4. Repeat this procedure for each disc rpm (see Table 5.00-13).
5. If the IM fires the gap at all indicated speeds, proceed to the next test. Replace the IM's power board assembly if it does not meet the specifications (see "Ignition Module Repair" in this section).

Firing Pattern Testing - Bench Test

NOTE: Refer to Table 5.00-6 (IM Specification Table) for the firing pattern pertaining to the particular IM being tested.

1. Set the degree wheel at "0" degrees for output "A" of the primary harness.
2. Run the test bench. Record the firing pattern disc degrees for output "A" which should be zero.
3. Record the firing pattern disc degrees for all other outputs used by the particular IM being tested. (Example: IM model P/N 740608 uses firing pattern: A-B-C-D-E-F-H-I = 0-45-90-135-180-225-270-315 firing pattern disc degrees). Use a timing switch to alternate between the remaining outputs.
4. Compare the recorded data with the firing patterns listed in Table 5.00-6. If the timing pattern does not match the table, replace the IM's logic board assembly (see "Ignition Module Repair" in this section).

Ignition Timing Testing - Bench Test



Disconnect the power supply to the Ignition Module when servicing the ignition system. Failure to disconnect the power supply can result in electrical shock causing personal injury or death.

1. Disconnect the power supply to the IM.
 2. Ground the "D" lead in the ignition wiring harness to activate timing switch marked "A" on the IM. Connect the power supply to the IM.
 3. Operate the test bench.
 4. Rotate the "A" switch to the "0" position to place the ignition in its most retarded setting for this timing switch.
 5. Record the firing pattern disc degrees for output "A" of the Primary Coil Harness.
 6. Use a screwdriver to slowly rotate switch "A" upwards on the dial (0 - 15). Record the ignition timing at each point. The ignition timing should increase one half (0.5) disc degrees for each upward position change of the timing switch.
 7. Turn off the test bench.
 8. Disconnect the power supply to the IM.
 9. Unground the "D" lead in the Power Pickup Harness to activate timing switch marked "B" on the IM. Connect the power supply to the IM.
 10. Rotate the "B" switch to the "0" position to place the module in its most retarded setting for this timing switch.
 11. Operate the test bench.
 12. Record the firing pattern disc degrees for output "A" of the Primary Coil Harness.
 13. Use a screwdriver to slowly rotate switch "B" upwards on the dial (0 - 15). Record the ignition timing at each point. The ignition timing should increase one half (0.5) disc degrees for each upward position change of the timing switch.
- NOTE:** An overlap exists between timing switch "A" and "B."

If the IM's timing switches respond correctly, proceed to the next test. If the IM's timing switches do not respond in this manner, replace the logic board assembly and retest (see "Ignition Module Repair" in this section).

IGNITION MODULE DIAGNOSTICS AND TROUBLESHOOTING

7 Pin And 3 Pin Connector Testing - Bench Test

1. Connect the voltmeter positive and negative leads to the corresponding pin or wire listed in Table 5.00-11 (see Figure 5.00-6).
2. Record each reading.
3. If the results comply with Table 5.00-11, proceed to the next test. Follow the corrective action column of Table 5.00-11 if the readings are out of specification.

Oscilloscope Testing - Bench Test

The oscilloscope test checks the voltage pattern at the ignition coil and the firing position of the cylinder. A malfunctioning SCR or a bad coil will affect the voltage pattern and/or its position.

NOTE: An oscilloscope (single channel) and two 10:1 oscilloscope probes are required to perform these tests. The signals being monitored are 150 - 200 VDC, positive polarity. The oscilloscope tests are written for a single channel oscilloscope. The use of a dual channel oscilloscope is permitted.

1. Connect the oscilloscope trigger input to the positive (+) "A" coil terminal.
2. Connect the reading probe to the positive (+) coil terminal of each coil being checked and attach the oscilloscope probe ground to an engine ground.
3. Operate the test bench.
4. View the oscilloscope. Compare with the example patterns shown in Figure 5.00-7.

NOTE: The waveforms displayed on the oscilloscope should be similar in output (140 - 160 VDC) but may differ in the time base because of the timing disc speed or oscilloscope time base setting.

5. Turn off the test bench.
6. If the waveforms are not consistent with Figure 5.00-7, replace the IM's power board assembly (see "Ignition Module Repair" in this section).

Storage Capacitor Voltage Pattern Testing - Bench Test

The storage capacitor voltage pattern test checks the voltage pattern on the storage capacitor which is affected by the SCRs.

NOTE: An oscilloscope (single channel) and two 10:1 oscilloscope probes are required to perform these tests. The signals being monitored are 150 - 200 VDC, positive polarity. The oscilloscope tests are written for a single channel oscilloscope. The use of a dual channel oscilloscope is permitted.

NOTE: Refer to Figure 5.00-8 for the scope pattern pertaining to the particular IM model being tested.

1. Connect the trigger input of the oscilloscope to the positive (+) "A" primary coil lead.
2. Connect the oscilloscope reading probe to the "G" lead of the Primary Coil Harness and attach the oscilloscope probe ground to an engine ground.

NOTE: The "G" lead pattern displays all firings of the unit.

NOTE: With the "G" lead connected DIRECTLY to the scope, the scope or meter should read 140 - 160 VDC.

NOTE: The VGF series of engines does not include the "G" lead in the Primary Coil Harness. Special pigtail adaptors are available from Waukesha Engine for use with oscilloscope testing.

NOTE: The patterns displayed on the oscilloscope should be similar in output (140 - 160 VDC) but may differ in the time base because of the timing disc speed or oscilloscope time base setting.

3. Operate the test bench. Observe the oscilloscope patterns. The patterns displayed should correspond with those in Figure 5.00-8.
4. Turn off the test bench.
5. If the patterns are not consistent with Figure 5.00-8, replace the IM's power board assembly (see "Ignition Module Repair" in this section).

HALL-EFFECT PICKUP TESTING

NOTE: Use the CEC Ignition Tester (P/N 475032) to test the Hall-effect pickup. If the tool is unavailable, use an ohmmeter and a source of 8 - 12 VDC. The DC source may be a small battery or a commercial power supply.

Hall-effect Pickup Testing On Engine With CEC Ignition Tester

The CEC Ignition Tester (P/N 475032) is designed to quickly troubleshoot the various components of the IM system (see Figure 5.00-10).

The Ignition Tester instructions that follow check the timing disc/gear magnets, Hall-effect pickup, and the wiring up to the IM.

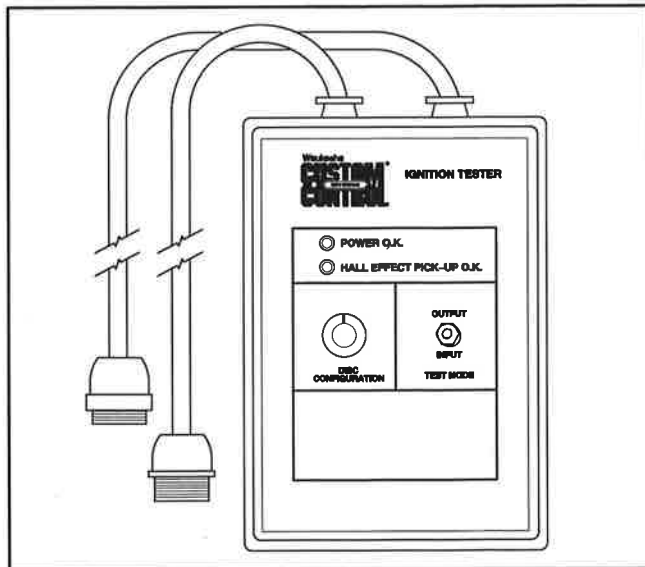


Figure 5.00-10. CEC Ignition Tester

⚠ WARNING

Verify that the engine is purged of all fuel gas prior to using the test unit. Failure to do so may cause the engine to rotate or start which could cause severe personal injury or engine damage.

⚠ WARNING

Do not install, set up, maintain, or operate any electrical components unless you are a technically qualified individual who is familiar with the electrical elements involved. Electrical shock can cause severe personal injury or death.

⚠ CAUTION Disconnect power supply to Ignition Module before completing test with CEC Ignition Tester. Electrical test equipment may be damaged if the tests are not performed properly.

1. Disconnect power from IM.
 2. Place the "OUTPUT/INPUT" switch on the Ignition Tester to the "INPUT" position.
 3. Disconnect the 7 pin Power Pickup Harness from the IM.
 4. Plug the female cable from the Ignition Tester into the IM 7 pin connector.
 5. Plug the male cable from the Ignition Tester into the free end of the 7 pin Power Pickup Harness.
 6. Apply 10 - 32 VDC power to the IM. The green "POWER O.K." LED on the Ignition Tester will light indicating power is applied to the IM. The LED does not indicate that the power supply is within specification, but that power is applied.
 7. Rotate the engine so that one of the timing magnets is opposite the Hall-effect pickup. The "HALL EFFECT PICK-UP O.K." LED should light indicating proper operation of the Hall-effect pickup. If the LED does not light, this indicates that a problem exists with the Hall-effect pickup, the Power Pickup Harness, or the pickup air gap is exceeding gap tolerance.
- NOTE:** The CEC Ignition Tester can also be used to complete a test of the IM. Refer to "Testing The IM With The CEC Ignition Tester" earlier in this section to perform the test.
8. After testing is complete, disconnect the Ignition Tester and reconnect the Power Pickup Harness to the IM.

IGNITION MODULE DIAGNOSTICS AND TROUBLESHOOTING

Hall-effect Pickup Testing Off Engine With Ohmmeter

NOTE: Use Simpson Model 260 or equivalent analog volt-ohmmeter to perform this test.

1. Connect the ohmmeter to the pins "A" and ground "C" (see Figure 5.00-11). Set the ohmmeter scale to R x 10,000.

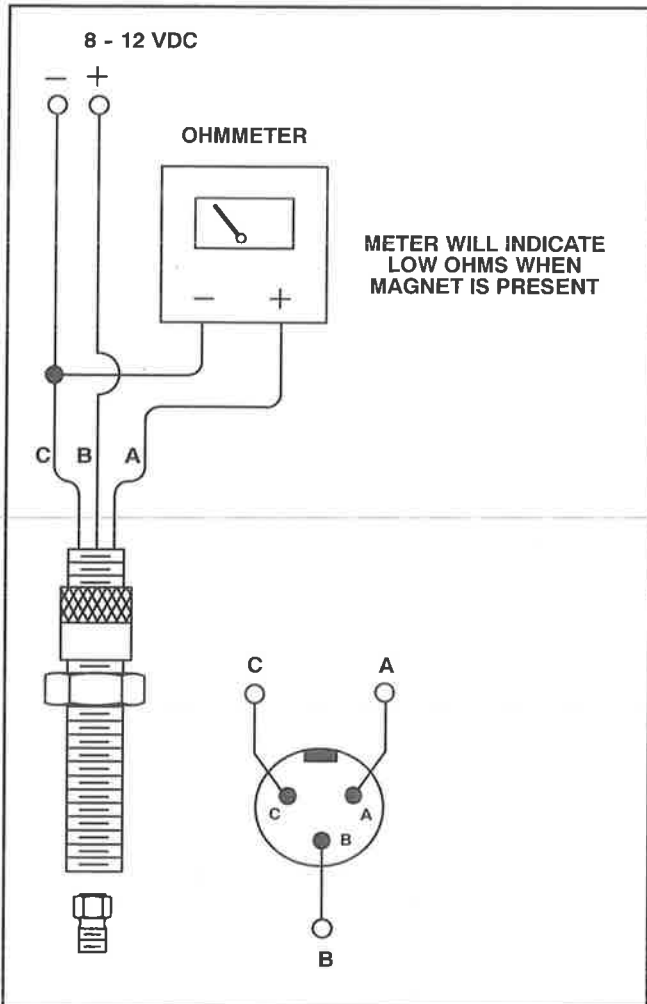


Figure 5.00-11. Hall-effect Pickup Test With Ohmmeter

2. Connect the positive lead of an 8 - 12 volt power supply to the "B" pin and the negative lead to the "C" pin.
3. Observe the ohmmeter while moving a magnet (P/N 305509) or timing disc with magnets directly in front of the Hall-effect pickup. The ohmmeter should read low ohms with the magnet in place.
4. If the meter reads infinite ohms (no deflection) with the magnet in place, replace the Hall-effect pickup.

Hall-effect Pickup Testing On Engine With Ohmmeter

WARNING

Turn the fuel and ignition OFF when performing this test with the Hall-effect pickup on the engine. Failure to shut the fuel and ignition off may result in an exhaust explosion causing severe engine damage and/or personal injury or death.

1. Reset Hall-effect pickup gap prior to test by completing the following steps:
 - A. Thread the Hall-effect pickup into the pickup mounting hole until the pickup comes in contact with the timing disc/gear.
 - B. Scribe a reference mark on the Hall-effect pickup and at the same point mark the housing or pickup bracket.
 - C. Using the reference mark on the pickup as the starting point, turn out the Hall-effect pickup counterclockwise to the amount listed in Table 5.00-14 to set the pickup to timing disc clearance.
 - D. After the clearance is set, snug the locking nut.

Table 5.00-14. Hall-effect Pickup Air Gap

ENGINE MODEL	HALL-EFFECT PICKUP GAP
VGF 6 And 8 Cylinder	3/4 Turn Out (± 1/16 of a turn)
VGF 12 And 16 Cylinder	3/4 Turn Out (± 1/16 of a turn)
VHP 6, 12, and 16 Cylinder	3/4 Turn Out (± 1/16 of a turn)
AT25 12 Cylinder	3/4 Turn Out (± 1/16 of a turn)
AT27 8 Cylinder (Cam Gear and Flywheel Pickup)	1 Full Turn Out (+0, -1/16 of a turn)
AT27 12 Cylinder (Cam Gear and Flywheel Pickup)	1 Full Turn Out (+0, -1/16 of a turn)

NOTE: Use Simpson Model 260 or equivalent analog volt-ohmmeter to perform this test.

2. Connect an ohmmeter to the pins "A" and ground "C" (see Figure 5.00-11). Set the ohmmeter scale to R x 10,000.
3. Connect the positive lead of an 8 - 12 volt power supply to pin "B" and the negative lead to pin "C."

4. Observe the ohmmeter while cranking the engine over with the starter (NO fuel or ignition). The ohmmeter should read low ohms every time a magnet passes by the pickup.

5. If the meter reads infinite ohms (no deflection) with a magnet in place, replace the Hall-effect pickup.

IGNITION COILS TESTING

The following test is to check the resistance of the primary and secondary wiring in the ignition coils. Replace any coils not measured to be within the stated ranges.

NOTE: The use of an ohmmeter is required for the following test.

⚠ WARNING

Disconnect the power supply to the Ignition Module when servicing the ignition system. Failure to disconnect the power supply can result in electrical shock causing personal injury or death.

1. Disconnect the power supply to the IM.
2. Disconnect the primary electrical wiring from the coil(s) to be tested.
3. Disconnect the secondary wiring (spark plug wire) from the coil(s) to be tested.
4. Connect the ohmmeter probes to the locations listed in Table 5.00-15.

Table 5.00-15. Coil Resistance

COIL P/N	PRIMARY	SECONDARY
60615F	0.2 - 0.4 Ohms (Pin A To Pin B)	8000 - 9600 Ohms (Output To Case)
69694	0.1 - 0.2 Ohms (Pin + To Pin -)	5500 - 6900 Ohms (Negative To H.V. Cup)
69694E	0.3 - 0.5 Ohms (Pin A To Pin B)	7500 - 10,200 Ohms (Flange To H.V. Cup)
69694F	0.3 - 0.5 Ohms (Pin A To Pin B)	7500 - 10,200 Ohms (Flange To H.V. Cup)
69694G	0.3 - 0.5 Ohms (Pin A To Pin B)	7200 - 10,200 Ohms (Flange To H.V. Cup)

5. Record the ohmmeter reading and compare results with those in Table 5.00-15.

NOTE: Secondary resistance will vary somewhat with temperature.

6. If the readings are acceptable, connect the primary and secondary wiring to the coil. Replace the ignition coil if the readings are not within specification and connect the primary and secondary wiring to the coil.

7. Repeat this procedure for all ignition coils tested.

8. Connect power supply to the IM.

IGNITION MODULE REPAIR

NOTE: To retain Canadian Standards Association (CSA) approval for a Custom Engine Control[®] IM, the module **MUST** be returned to the manufacturer for any modifications required to the circuit board (disassembly, board replacement). A circuit board modified by anyone other than the manufacturer will no longer be CSA approved. **This is a CSA requirement!**

This section contains replacement procedures for the circuit board assemblies located inside the IM. The two circuit boards located inside the IM are the power board assembly and logic board assembly (see Figure 5.00-12). Once a failed board is diagnosed, this section is to be used to remove and replace the defective board(s) and gaskets.

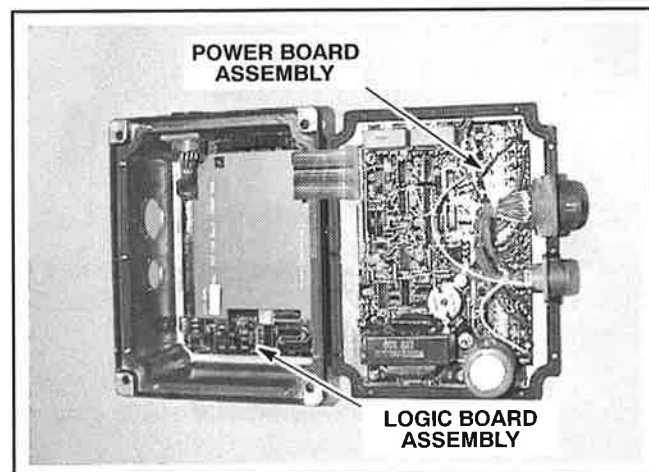


Figure 5.00-12. View Of Circuit Board Assemblies Inside Ignition Module

IGNITION MODULE DIAGNOSTICS AND TROUBLESHOOTING

The IM must be subjected to the five bench tests (Performance, Firing Pattern, Ignition Timing, Oscilloscope, and Storage Capacitor Voltage Pattern) at elevated, 150° F (65° C) temperature as described previously in this section after repair, to verify that the ignition meets the original specifications. After the troubleshooting section has been used to determine the problem component(s), this section will be used to remove and replace the internal boards. Use the Figure 5.00-3 and Table 5.00-5 to identify the proper part(s) and part number(s).

NOTE: Replacement of electrical components located on the circuit boards is not permitted. Each circuit board is to be replaced as an assembly.

Use a IM Gasket/Hardware Kit (P/N A740815) when doing any repair work on a IM. The kit contains all gaskets and insulated pads needed for the IM's re-assembly. See Table 5.00-5 for a list of components found in this kit.

CAUTION Use a static mat and an electrical wrist strap when repairing a Ignition Module. Static charges can permanently damage the Ignition Module's internal circuit boards.

Required Equipment

- Static Mat
- Wrist Strap
- 3/16" Regular Screwdriver
- #2 Phillips Screwdriver
- 1/2" Wrench
- 1/4" Nutdriver

IGNITION MODULE DISASSEMBLY

NOTE: All IMs MUST be retested as described in "Ignition Module Testing" whenever repairs (including assembly and disassembly) take place.

Place the IM on a static mat. The technician must use a wrist strap to reduce the possibility of static charges being applied to the circuit boards.

Separating Power Board And Logic Board Assemblies

1. Before disassembling IM, check and note the setting of the timing switches "A" and "B" on the side of the IM. If the timing switch position(s) change during disassembly/reassembly, you will know what position they were set to prior to disassembly.
2. Remove the eight 6-32 x 3/8" screws securing the 7 pin and 10 or 19 pin circular connectors to the IM housing (see Figure 5.00-13).

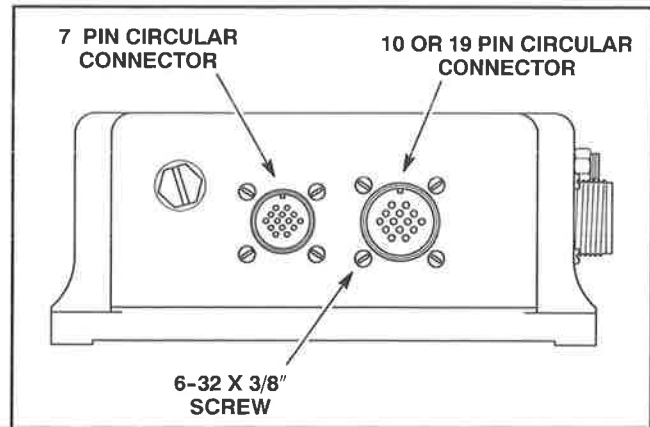


Figure 5.00-13. Ignition Module - Side View

3. Rotate the IM so the backplate is facing upward and place IM onto the static mat.
4. Remove the ten 8-32 x 1/2" seal screws that secure the backplate to the IM housing (see Figure 5.00-14).

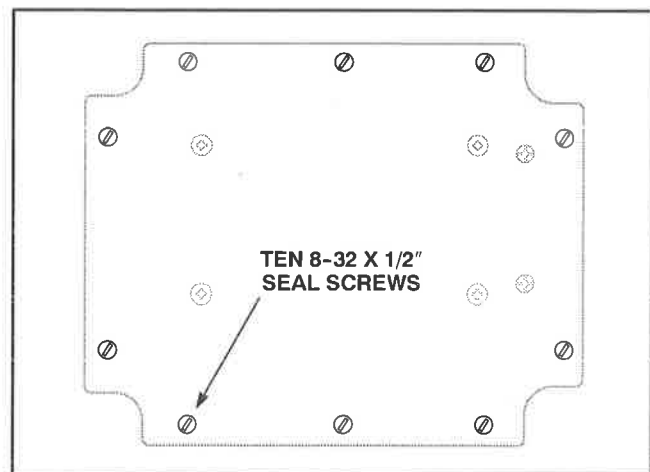


Figure 5.00-14. Backplate Of Ignition Module

5. Carefully push the two circular connectors (the 7 pin connector and the 10 or 19 pin connector) into the IM housing.

6. **Being careful not to damage any wires**, remove the backplate with the power board assembly still attached. The power board assembly and logic board assembly are connected with a ribbon cable.

7. Disconnect the ribbon cable from the power board assembly.

8. Remove the gasket from IM housing and/or backplate and clean both mounting surfaces.

Disassembling Power Board Assembly

1. Remove the gaskets from the two circular connectors (the 7 pin connector and the 10 or 19 pin connector).

2. Remove the two screws holding Q1A and Q1B in place from the backside of the backplate (see Figure 5.00-15 and Figure 5.00-16).

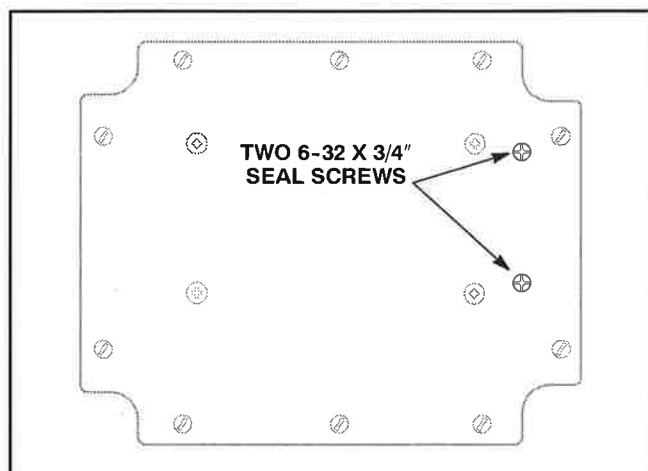


Figure 5.00-15. Backplate Of Ignition Module

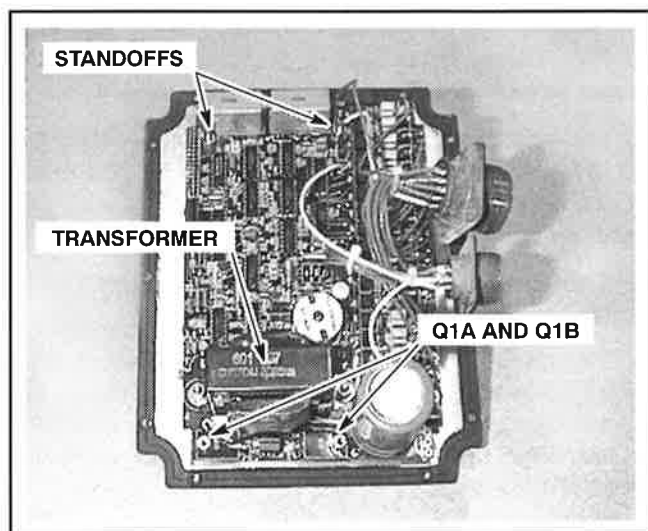


Figure 5.00-16. Power Board Assembly Inside Ignition Module

3. Using a nutdriver, remove the two standoffs on the topside of power board assembly opposite of transformer (see Figure 5.00-16).

4. Remove the two standoffs, flat washers, and lock washers securing transformer to power board assembly.

5. Carefully lift the power board assembly off of the backplate while holding transformer (transformer is **NOT** mounted to board).

6. Leave remaining four screws and standoffs on backplate (see Figure 5.00-17).

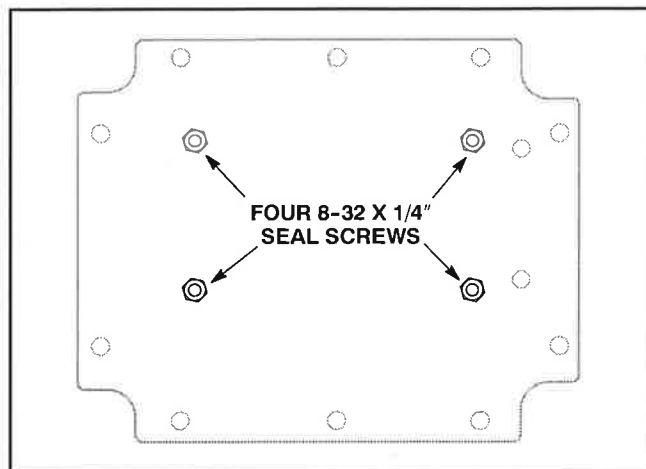


Figure 5.00-17. Remaining Installed Screws And Standoffs On Backplate

Disassembling Logic Board Assembly

1. Remove the white caps from the timing switches "A" and "B" on side of the IM.

2. Using a wrench, remove the two securing nuts attaching the timing switches to the IM housing.

3. Remove the four screws holding the ground plane to logic board assembly and lift out ground plane (see Figure 5.00-18).

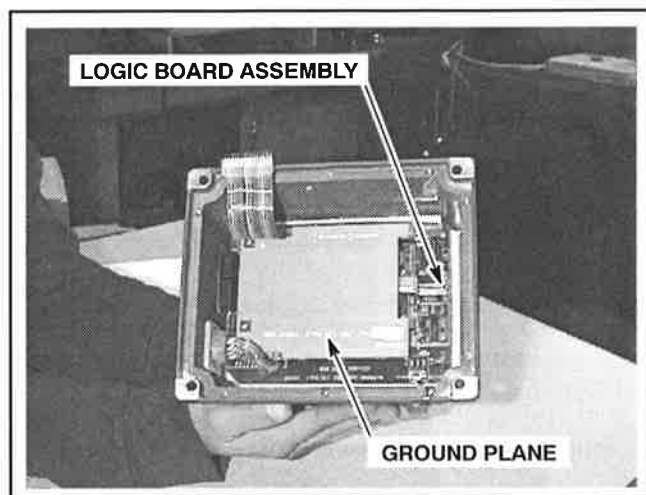


Figure 5.00-18. Logic Board Assembly

IGNITION MODULE DIAGNOSTICS AND TROUBLESHOOTING

4. Remove the four 6-32 x 3/8" screws securing the 14 pin circular connector to the IM housing (see Figure 5.00-19).

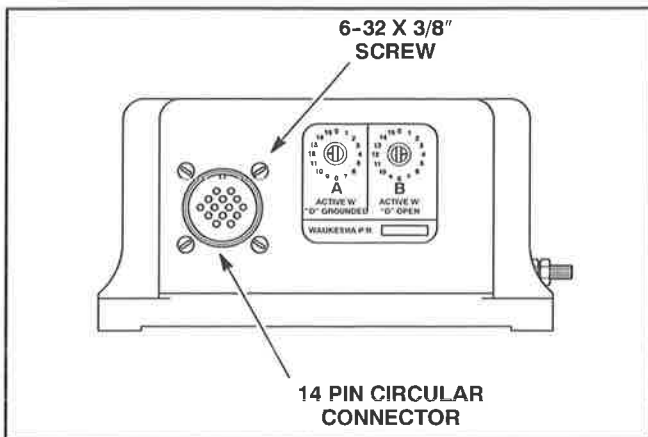


Figure 5.00-19. Ignition Module - Side View

5. Carefully push the 14 pin circular connector into IM housing.
6. Using a nut driver, remove the four standoffs holding the logic board assembly in place.
7. Lift up on the end of the logic board assembly opposite of the timing switches. Carefully remove the logic board assembly by sliding the circuit board up and away from the timing switch holes.
8. Remove the gasket from the timing switch knobs and the gasket from the 14 pin circular connector.

IGNITION MODULE ASSEMBLY

Assembling Logic Board Assembly

1. Install new gasket onto the timing switches.
2. Install new gasket onto the 14 pin circular connector on the logic board assembly.
3. Carefully position the logic board assembly above the open end of the IM housing with the components facing up.
4. Slide the timing switch end of the logic board assembly into the IM housing.
5. Continue to slide the circuit board assembly into the IM housing. Make sure that the timing switches are placed into the appropriate holes in the housing.
6. Verify that the logic board assembly is sitting flat in the IM housing.
7. Place the 14 pin circular connector in hole in IM housing and fasten connector with screws.

8. Install the two securing nuts onto the timing switches securing the timing switches to the housing. Tighten nuts alternately and carefully so standoff holes align with the holes on the logic board assembly.

9. If necessary, adjust timing switches "A" and "B" so that the switches are in the correct/same position they were before disassembly and reassembly of the IM.

10. Install white caps onto timing switches "A" and "B" on IM.

11. Install the four standoffs mounting logic board assembly to housing and tighten with nutdriver (do not over tighten).

12. Using four screws, mount the ground plane to the standoffs on the logic board assembly.

Assembling Power Board Assembly

1. Place power board assembly on backplate with transformer on screws (with mounting screws and standoffs still in position on backplate).
2. Place a flat washer then lock washer on each screw holding transformer.
3. Place a standoff on each of the four screws holding the power board assembly on backplate and tighten standoffs with nutdriver.
4. Install two screws (6-32 x 3/4") through bottom of backplate, mounting Q1A and Q1B.
5. Install new gaskets on the 7 pin circular connector and the 10 or 19 pin circular connector.
6. Install new gasket on IM housing.

Completing IM Assembly

1. Plug ribbon cable from logic board assembly into power board assembly (note pin orientation).
2. Place circular connectors (7 pin connector and 10 or 19 pin connector) in holes in IM housing and mount connectors with appropriate screws (make sure gaskets are in place) (see Figure 5.00-20).
3. Screw backplate to housing using appropriate screws.
4. **The IM must be subjected to the five bench tests (Performance, Firing Pattern, Ignition Timing, Oscilloscope, and Storage Capacitor Voltage Pattern) at elevated, 150° F (65° C) temperature to verify that the ignition meets the original specifications.**

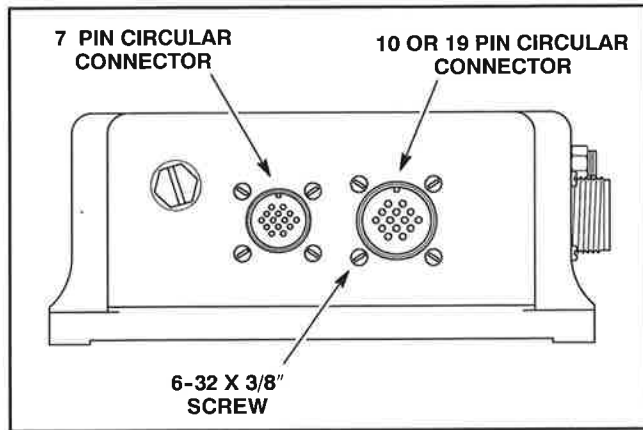


Figure 5.00-20. Ignition Module - Side View

TOOL DEFINITIONS

Analog Volt Ohmmeter (VOM): An industry standard analog meter such as the Simpson 260 VOM (or equal) used to measure AC voltage, DC voltage, Amperes and Ohms in electrical circuits. Some voltmeters use reverse polarity, which will give incorrect results.

Crimping Tools, Wire Cutters, And Wire Strippers: Tools which are useful in making electrical connections. Electrical connections that are soldered after being crimped with ratchet style crimpers offer the best connections possible. Soldering protects the exposed copper of a copper wire from corroding due to H₂S or oxidation. Ratchet crimpers provide uniform crimps with proper compression regardless of the technician.

Digital Volt Ohmmeter (VOM) (Optional): A tool that measures voltages and resistances more accurately than analog VOM meters, but may have problems displaying these readings in high electrical noise environments such as around CD ignition systems. Features that are an advantage over analog meters are: peak hold, peak minimum and maximum storage.

Megger: A useful tool to help find voltage leakage between wires or ground when an ohmmeter does not detect a short. Meggers use a 500 volt signal to test for short circuits that may only occur under conditions of high voltage. This voltage is similar to the Capacitor Discharge (CD) ignition voltage and will help to detect moisture problems in conduits, connectors, and ignition primary harnesses.

Oscilloscope: An instrument in which the variations in voltage appear and can be measured by reading a visible wave form. A single or dual channel with external trigger capabilities and two 10:1 probes are required (100:1 probes are also acceptable). A 10 MHz oscilloscope is fast enough for field requirements (digital scope is not required).

Timing Light: A tool which is used to measure an engine's ignition timing. An inductive type timing light functions by clamping the inductive pickup over the spark plug wire and pointing the light emitting end of the timing light onto a timing strip usually located on the engine's flywheel. It can also be used to determine if energy stored in the storage capacitor is being delivered to the primary of the coil. Battery power types (two "D" cells) are the most convenient.

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**WAUKESHA ENGINE DIVISION, DRESSER EQUIPMENT GROUP, INC.
EXPRESS LIMITED WARRANTY FOR CUSTOM ENGINE CONTROLS®**

INTRODUCTION

The Custom Engine Control® (CEC) are sold as standard, or as options on new Engines or as Genuine Service Parts, and includes the Detonation Sensing Module (DSM), Air Fuel Module (AFM), Turbocharger Control Module (TCM), and Ignition Module (IM), or any other control device identified as a CEC product.

I. TERMS OF EXPRESS LIMITED WARRANTY

Waukesha Engine Division warrants that it will repair or replace, AT ITS ELECTION AND EXPENSE, any CEC installed on an engine, or Enginator®, or product (hereinafter referred to as "Products") manufactured by Waukesha, or purchased as a Genuine Service Part, which proves to have had a defect in material or workmanship.

II. TERM LIMITATIONS OF EXPRESS LIMITED WARRANTY

- A. This coverage shall commence upon initial new Products start-up date or the purchase date, in the case of service parts sales, and shall expire upon the earlier of the following:
1. New Products
 - A. 12 months after the initial new Product start-up date; or
 - B. 24 months after the original shipment date of the covered Products by Waukesha Engine Division.
 2. Genuine Service Parts
 - A. 12 months from the date the CEC is put into service; or
 - B. 18 months from the purchase date.
- B. Notwithstanding the foregoing, Waukesha further warrants that it will repair or replace, AT ITS ELECTION AND EXPENSE, any component of the Waukesha Product damaged as the direct result of a warrantable defect in a CEC product.

III. WAUKESHA'S RESPONSIBILITIES UNDER THE EXPRESS LIMITED WARRANTY

Waukesha shall be responsible for:

- A. The repair or replacement, at Waukesha's election, of covered defective parts and all reasonable labor required regarding a warranted failure during the express limited warranty term. All such labor shall be provided by Waukesha's authorized contractor or distributor.
- B. For the repair of CECs installed on Products shipped from Waukesha, reasonable and necessary travel and expenses incurred by Waukesha's authorized contractor or distributor.
- C. Replacement of lubricating oil, coolant, filter elements, Waukesha supplied engine components, or other normal maintenance items that are contaminated and/or damaged as a direct result of a warranted failure.

IV. OWNER'S RESPONSIBILITIES UNDER THE EXPRESS LIMITED WARRANTY

Owner shall be responsible for:

- A. The operation and maintenance of the Products within the guidelines established by Waukesha.
- B. Making the Products available to Waukesha or Waukesha's authorized contractors or distributors for any warranty repair, during normal business hours.
- C. All additional costs incurred for premium or overtime labor, should owner request that repairs be made on a premium or overtime schedule.
- D. All costs incurred as the result of removal or reinstallation of the Products as may be required to effect any warranted repair.
- E. All administrative costs and expenses resulting from a warranted failure.
- F. Any costs of transportation, towing, repair facilities, or associated costs.
- G. All travel, mileage, and other related Distributor costs and expenses associated with repair under the terms of the Service Parts Warranty.
- H. All additional labor time in excess of Waukesha's Labor Guide for the warrantable repair.
- I. Loss of revenue and loss of/or damage to real and/or personal property.

V. LIMITATION OF WAUKESHA'S OBLIGATIONS

The obligations of Waukesha under this express limited warranty shall be waived and voided, and Waukesha shall not, thereafter, be responsible for:

- A. Any failure resulting from owner or operator abuse or neglect, including but not by way of limitation, any operation, installation, application, or maintenance practice not in accordance with guidelines or specifications established by Waukesha; or
- B. Any failure resulting from unauthorized modifications or repairs of the Products; or
- C. Any failure resulting from overload, overspeed, overheat, accident, improper storage; or
- D. Failure of owner to promptly provide notice of a claimed defect; or
- E. Failure of Products for which Waukesha did not receive properly completed start-up reports; or
- F. Repairs of a covered failure performed with non-genuine Waukesha parts; or
- G. Repairs of a covered failure performed by non-authorized contractors or distributors; or
- H. Failure to make Products available to Waukesha or its authorized representatives; or
- I. Failure to supply documents such as drawings and specifications relating to the specific application of the Products; or
- J. Improper diagnosis of a Product problem for which a CEC product is replaced.
- K. Failure of Service Parts for which Waukesha did not receive proper documentation concerning the Service Parts purchase date from an authorized Waukesha Engine Distributor; or
- L. Any failure of a Service Part resulting from misapplication or improper repair procedures; or
- M. Any failure or damage resulting from the improper or extended storage of a Service Part; or
- N. Freight, Customs, Broker Fees, and Import Duties if appropriate documentation is not provided.

VI. APPLICABILITY AND EXPIRATION

The warranties set out above are extended to all owners in the original chain of distribution. The warranties and obligations of Waukesha shall expire and be of no further effect upon the dates of expiration of the applicable warranty periods.

VII. WARRANTY ADMINISTRATION

This warranty is administered exclusively by an authorized Waukesha Distributor. The invoice for the failed Service Parts must be provided to the Distributor to determine whether the warranty is applicable.

Contact the nearest authorized Waukesha Distributor for assistance with warranty matters or questions. The location of the nearest authorized Distributor is available by contacting Waukesha Engine Division at (414) 547-3311.

THE FOREGOING SETS FORTH WAUKESHA'S ONLY OBLIGATIONS AND OWNERS' EXCLUSIVE REMEDY FOR BREACH OF WARRANTY, WHETHER SUCH CLAIMS ARE BASED ON BREACH OF CONTRACT, TORT (INCLUDING NEGLIGENCE AND STRICT LIABILITY), OR OTHER THEORIES, AND THE FOREGOING IS EXPRESSLY IN LIEU OF OTHER WARRANTIES WHATSOEVER EXPRESSED, IMPLIED, AND STATUTORY, INCLUDING WITHOUT LIMITATION, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS.

Notwithstanding the preceding, in no event shall Waukesha be liable for any direct, special, incidental, or consequential damages (whether denominated in contract, tort strict liability, negligence, or other theories) arising out of this Agreement or the use of any Products provided under this Agreement.

Any action arising hereunder or relating hereto, whether based on breach of contract, tort (including negligence and strict liability), or other theories must be commenced within two (2) years after the cause of action accrues or it shall be barred.

BINDING ARBITRATION

- (a) Buyer and Seller shall attempt, in good faith, to resolve any dispute arising out of or relating to this agreement, or the products and/or services provided hereunder, promptly by negotiation between executives. If the matter has not been resolved within sixty (60) days of a party's request for negotiation, either party may initiate arbitration as herein after provided.
- (b) Any dispute arising out of or related to this agreement or the products and/or services provided hereunder which has not been resolved by the negotiation procedure described above, shall be settled by binding arbitration administered by the American Arbitration Association in accordance with its Commercial Arbitration Rules and judgment on the award rendered by the arbitrator(s) may be entered in any court having jurisdiction thereof.
- (c) Unless Buyer and Seller otherwise agree in writing, the arbitration panel shall consist of three arbitrators. The arbitrator(s) shall have no authority to award punitive or other damages not measured by the prevailing party's actual damages and may not, in any event, make any ruling, finding or award that does not conform to the terms and condition of this agreement. The law of Texas shall govern.
- (d) The arbitration proceeding shall be conducted in English, in Dallas, Texas.

See Form M-462 for the most current warranty terms. Effective April 1, 1999

Waukesha Engine Division

We welcome your comments

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G - Gas Compression
 P - Power Generation
 M - Mechanical Drive
 C - Continuous
 I - Intermittent
 S - Standby

G P M C
 G P M C
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KD-200

VHP 6, 12, AND 16 CYLINDER OPERATION & MAINTENANCE

First Edition

DRESSER Waukesha

Form 6277

SERIAL NO.


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VHP 6, 12, AND 16 CYLINDER OPERATION AND MAINTENANCE



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TABLES

Your purchase of a Waukesha VHP Series engine was a wise investment. In the industrial engine field the name, Waukesha Engine, stands for quality and durability. With normal care and maintenance this engine will provide many years of reliable service.

Before placing the engine in service read Chapters 1 and 2 very carefully. These chapters cover Safety, General Information and Engine Operation.

Section 1.00 - *Warning Tags And Decal Location* - gives the location of all warning tags and decals and will show you a duplicate of each tag is illustrated in case the decals or tags have been lost or damaged.

Section 1.05 - *Safety Section* - Provides a list of warnings and cautions to make you aware of the dangers present during operation and maintenance of the engine. - **READ THEM CAREFULLY AND FOLLOW THEM COMPLETELY** -

Section 1.10 - *Rigging and Lifting Engines* - Provides information on engine weights and proper lifting procedures.

Section 1.15 - *General Information* - Provides basic data on the engines such as; engine plate data, specifications and description.

Section 1.20 - *Engine Systems* - Provides basic information on each engine system.

Section 2.00 - *Engine Startup and Shutdown* - provides prestart inspection, troubleshooting, routine startup and shutdown.

This manual contains both operation and maintenance instructions for the VHP engines. There are four chapters within the manual and each chapter contains one or more sections. The title of each chapter or section appears at the top of each page. To locate information on a specific topic, refer to the Table of Contents at the front of the manual or the Index at the back of the manual.

ALWAYS BE ALERT FOR THE SPECIAL WARNINGS WITHIN THE MANUAL TEXT. THESE WARNINGS PRECEDE INFORMATION THAT IS CRUCIAL TO YOUR SAFETY AS WELL AS OTHER PERSONNEL WORKING ON OR NEAR THE ENGINE. CAUTIONS OR NOTES IN THE MANUAL CONTAIN INFORMATION THAT RELATES TO POSSIBLE DAMAGE TO THE ENGINE OR ITS COMPONENTS DURING ENGINE OPERATION OR MAINTENANCE PROCEDURES.

Recommendations and data contained in the manual is the latest information available at the time of this printing and is subject to change without notice. Since engine accessories may vary due to customer specifications consult your local distributor or Waukesha Engine Division Service Operations Department for any information on subjects beyond the scope of this manual.

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SECTION 1.00 - WARNING TAGS AND DECAL LOCATIONS

SECTION 1.05 - SAFETY

SECTION 1.10 - RIGGING AND LIFTING ENGINES

SECTION 1.15 - GENERAL INFORMATION



SECTION 1.00

WARNING TAGS AND DECAL LOCATIONS

WARNING TAGS AND DECAL LOCATIONS

Warning tags and decals are placed so that they are visible and readable by the operator when the engine is running. This section provides detailed diagrams and location of the safety labels on VHP engines.



All warning tags and decals must be visible and readable to the operator when the engine is running. Make sure all warning tags and decals remain legible and attached. Likewise, all warning tags and decals removed during any repair work must be replaced in their original position before the engine is placed back into service. Old or badly worn decals and tags should also be replaced. Failure to properly replace these important tags and decals can result in severe personal injury or death.

***NOTE:** The labels shown in this manual are for current production engines. Your engine may have the previous labels, which do not have visuals. The previous labels, although they look different, will contain similar wordage and will be located very close to the position of the new labels.*

***NOTE:** Not all labels are installed on all engines. Application will depend on model of engine and optional equipment ordered. Example: air/gas starter instead of an electrical starter.*

Clean surfaces of engine of all dirt, oil, etc. before applying labels.

WARNING TAGS AND DECAL LOCATIONS

VHP 6 CYLINDER ENGINES

The warning labels on the VHP 6 cylinder engine have specific placement, and must be replaced if they are defaced or removed for any reason. Table 1.00-1 describes where each label is located. Figure 1.00-1 shows the exact location of each label.

Table 1.00-1. VHP 6 Cylinder Engine Safety Labels

P/N	LABEL TYPE	TAG/PLATE TYPE	SUBJECT	LOCATION:
211910A	Warning	-	Safety Guard	<ul style="list-style-type: none">• On the front of governor drive housing
211910J	Warning	-	Safety Guard	<ul style="list-style-type: none">• On the front gear housing
211910K	Warning	-	Safety Guard	<ul style="list-style-type: none">• On the flywheel housing (G) or the intercooler housing (GSI, GL)
211910N	Warning	-	Maximum Gas Inlet Pressure	<ul style="list-style-type: none">• On carburetor body, right side of engine
211911B	-	Warning	Built Without Engine Protection	<ul style="list-style-type: none">• Nytyed on governor control rod on right side of engine.
211911C	Warning	-	Barring Device	<ul style="list-style-type: none">• On side of crankcase, near barring device
211920D	Caution	-	Hot Components	<ul style="list-style-type: none">• Located next to turbocharger or exhaust outlet
211920F	Caution	-	Eye/Ear Protection	<ul style="list-style-type: none">• On control panel on right side of engine
211930A	Safety	-	Lifting Instructions	<ul style="list-style-type: none">• On front and rear lifting eyes

WARNING TAGS AND DECAL LOCATIONS

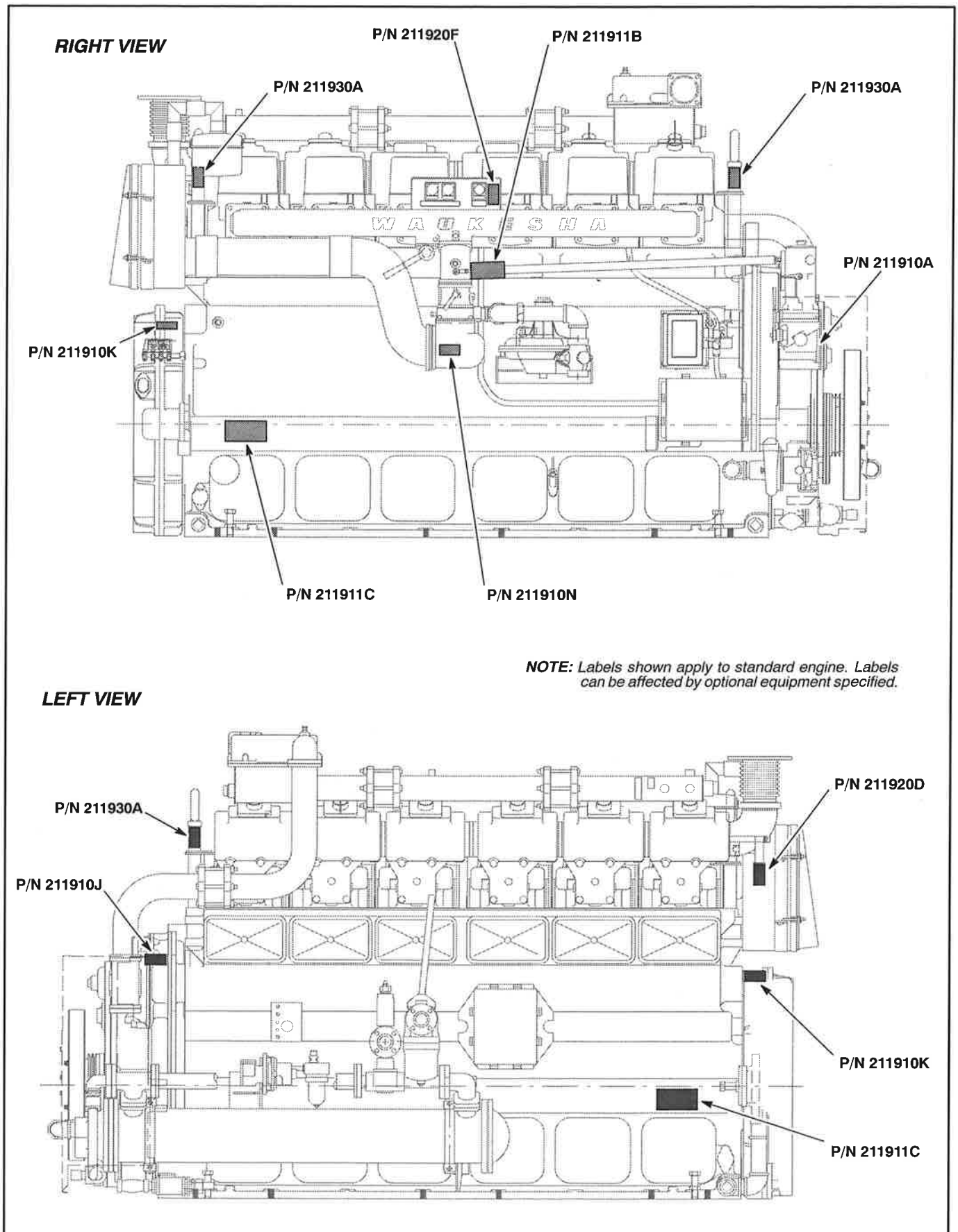


Figure 1.00-1. VHP 6 Cylinder Safety Label Locations

WARNING TAGS AND DECAL LOCATIONS

VHP 12 CYLINDER ENGINES

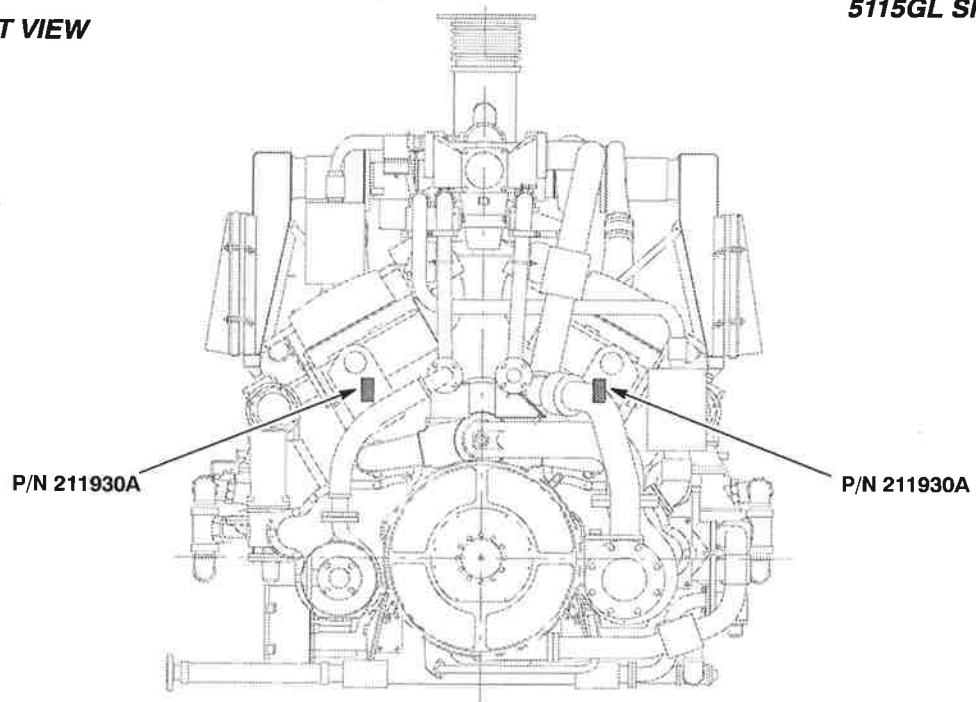
The warning labels on the VHP 12 cylinder engine have specific placement, and must be replaced if they are defaced or removed for any reason. Table 1.00-2 describes where each label is located. Figure 1.00-2 and Figure 1.00-3 show exact location of each label.

Table 1.00-2. VHP 12 Cylinder Engine Safety Labels

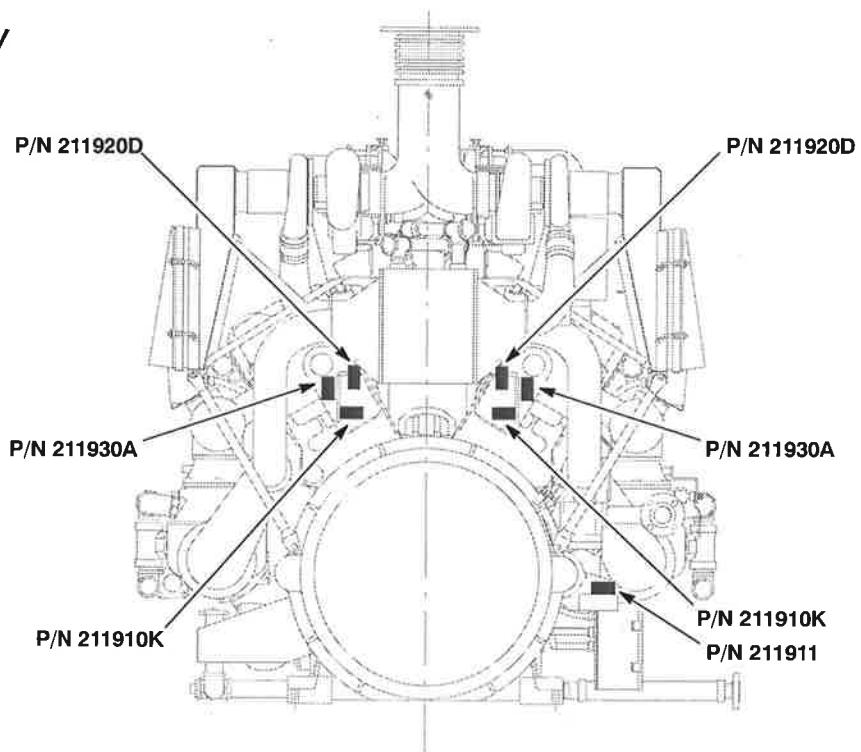
P/N	LABEL TYPE	TAG/PLATE TYPE	SUBJECT	LOCATION:
211910A	Warning	-	Safety Guard	<ul style="list-style-type: none"> On the governor drive (G engines only)
211910J	Warning	-	Safety Guard	<ul style="list-style-type: none"> On the front gear housing
211910K	Warning	-	Safety Guard	<ul style="list-style-type: none"> On the intercooler support brackets On the rear lifting eyes (G engines only)
211910N	Warning	-	Maximum Gas Inlet Pressure	<ul style="list-style-type: none"> On carburetor bodies, both sides of engine On air cleaner/carburetor housing both sides of engine (Draw - thru engines only)
211911B	-	Warning	Built Without Engine Protection	<ul style="list-style-type: none"> Nytyed on governor control rod on right side of engine.
211911C	Warning	-	Barring Device	<ul style="list-style-type: none"> On both sides of crankcase, near barring device
211911D	-	Warning	Built Without Ignition System	<ul style="list-style-type: none"> On the empty magneto drive housing
211920D	Caution	-	Hot Components	<ul style="list-style-type: none"> On the rear lifting eyes (G engines only) On both sides of the water manifold, directly behind the exhaust outlet (G engines only)
211920E	Caution	-	Hot Components	<ul style="list-style-type: none"> On heat shield near turbochargers or exhaust outlet
211920F	Caution	-	Eye/Ear Protection	<ul style="list-style-type: none"> On control panel on each side of engine
211930A	Safety	-	Lifting Instructions	<ul style="list-style-type: none"> On front and rear lifting eyes, both sides of engine
211910L	Warning	-	Safety Guard	<ul style="list-style-type: none"> On water pipe on front on engine On right and left water inlet tubes
211910S	Warning	-	Vent Flammable Gas	<ul style="list-style-type: none"> On right flywheel housing
211910W	Warning	-	Vent Flammable Gas	<ul style="list-style-type: none"> On prelube mounting bracket
211911	Warning	-	Gas Inlet Pressure	<ul style="list-style-type: none"> On right rear by the air/gas starter
211911E	Warning	-	Gas Inlet Pressure	<ul style="list-style-type: none"> On right flywheel housing

FRONT VIEW

5115GL SHOWN



REAR VIEW



NOTE: Labels shown apply to standard engine. Labels can be affected by optional equipment specified.

Figure 1.00-2. VHP 12 Cylinder Safety Label Locations

WARNING TAGS AND DECAL LOCATIONS

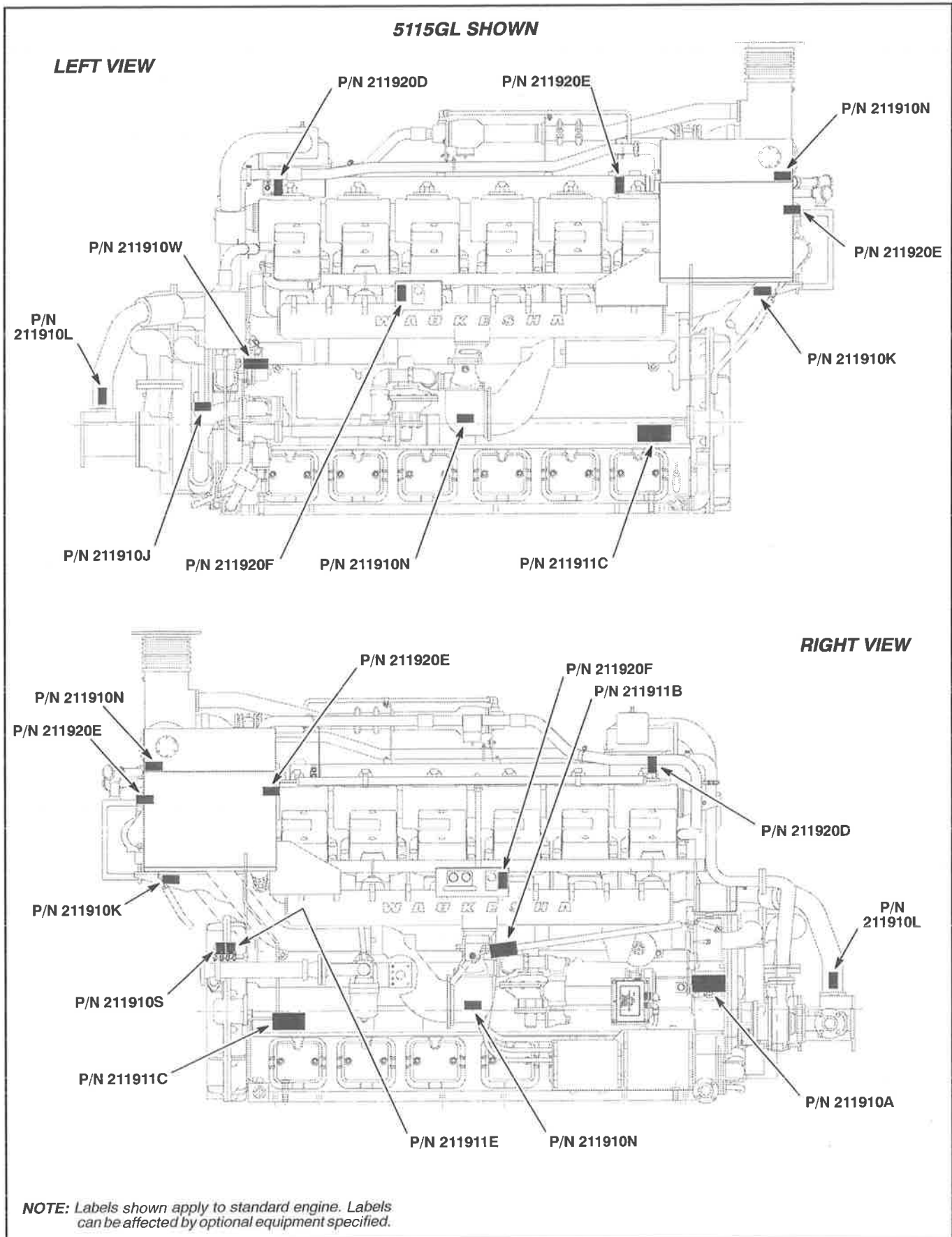


Figure 1.00-3. VHP 12 Cylinder Safety Label Locations

VHP 16 CYLINDER ENGINES

The warning labels on the VHP 16 cylinder engine have specific placement, and must be replaced if they are defaced or removed for any reason. Table 1.00-3 describes where each label is located. Figure 1.00-4 and Figure 1.00-5 show exact location of each label.

Table 1.00-3. VHP 16 Cylinder Engine Safety Labels

P/N	LABEL TYPE	TAG/PLATE TYPE	SUBJECT	LOCATION:
211910J	Warning	-	Safety Guard	• On the front gear housing
211910N	Warning	-	Maximum Gas Inlet Pressure	• On oil pan, below the regulators, both sides of engine
211911B	-	Warning	Built Without Engine Protection	• Nytyed on governor control rod on right side of engine.
211911C	Warning	-	Barring Device	• On side of crankcase, near barring device
211920E	Caution	-	Hot Components	• On sides of intercoolers, near turbochargers or exhaust outlet, both sides of engine
211920F	Caution	-	Eye/Ear Protection	• On engine control panel
211930A	Safety	-	Lifting Instructions	• On front and rear lifting eyes, both sides of engine
211910M	Warning	-	Safety Guard	• On back plate of engine, both sides of the flywheel

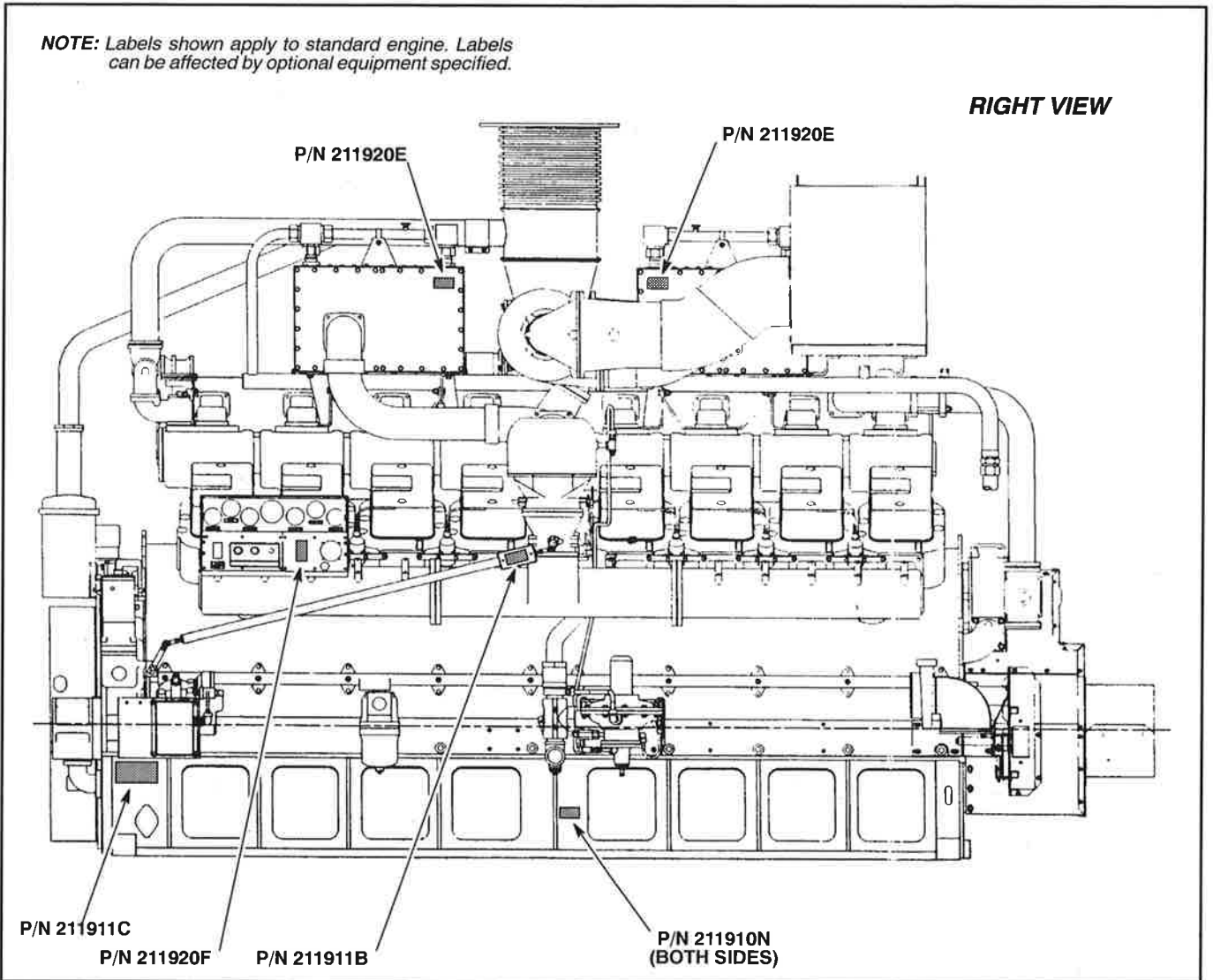


Figure 1.00-4. VHP 16 Cylinder Safety Label Locations

WARNING TAGS AND DECAL LOCATIONS

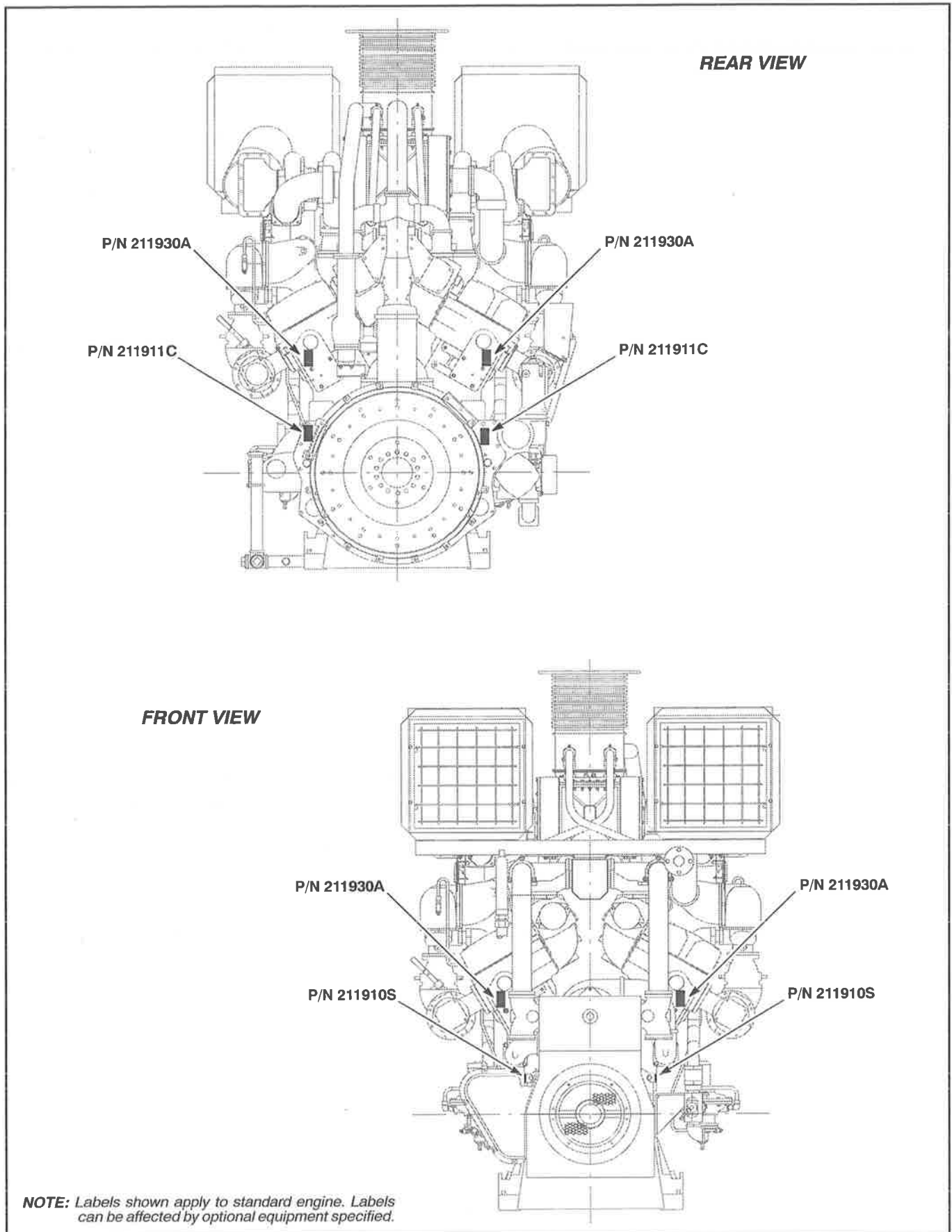


Figure 1.00-5. VHP 16 Cylinder Safety Label Locations



Figure 1.00-6. Warning Label - P/N 211910A - Safety Guard



Figure 1.00-7. Warning Label - P/N 211910J - Safety Guard



Figure 1.00-8. Warning Label - P/N 211910K - Safety Guard



Figure 1.00-9. Warning Label - P/N 211910L - Safety Guard

WARNING TAGS AND DECAL LOCATIONS



Figure 1.00-10. Warning Label - P/N 211910M - Safety Guard



Figure 1.00-12. Warning Label - P/N 211910S - Vent Flammable Gas



Figure 1.00-11. Warning Label - P/N 211910N - Maximum Gas Regulator Pressure



Figure 1.00-13. Warning Label - P/N 211911 - Maximum Air Prelude Motor Pressure



Figure 1.00-14. Warning Label - P/N 211910W - Gas Venting



Figure 1.00-15. Warning Label - P/N 211911B - Built Without Engine Protection



Figure 1.00-16. Warning Label - P/N 211911C - Barring Device

WARNING TAGS AND DECAL LOCATIONS



Figure 1.00-17. Warning Label - P/N 211911D - Built Without An Ignition System

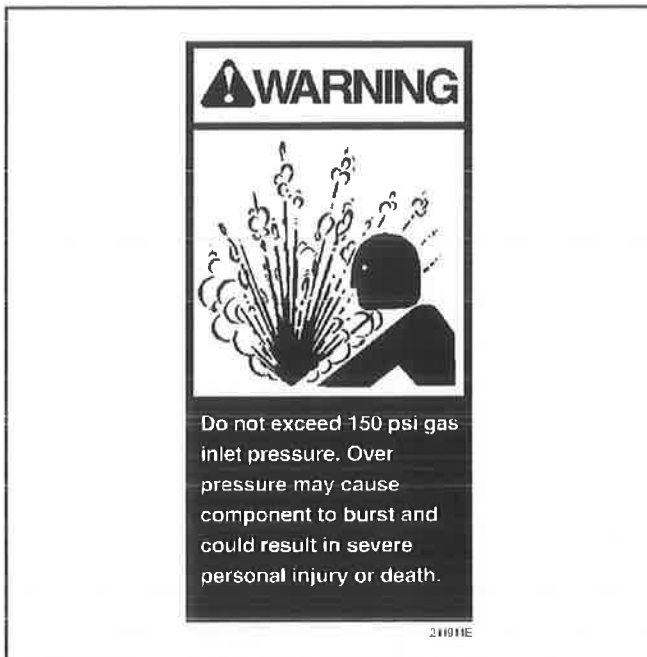


Figure 1.00-18. Warning Label - P/N 211911E - 150 psi Gas Inlet Pressure



Figure 1.00-19. Caution Label - P/N 211920D - Hot Surface



Figure 1.00-20. Caution Label - P/N 211920E - Hot Components



Figure 1.00-21. Caution Label - P/N 211920F - Eye/Ear Protection



Figure 1.00-22. Safety Instructions - P/N 211930A - Lifting Instructions

WARNING TAGS AND DECAL LOCATIONS

SECTION 1.05

SAFETY

SAFETY INTRODUCTION

The following safety precautions are published for your information. Waukesha Engine Division, Dresser Industries, Inc., does not, by the publication of these precautions, imply or in any way represent that they are the sum of all dangers present near industrial engines or fuel rating test units. If you are installing, operating or servicing a Waukesha product, it is your responsibility to ensure full compliance with all applicable safety codes and requirements. All requirements of the Federal Occupational Safety and Health Act must be met when Waukesha products are operated in areas that are under the jurisdiction of the United States of America. Waukesha products operated in other countries must be installed, operated and serviced in compliance with any and all applicable safety requirements of that country.

For details on safety rules and regulations in the United States, contact your local office of the Occupational Safety and Health Administration (OSHA).

The words "danger", "warning", "caution" and "note" are used throughout this manual to highlight important information. Be certain that the meanings of these alerts are known to all who work on or near the equipment.

NOTE: *This symbol identifies information which is NECESSARY TO THE PROPER OPERATION, MAINTENANCE OR REPAIR OF THE EQUIPMENT.*

 **CAUTION** This symbol identifies information about hazards or unsafe practices. Disregarding this information could result in PRODUCT DAMAGE AND/OR PERSONAL INJURY.

 **WARNING**
This symbol identifies information about hazards or unsafe practices. Disregarding this information could result in SEVERE PERSONAL INJURY OR DEATH.

 **DANGER**

This symbol identifies information about immediate hazards. Disregarding this information *will* result in SEVERE PERSONAL INJURY OR DEATH.

SAFETY TAGS AND DECALS

 **WARNING**

To avoid severe personal injury or death, all warning tags and decals must be visible and legible to the operator while the equipment is operating.

EQUIPMENT REPAIR AND SERVICE

Proper maintenance, service and repair are important to the safe, reliable operation of the unit and related equipment. Do not use any procedure not recommended in the Waukesha Engine manuals for this equipment.

 **WARNING**

To prevent severe personal injury or death, always stop the unit before cleaning, servicing or repairing the unit or any driven equipment.

Place all controls in the OFF position and disconnect or lock out starters to prevent accidental restarting. If possible, lock all controls in the OFF position and take the key. Put a sign on the control panel warning that the unit is being serviced.

Close all manual control valves, disconnect and lock out all energy sources to the unit, including all fuel, electric, hydraulic, and pneumatic connections.

Disconnect or lock out driven equipment to prevent the possibility of the driven equipment rotating the disabled engine.

SAFETY

WARNING

To avoid severe personal injury or death, ensure that all tools and other objects are removed from the unit and any driven equipment before restarting the unit.

WARNING

Allow the engine to cool to room temperature before cleaning, servicing or repairing the unit. Hot components or fluids can cause severe personal injury or death.

Some engine components and fluids are extremely hot even after the engine has been shut down. Allow sufficient time for all engine components and fluids to cool to room temperature before attempting any service procedure.

ACIDS

WARNING

Comply with the acid manufacturer's recommendations for proper use and handling of acids. Improper handling or misuse could result in severe personal injury or death.

BATTERIES

WARNING

Comply with the battery manufacturer's recommendations for procedures concerning proper battery use and maintenance. Improper maintenance or misuse could result in severe personal injury or death.

BODY PROTECTION

WARNING

Always wear OSHA approved body, sight, hearing and respiratory system protection. Never wear loose clothing, jewelry or long hair around an engine. The use of improper attire or failure to use protective equipment may result in severe personal injury or death.

CHEMICALS

GENERAL

WARNING

Always read and comply with safety labels on all containers. Do not remove or deface the container labels. Improper handling or misuse could result in severe personal injury or death.

CLEANING SOLVENTS

WARNING

Comply with the solvent manufacturer's recommendations for proper use and handling of solvents. Improper handling or misuse could result in severe personal injury or death. Do not use gasoline, paint thinners or other highly volatile fluids for cleaning.

LIQUID NITROGEN/DRY ICE

WARNING

Comply with the liquid nitrogen/dry ice manufacturer's recommendations for proper use and handling of liquid nitrogen/dry ice. Improper handling or use could result in severe personal injury or death.

COMPONENTS

HEATED OR FROZEN

WARNING

Always wear protective equipment when installing or removing heated or frozen components. Some components are heated or cooled to extreme temperatures for proper installation or removal. Direct contact with these parts could cause severe personal injury or death.

INTERFERENCE FIT

WARNING

Always wear protective equipment when installing or removing components with an interference fit. Installation or removal of interference components may cause flying debris. Failure to use protective equipment may result in severe personal injury or death.

COOLING SYSTEM** WARNING**

Always wear protective clothing when venting, flushing or blowing down the cooling system. Operational coolant temperatures can range from 180° - 250° F (82° - 121° C). Contact with hot coolant or coolant vapor can cause severe personal injury or death.

 WARNING

Do not service the cooling system while the engine is operating or when the coolant is hot. Operational coolant temperatures can range from 180° - 250° F (82° - 121° C). Contact with hot coolant or vapor can cause severe personal injury or death.

ELECTRICAL**GENERAL**** WARNING**

Do not install, set up, maintain or operate any electrical components unless you are a technically qualified individual who is familiar with the electrical elements involved. Electrical shock can cause severe personal injury or death.

 WARNING

Disconnect all electrical power supplies before making any connections or servicing any part of the electrical system. Electrical shock can cause severe personal injury or death.

IGNITION** WARNING**

Avoid contact with ignition units and wiring. Ignition system components can store electrical energy and if contacted can cause electrical shocks. Electrical shock can cause severe personal injury or death.

 WARNING

Properly discharge any electrical component that has the capability to store electrical energy before connecting or servicing that component. Electrical shock can cause severe personal injury or death.

EXHAUST** WARNING**

Do not inhale engine exhaust gases. Exhaust gases are highly toxic and could cause severe personal injury or death.

Ensure exhaust systems are leak free and that all exhaust gases are properly vented.

 WARNING

Do not touch or service any heated exhaust components. Allow sufficient time for exhaust components to cool to room temperature before attempting any service procedure. Contact with hot exhaust system components can cause severe personal injury or death.

FIRE PROTECTION** WARNING**

Refer to local and federal fire regulations for guidelines for proper site fire protection. Fires can cause severe personal injury or death.

FUELS**GENERAL**** WARNING**

Ensure that there are no leaks in the fuel supply. Engine fuels are highly combustible and can ignite or explode causing severe personal injury or death.

SAFETY

GASEOUS

WARNING

Do not inhale gaseous fuels. Some components of fuel gas are odorless, tasteless, and highly toxic. Inhalation of gaseous fuels can cause severe personal injury or death.

WARNING

Shut off the fuel supply if a gaseous engine has been cranked excessively without starting. Crank the engine to purge the cylinders and exhaust system of accumulated unburned fuel. Failure to purge accumulated unburned fuel in the engine and exhaust system can result in an explosion resulting in severe personal injury or death.

LIQUID

WARNING

Do not ingest liquid fuels or breathe in their vapors. Liquid fuels may be highly toxic and can result in severe personal injury or death.

WARNING

Use protective equipment when working with liquid fuels and related components. Liquid fuel can be absorbed into the body resulting in severe personal injury or death.

INTOXICANTS AND NARCOTICS

WARNING

Do not allow anyone under the influence of intoxicants and/or narcotics to work on or around industrial engines. Workers under the influence of intoxicants and/or narcotics are a hazard both to themselves and other employees and can cause severe personal injury or death to themselves or others.

PRESSURIZED FLUIDS/GAS/AIR

WARNING

Never use pressurized fluids/gas/air to clean clothing or body parts. Never use body parts to check for leaks or flow rates. Pressurized fluids/gas/air injected into the body can cause severe personal injury or death.

Observe all applicable local and federal regulations relating to pressurized fluid/gas/air.

PROTECTIVE GUARDS

WARNING

Provide guarding to protect persons or structures from rotating or heated parts. Contact with rotating or heated parts can result in severe personal injury or death.

It is the responsibility of the engine owner to specify and provide guarding.

SPRINGS

WARNING

Use appropriate equipment and protective gear when servicing or using products that contains springs. Springs, under tension or compression, can eject if improper equipment or procedures are used. Failure to take adequate precautions can result in serious personal injury or death.

TOOLS

ELECTRICAL

WARNING

Do not install, set up, maintain or operate any electrical tools unless you are a technically qualified individual who is familiar with them. Electrical tools use electricity and if used improperly could cause severe personal injury or death.

HYDRAULIC

 WARNING

Do not install, set up, maintain or operate any hydraulic tools unless you are a technically qualified individual who is familiar with them. Hydraulic tools use extremely high hydraulic pressure and if used improperly could cause severe personal injury or death.

 CAUTION Always follow recommended procedures when using hydraulic tensioning devices. Improper use of hydraulic tensioning tools can cause severe engine damage.

PNEUMATIC

 WARNING

Do not install, set up, maintain or operate any pneumatic tools unless you are a technically qualified individual who is familiar with them. Pneumatic tools use pressurized air and if used improperly could cause severe personal injury or death.

WEIGHT

 WARNING

Always consider the weight of the item being lifted and use only properly rated lifting equipment and approved lifting methods. Failure to take adequate precautions can result in serious personal injury or death.

 WARNING

Never walk or stand under an engine or component while it is suspended. Failure to adhere to this could result in severe personal injury or death.

WELDING


GENERAL

 WARNING

Comply with the welder manufacturer's recommendations for procedures concerning proper use of the welder. Improper welder use can result in severe personal injury or death.

ON ENGINE

 CAUTION Ensure that the welder is properly grounded before attempting to weld on or near an engine. Failure to properly ground the welder could result in severe engine damage.

 CAUTION Disconnect the ignition harness before welding on or near an engine to eliminate charging of an ignition system capacitor. Failure to disconnect the ignition harness could result in severe engine damage.

SECTION 1.10

RIGGING AND LIFTING ENGINES

ENGINE RIGGING AND LIFTING

WARNING

Exercise extreme care when moving the engine or its components. Never walk or stand directly under an engine or component while it is suspended. Always consider the weight of the engine or the components involved when selecting hoisting chains and lifting equipment. Be positive about the rated capacity of lifting equipment. Use only properly maintained lifting equipment with a lifting capacity which exceeds the known weight of the object to be lifted. Disregarding this information could result in severe personal injury or death.

Table 1.10-1 shows the approximate dry weight of the VHP gas engines.

Table 1.10-1. Engine Dry Weights

ENGINE	WEIGHT	
	lb.	kg
F2895G	14,500	6,580
F2895GSI	15,000	6,800
2895GL	15,000	6,800
F3521G	14,500	6,580
F3521GSI	15,000	6,800
3521GL	15,000	6,800
L5108G	20,500	9,300
L5108GSI	21,000	9,525
5108GL	21,000	9,525
L5790G	20,500	9,300
L5790GSI	21,000	9,525
5790GL	21,000	9,525
L7042G	20,500	9,300
L7042GSI	21,000	9,525
7042GL	21,000	9,525
5115GL	23,050	10,477
P9390G	25,000	11,340
P9390GSI	28,750	13,040
9390GL	28,750	13,040

LOCATION OF THE LIFTING EYES

WARNING

Always lift the engine using the approved lifting eyes. The VHP 6 cylinder gas engines are equipped with two lifting eyes on top of the engine; 12 and 16 cylinder gas engines are equipped with two pairs of lifting eyes, one pair on each cylinder bank. Lifting eyes are only meant for lifting the engine. Do not use to lift driven or auxiliary equipment that may be attached to the engine. Disregarding this information could result in severe personal injury or death.

The VHP 6 cylinder engine is equipped with two lifting eyes on top of the engine, 12 and 16 cylinder engines are equipped with two pairs of lifting eyes, one pair on each cylinder bank. The lifting eyes are only meant for lifting the engine. Do not use the lifting eyes to lift driven equipment that may be attached to the engine.

CORRECT METHOD OF RIGGING AND LIFTING ENGINE

Lifting chains should be positioned so that they do not rub or bind against parts of the engine. A properly rigged engine will be able to be lifted in such a manner that the chains will not damage the engine. See Figure 1.10-1 and Figure 1.10-2 for examples of engine lifting.

WARNING

To avoid severe personal injury or death, follow approved rigging procedures to ensure that no undue strain is placed on the lifting eyes and hoisting chains/cable sling when the engine is raised. Use the proper spreader beam to avoid damage to the engine.

RIGGING AND LIFTING ENGINES

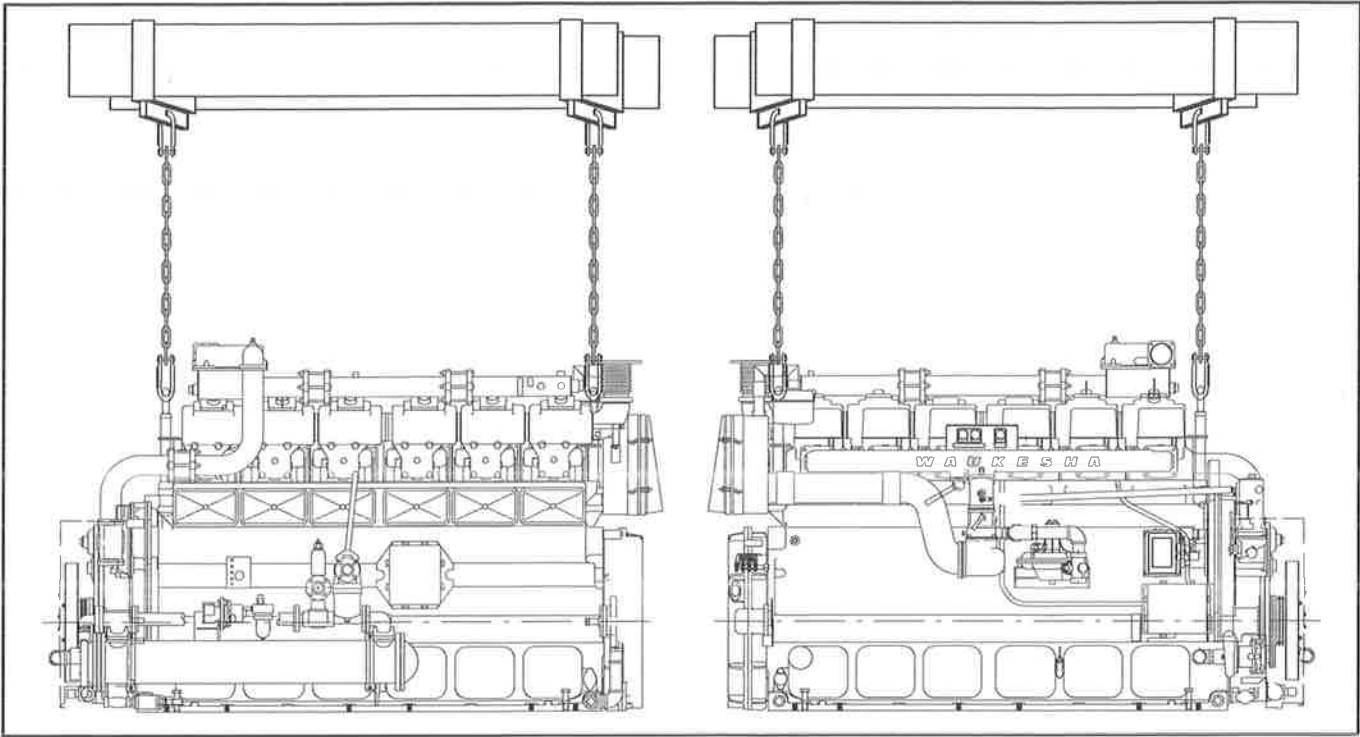


Figure 1.10-1. Correct Method Of Lifting Engine - 6 Cylinder - Side Views

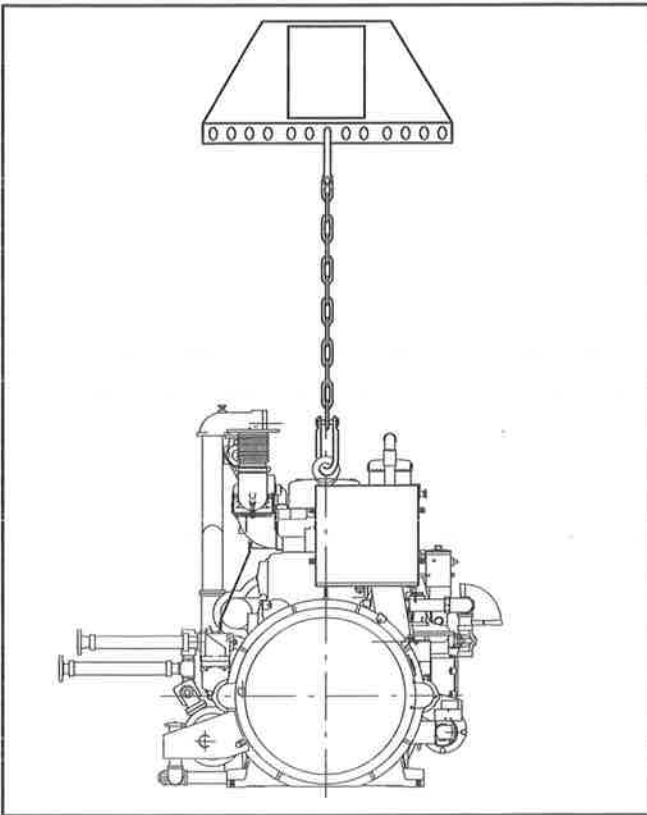


Figure 1.10-2. Correct Method Of Lifting Engine - 6 Cylinder - Rear View

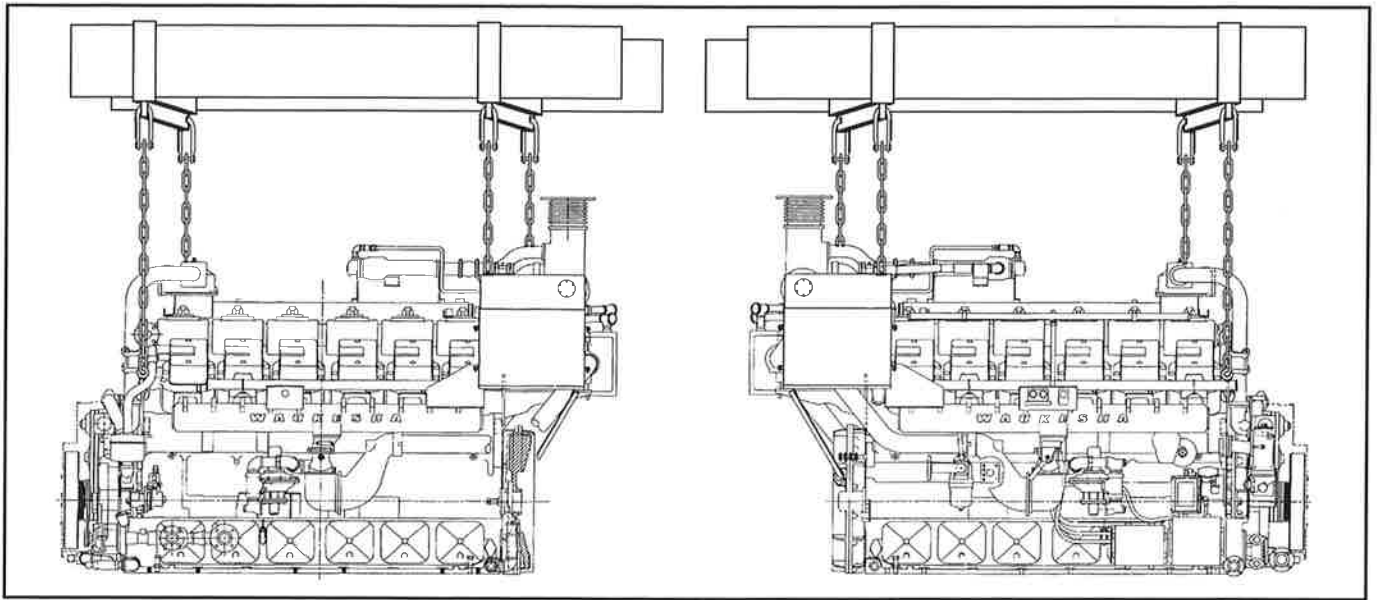


Figure 1.10-3. Correct Method Of Lifting 12 And 16 Cylinder Engines - 12 Cylinder Side Views Shown

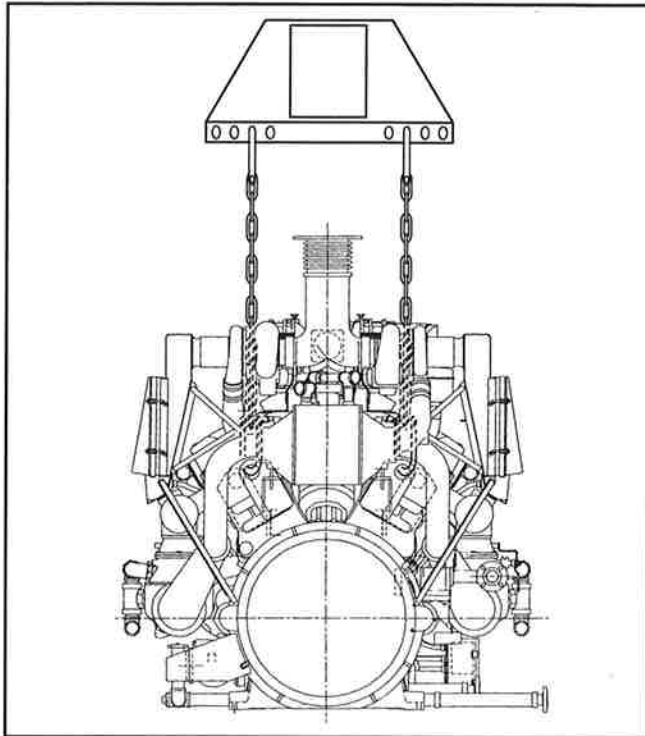


Figure 1.10-4. Correct Method Of Lifting 12 And 16 Cylinder Engines - 12 Cylinder Rear View Shown

SECTION 1.15

GENERAL INFORMATION

GENERAL INFORMATION

VHP G, GSI and GL engines (see Table 1.15-1) are 4-cycle; 6 cylinder engines are in-line configuration, while 12 and 16 cylinder engines are V-configuration. All engines rotate in the standard counter-clockwise direction, as viewed from the rear (flywheel) end.

Table 1.15-1. Engine Models

6 Cylinder Engines	F2895G F2895GSI 2895GL F3521G F3521GSI 3521GL
12 Cylinder Engines	L5108G L5108GSI 5108GL L5790G L5790GSI 5790GL L7042G L7042GSI 7042GL 5115GL
16 Cylinder Engines	P9390G P9390GSI 9390GL

The basic "G" engines are naturally aspirated.

The "GSI" engines are turbocharged and intercooled.

The "GL" engine is turbocharged, intercooled and lean burn. These engines are designed for low fuel consumption and reduced exhaust emissions. The prechamber design utilizes combustion of a stratified charge. A rich fuel mixture is provided to one part of the cylinder, and a lean fuel mixture to the rest of the cylinder, with the burning taking place in stages. To accomplish this, a small auxiliary combustion chamber, referred to as a prechamber, is located in the cylinder head. The rich fuel mixture is supplied to this chamber while the lean mixture fills the main combustion chamber. When the spark plug ignites the prechamber fuel, a flame torch projects from orifices in the prechamber to ignite the lean mixture in the main chamber. The consistent ignition of the rich mixture in the prechamber ensures complete combustion within the main chamber.

Refer to Figure 1.15-4 thru Figure 1.15-16 for engine identification views.

FEATURES AND BENEFITS

The design features of the VHP engine family include:

- High horsepower
- Sturdy construction, rugged and compact
- Low exhaust emissions
- Easy access and serviceability to all major components
- Fuel efficient and minimal fuel system complexity

BASIC ENGINE DESCRIPTION

The crankcase is a rigid gray iron casting (16 cylinder engines are two piece). The main bearings are replaceable. The counterweighted crankshaft is made of forged steel and has seven main bearing journals (16 cylinder engines have ten journals). Each engine is equipped with a viscous vibration damper.

There are interchangeable cylinder heads, each with two intake and two exhaust valves. Both exhaust and intake valve seat inserts are replaceable. Roller type valve lifters and hydraulic push rods are standard with the exception of the 5115GL which uses non-hydraulic push rods. The camshaft is heavy duty for long life. The connecting rods are made from drop forged steel and are rifle drilled. The cylinders have replaceable wet cylinder sleeves. The pistons use a full floating piston pin. The flywheel is machined and has a ring gear attached.

The exhaust driven turbocharger (on GSI and GL models) compresses intake air. This charged air is cooled in the intercooler and then enters the carburetor and mixes with pressurized fuel gas. The turbocharged air/fuel mixture enhances the engine's power and performance. On draw-thru equipped GSI and GL models, the turbocharger draws fuel and intake air from the air intake and carburetor(s) (mounted on the air filter housing(s) and compresses the mixture. The mixture is cooled through the intercooler and then enters the intake manifold(s).

GENERAL INFORMATION

The pressurized lubricating system consists of an oil sump, pump, piping network, filters, strainers and cooler. The full flow oil filter is externally mounted, separate from the engine. The system also consists of an externally mounted oil cooler.

The cooling system has two water pumps. The main water pump circulates the jacket water of the engine. The auxiliary water pump, circulates water for the oil cooler and the intercooler. The engine jacket, cylinder heads, exhaust manifold, oil and charged intake air are all water cooled.

COMPONENT DESCRIPTIONS

CRANKCASE

The crankcase is a gray iron casting (16 cylinder engines are two piece). For assembled rigidity, the main bearing caps are attached to the crankcase with both vertical studs and lateral tie bolts. This feature makes the crankcase assembly more rigid and lengthens the life of the main bearings.

CRANKSHAFT

The underslung crankshaft is made of a low alloy, high tensile strength forged steel. The crankshaft is counter-weighted to achieve a near perfect balance of rotating forces. 16 cylinder engine crankshafts are two piece.

A viscous vibration damper is installed on the forward end of the crankshaft along with a gear that drives the front end gear train and accessories. The flywheel, with ring gear, is installed on the rear end of the crankshaft and is machined to accept several options.

INTAKE MANIFOLD(S)

The air/fuel mixture passes through the intake manifold(s) where it is distributed to the individual cylinders.

EXHAUST MANIFOLD(S)

The exhaust port of each cylinder head is connected to one water-cooled segment of the exhaust manifold. The water-cooled exhaust manifold(s) assembly is comprised of individual segments (one for each cylinder head). Each exhaust manifold segment is joined to the next by a manifold pilot.

CONNECTING RODS

The connecting rods are machined to ensure maximum strength, precise balance and consistent weight between cylinders. They are made of a low alloy, high tensile strength forged steel, and are rifle-drilled to supply pressurized lube oil from the crankshaft to the piston pin bushings.

The split line of the rod and cap allows for removal of the connecting rod assembly up through the cylinder liner bore.

The serrated split line ensures precise alignment and transfer of loads. The caps and blades are also match numbered to ensure that each cap is mated with the correct blade during re-assembly.

The connecting rod cap fasteners, like all critical fasteners used on the engine, are torqued to specific values.

PISTONS

The pistons are machined from one-piece castings. Each piston is cam-ground. This means the dimension of the piston skirt at room temperature is slightly larger at a point 90 degrees to the piston pin bore. This feature allows the piston to expand from a shape that is somewhat oval to one that is almost perfectly round when operating at stabilized engine temperatures.

CYLINDER LINERS

Each wet type cylinder liner has a flange at its upper end to locate it in the crankcase upper deck. The liners have three external ring grooves to hold the lower crankcase bore seals.

CAMSHAFTS

The design of the camshaft lobe and cam minimizes valve overlap and reduces the flow of gases between the intake and exhaust ports. This improves fuel efficiency and lowers exhaust emissions.

CYLINDER HEAD AND VALVES

Each cylinder head has four valves, two intake and two exhaust, with overhead rocker and actuator arms. GL model cylinder heads have a prechamber bore in the center, and an additional bore to accommodate the fuel admission valve. The cylinder heads are water cooled, to reduce heat deformation during the combustion process.

TURBOCHARGER(S)

On GSI and GL models, high efficiency, radial flow turbochargers are mounted on the rear of the engine and generate the required boost levels for the engine.

CUSTOM ENGINE CONTROL® (CEC) IGNITION MODULE

Waukesha Engine's Custom Engine Control® Ignition Module (IM), is standard equipment on VHP engines. The CEC ignition system uses a Hall-effect pickup and a special timing disc to determine the exact position of the crankshaft. The CEC ignition module interprets the sensor's impulses to set the optimum ignition timing. The CEC module then directs a precisely timed voltage to the appropriate ignition coil.

**CUSTOM ENGINE CONTROL® (CEC)
DETONATION SENSING MODULE**

Waukesha Engine's Custom engine Control® Detonation Sensing Module (DSM), which functions with the CEC Ignition Module, is standard equipment on VHP engines. The DSM protects the engines from damage due to detonation on an individual cylinder basis. Engine mounted detonation sensors monitor engine output from each cylinder. When the signal exceeds a predetermined limit, the DSM retards the ignition timing for the cylinder associated with that sensor. As soon as conditions permit, the DSM will advance spark timing to the original timing set point.

INTERCOOLER(S)

The intercooler(s) (the box-type tube and fin assemblies mounted at the rear of the engine) are standard on GSI and GL models. The flow of air between the aluminum cooling fins, runs perpendicular to the vertical flow of cooling water in the copper tubes. The configuration of the upper and lower bonnets create a U-shaped path, that enables the cooling water to pass through the core assembly four times, before exiting the unit at the top. Header plates separate the air passing through the casing from the cooling water in the upper and lower bonnets.

A supply tube connected to the intercooler cooling water inlet, provides a continuous supply of cooling water to the wastegate(s)(one per turbocharger). The cooling water enters the lower housing of the wastegate(s) and passes through a cavity that encircles the valve guide. Exiting the outlet port on the opposite side of the lower housing, the water passes to the intercooler cooling water outlet through a water return tube.

CARBURETOR(S)

The carburetor(s) consists of a main body, with a conventional throttle valve and diaphragm operated gas metering valves. The flow of air through the carburetor(s) is controlled by the throttle valve in the carburetor throat, as in any other carburetor. The amount of air going to the engine is measured by air-flow measuring valves, which rise in direct proportion to the air volume passing through. The gas metering valves are mechanically fixed to the air measuring valves, and rise with them, thus opening the gas passages an amount proportionate to the air entering the engine. This establishes and holds a definite air/fuel ratio throughout the operating range. The actual movement of the parts results from the negative air pressure at the air measuring valves, which is communicated to the back side of each diaphragm through two small holes.

**SERIAL NUMBERS AND ENGINE
NAMEPLATE**

For ease in identification, the engine model, serial and specification numbers are stamped on a nameplate (see Figure 1.15-2 and Figure 1.15-3).

The VHP engine nameplate provides the following information: model number, serial number, date inspected, special application approval number (power approval), valve clearance, compression ratio, firing order, governed speed, altitude limit at which an engine derate takes place, primary and secondary fuel ratings which show the fuel, minimum WKI™, ignition timing, rated output in horsepower and kilowatts, and overload rating in horsepower and kilowatts. This nameplate is located on the lower left side of the crankcase, adjacent to the front of the engine.

When requesting information, you will need to reference both the engine model and serial numbers. If the nameplate is defaced or detached, the serial number may be obtained directly off the crankcase. To locate it, look directly above the nameplate location, on the cylinder head deck of the crankcase.

INSTRUMENT PANEL

Waukesha Engine's optional instrument panel is shipped loose and intended to be remote mounted on site (see Figure 1.15-1). The panel is operated on 24VDC. The instruments are:



Figure 1.15-1. Optional Remote Instrument Panel

- **Intake Manifold Pressure Gauge;** indicates the intake manifold pressure in inches/centimeters of mercury.

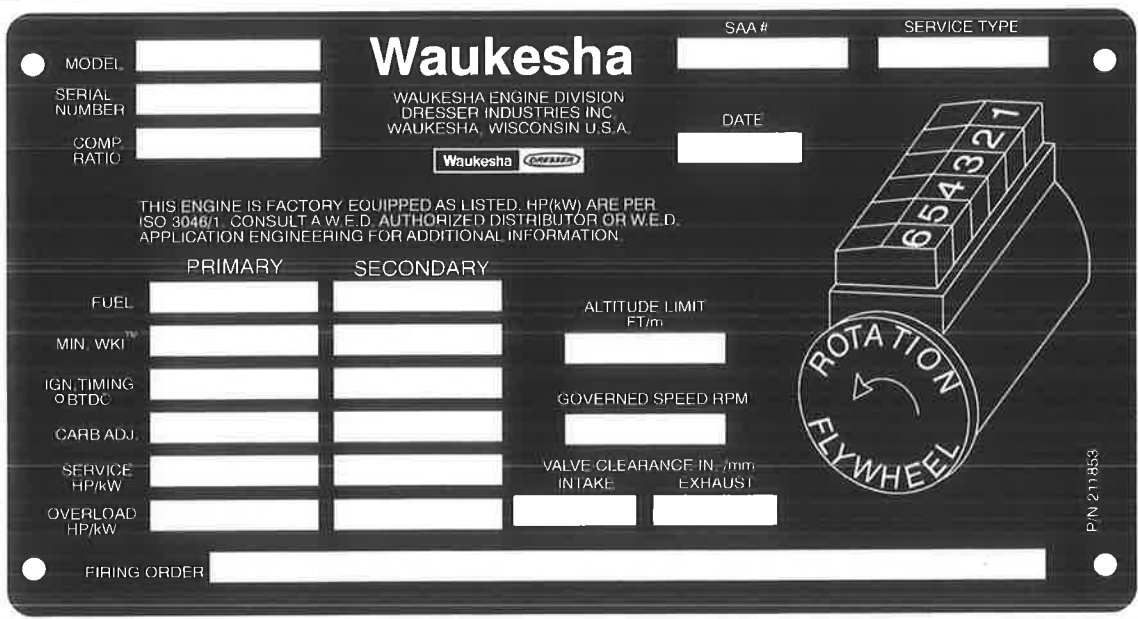
GENERAL INFORMATION

- **Digital Tachometer/Hour Meter;** indicates the engine speed in revolutions per minute (rpm) and the hours the engine has been in operation.
- **Intake Manifold Temperature Gauge;** indicates the temperature of the air/gas mixture within the intake manifold.
- **Lube Oil Pressure Gauge;** indicates the lube oil pressure at the oil header.
- **Lube Oil/Jacket Water Temperature Gauge;** indicates the lube oil temperature at the oil header and the outlet temperature of the engine coolant.
- **Exhaust Temperature Pyrometer;** indicates the temperature of the exhaust gases.

WARNING

Switches for alarms and automatic engine shut-down must be supplied by the customer. The sensors provided are for measuring and monitoring temperatures and WILL NOT shut the engine down if potentially harmful temperatures are reached. Disregarding this information could result in severe personal injury or death.

Engine instrument and safety shutdowns are not supplied as standard equipment, due to the wide variety of customer needs. Instruments and safety shut downs are the customer's responsibility. Oil pressure, intake manifold pressure, water temperature, exhaust temperature, main bearing, overspeed and oil temperature, are the minimum required for engine protection. Switches should be wired to an alarm to warn of high temperatures and low pressure as well as provide for automatic engine shutdown if potentially harmful temperatures, pressure or overspeed conditions exist.



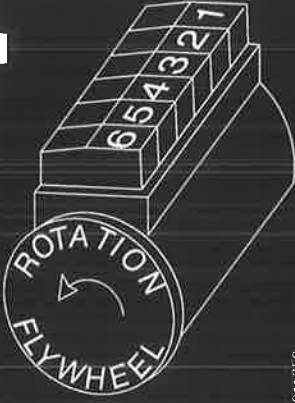
Waukesha
 WAUKESHA ENGINE DIVISION
 DRESSER INDUSTRIES INC.
 WAUKESHA, WISCONSIN U.S.A.

MODEL: _____ SAA #: _____ SERVICE TYPE: _____
 SERIAL NUMBER: _____ DATE: _____
 COMP. RATIO: _____

THIS ENGINE IS FACTORY EQUIPPED AS LISTED. HP(KW) ARE PER ISO 3046/1. CONSULT A W.E.D. AUTHORIZED DISTRIBUTOR OR W.E.D. APPLICATION ENGINEERING FOR ADDITIONAL INFORMATION.

	PRIMARY	SECONDARY	
FUEL	_____	_____	ALTITUDE LIMIT FT/m _____
MIN. WKI	_____	_____	GOVERNED SPEED RPM _____
IGN. TIMING °BTDC	_____	_____	VALVE CLEARANCE IN. /mm
CARB. ADJ.	_____	_____	INTAKE _____ EXHAUST _____
SERVICE HP/KW	_____	_____	
OVERLOAD HP/KW	_____	_____	

FIRING ORDER: _____

ROTATION FLYWHEEL 

P/N 211 853

Figure 1.15-2. Nameplate - Current Production

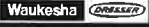
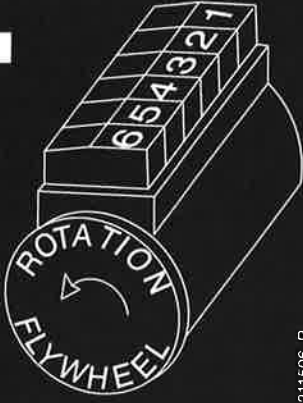
MODEL	<input type="text"/>	Waukesha WAUKESHA ENGINE DIVISION DRESSER INDUSTRIES INC. WAUKESHA, WISCONSIN U.S.A. 	SAA #	<input type="text"/>	SERVICE TYPE	<input type="text"/>
SERIAL NUMBER	<input type="text"/>		DATE	<input type="text"/>		
COMP RATIO	<input type="text"/>					
THIS ENGINE IS FACTORY EQUIPPED AS LISTED. HP(KW) ARE PER ISO 3046/1. CONSULT A W.E.D. AUTHORIZED DISTRIBUTOR OR W.E.D. APPLICATION ENGINEERING FOR ADDITIONAL INFORMATION.						
	PRIMARY	SECONDARY		ALTITUDE LIMIT FT/M		
FUEL	<input type="text"/>	<input type="text"/>		<input type="text"/>		
MIN. OCTANE	<input type="text"/>	<input type="text"/>		<input type="text"/>		
IGN. TIMING ° BTDC	<input type="text"/>	<input type="text"/>		GOVERNED SPEED RPM	<input type="text"/>	
CARB ADJ.	<input type="text"/>	<input type="text"/>		VALVE CLEARANCE IN. /mm		
SERVICE HP/kW	<input type="text"/>	<input type="text"/>		INTAKE	<input type="text"/>	
OVERLOAD HP/kW	<input type="text"/>	<input type="text"/>		EXHAUST	<input type="text"/>	
FIRING ORDER	<input type="text"/>					

Figure 1.15-3. Nameplate - Previous Production

GENERAL INFORMATION

ENGINE IDENTIFICATION VIEWS

SIX CYLINDER GL VIEWS

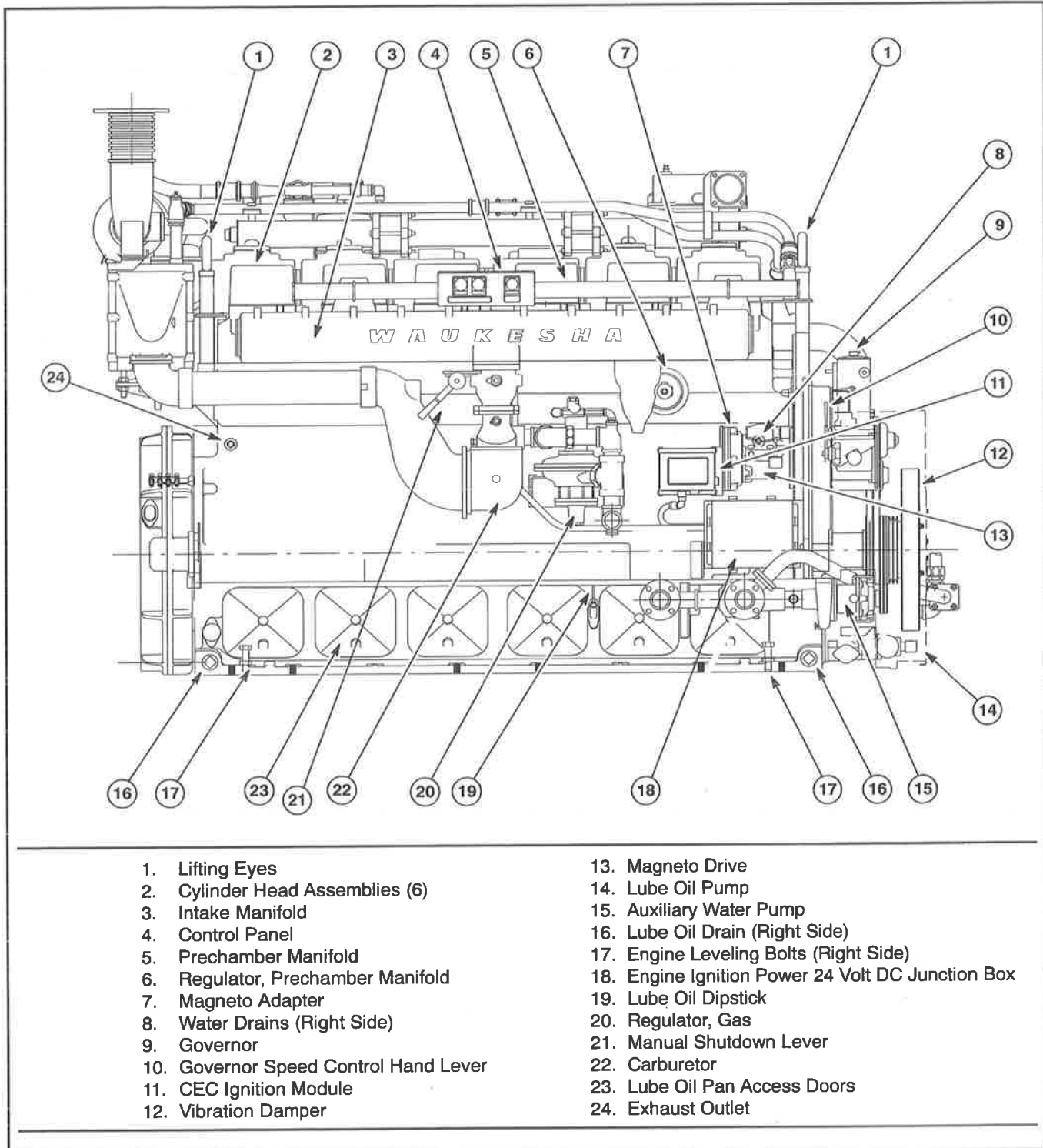


Figure 1.15-4. Right Side View - 6 Cylinder VHP GL

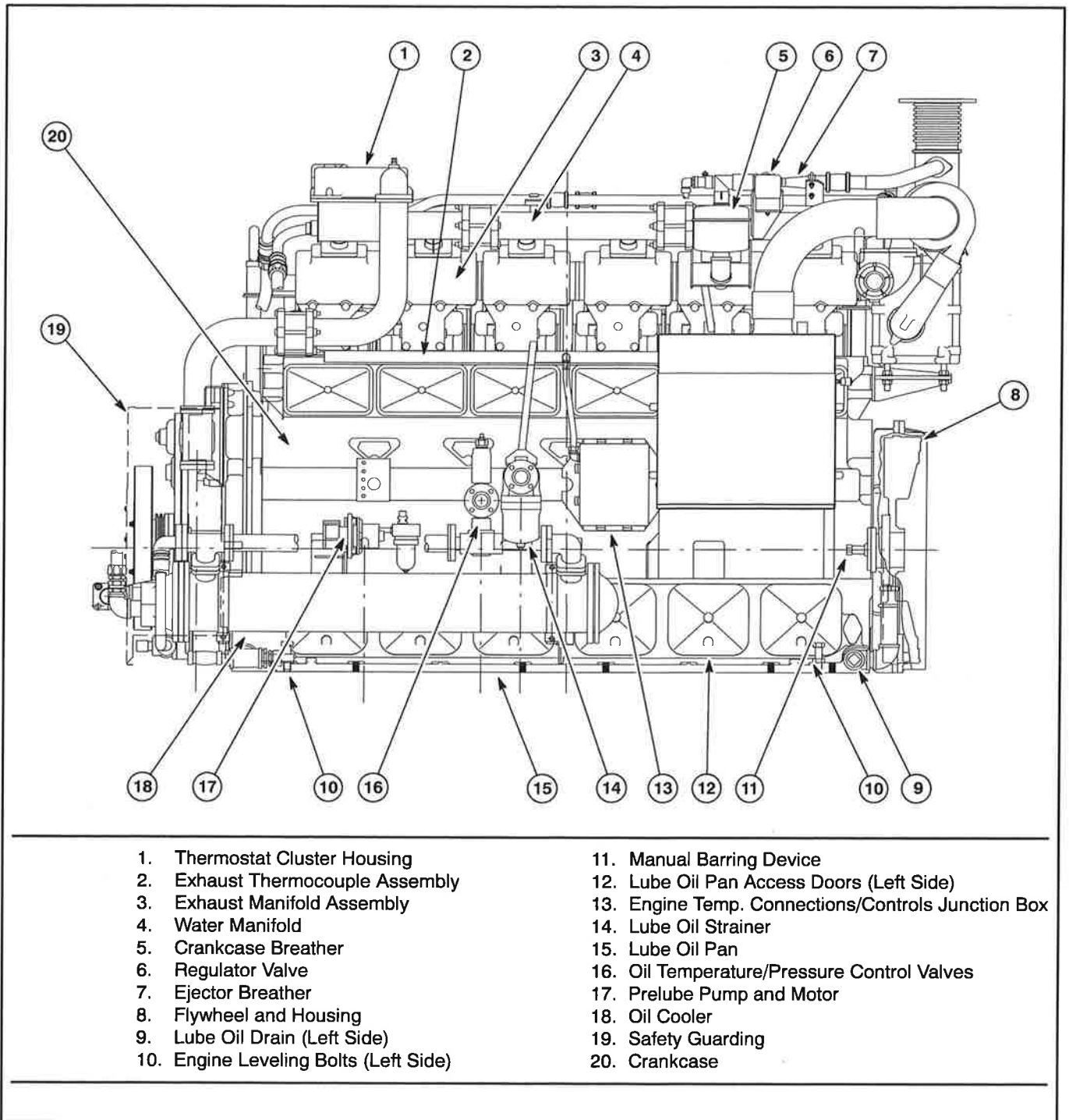


Figure 1.15-5. Left Side View - 6 Cylinder VHP GL

GENERAL INFORMATION

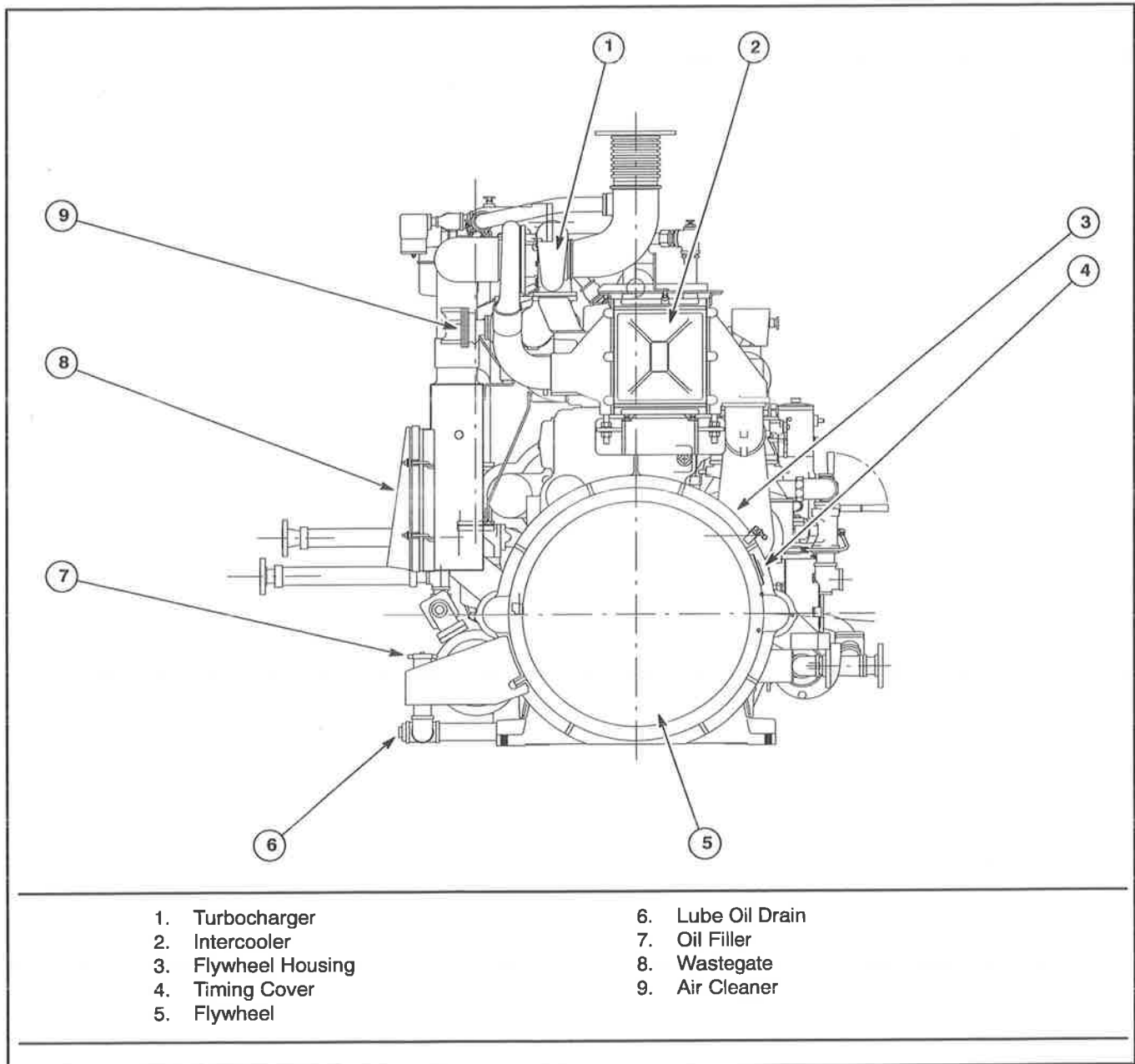
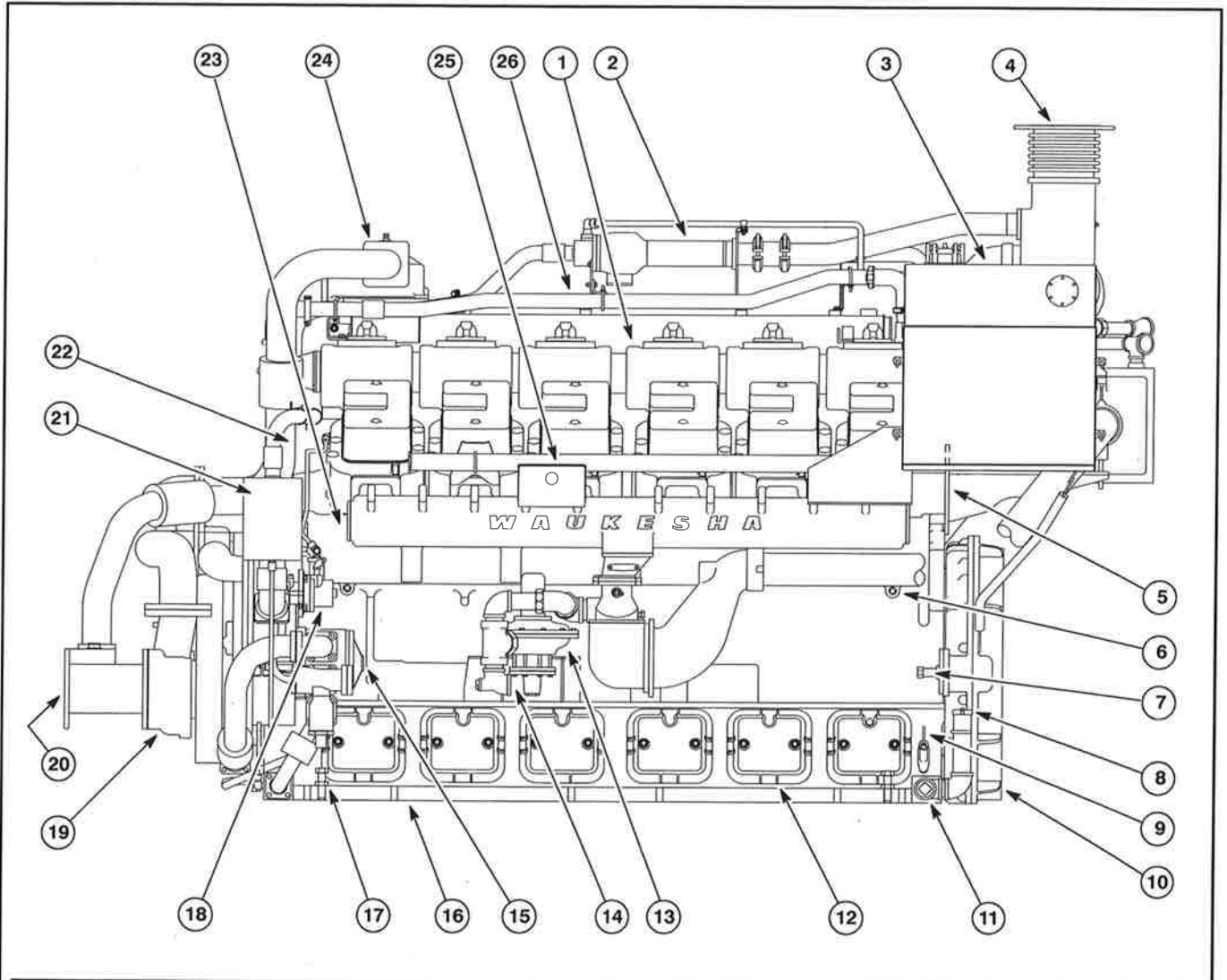


Figure 1.15-6. Rear View - 6 Cylinder VHP GL

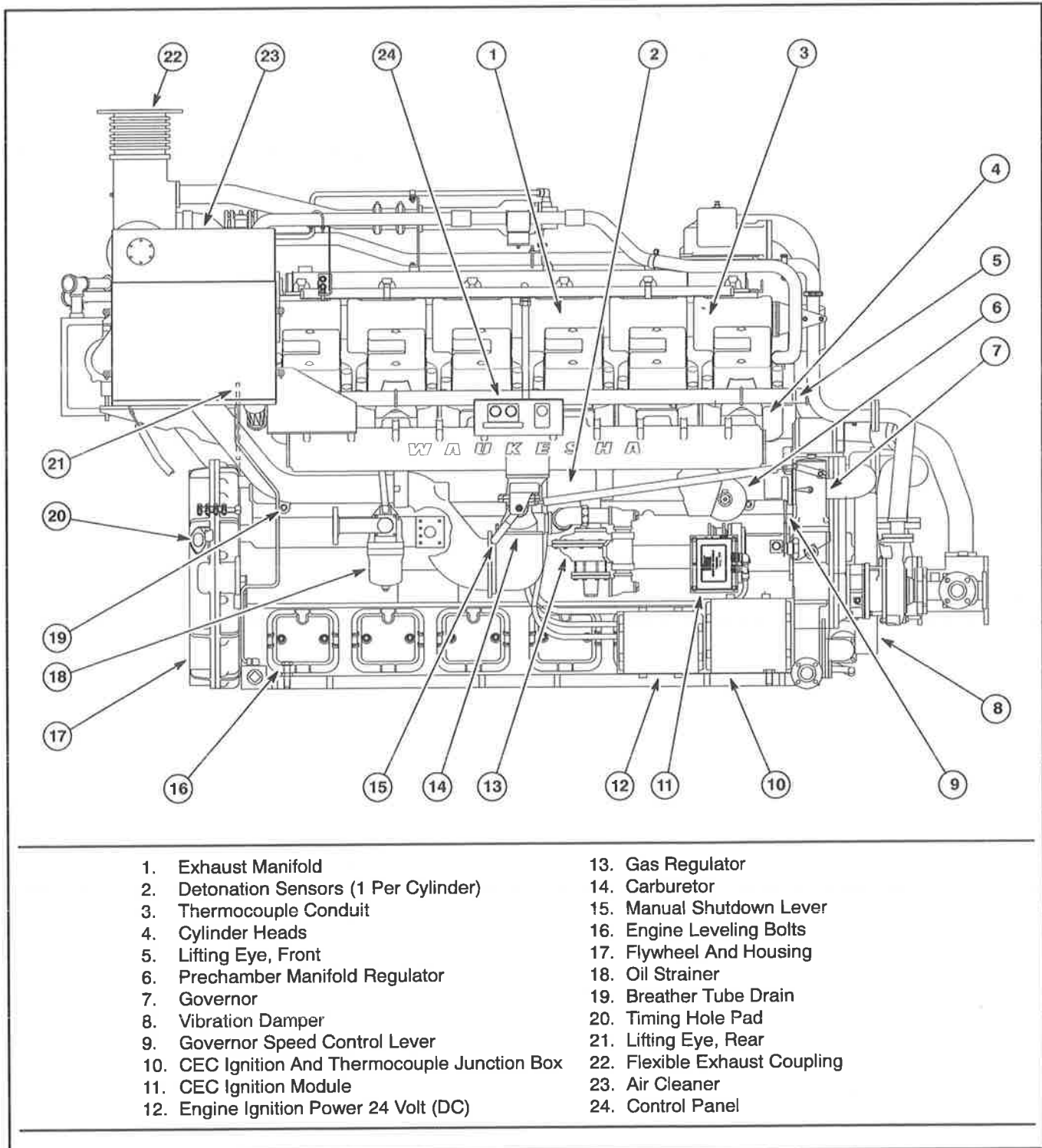
5115GL VIEWS



- | | |
|--------------------------|---|
| 1. Exhaust Manifold | 14. Gas Inlet |
| 2. Venturi Extractor | 15. Oil Pump |
| 3. Air Cleaner | 16. Oil Pan |
| 4. Exhaust Outlet Flange | 17. Engine Leveling Bolts |
| 5. Lifting Eye, Rear | 18. Air/Gas Prelube Pump Motor |
| 6. Water Drain | 19. Jacket Water Pump |
| 7. Barring Device | 20. Water Inlet Flange |
| 8. Oil Filler | 21. Crankcase Breather Oil Separator |
| 9. Oil Dipstick | 22. Lifting Eye, Front |
| 10. Flywheel Housing | 23. Detonation Sensors (1 Per Cylinder) |
| 11. Oil Drain | 24. Thermostat Cluster Housing |
| 12. Oil Pan Access Doors | 25. Control Panel |
| 13. Regulator, Gas | 26. Water Manifold |

Figure 1.15-7. Left Side View - 5115GL

GENERAL INFORMATION



- | | |
|--|-------------------------------|
| 1. Exhaust Manifold | 13. Gas Regulator |
| 2. Detonation Sensors (1 Per Cylinder) | 14. Carburetor |
| 3. Thermocouple Conduit | 15. Manual Shutdown Lever |
| 4. Cylinder Heads | 16. Engine Leveling Bolts |
| 5. Lifting Eye, Front | 17. Flywheel And Housing |
| 6. Prechamber Manifold Regulator | 18. Oil Strainer |
| 7. Governor | 19. Breather Tube Drain |
| 8. Vibration Damper | 20. Timing Hole Pad |
| 9. Governor Speed Control Lever | 21. Lifting Eye, Rear |
| 10. CEC Ignition And Thermocouple Junction Box | 22. Flexible Exhaust Coupling |
| 11. CEC Ignition Module | 23. Air Cleaner |
| 12. Engine Ignition Power 24 Volt (DC) | 24. Control Panel |

Figure 1.15-8. Right Side View - 5115GL

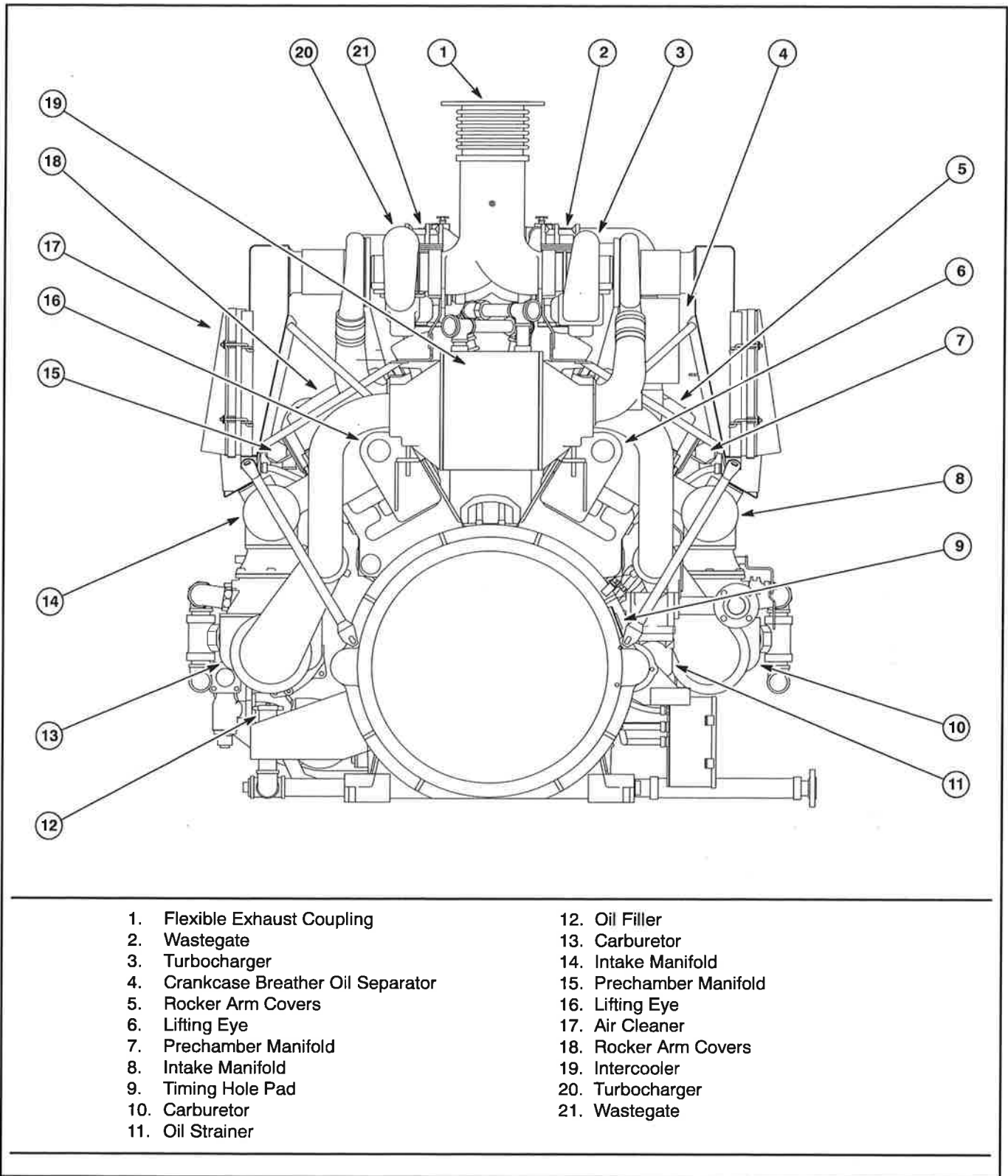
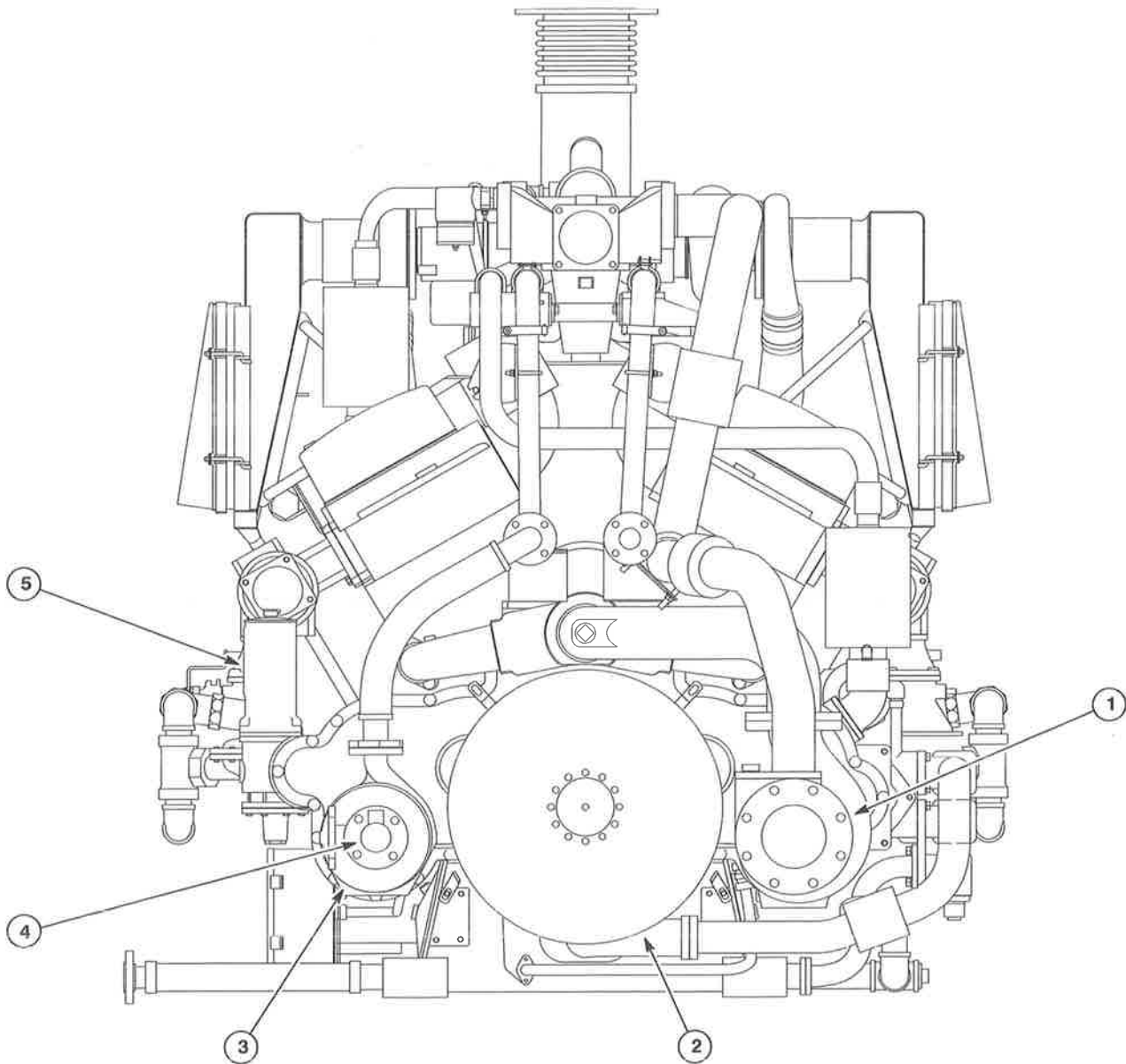


Figure 1.15-9. Rear View - 5115GL

GENERAL INFORMATION

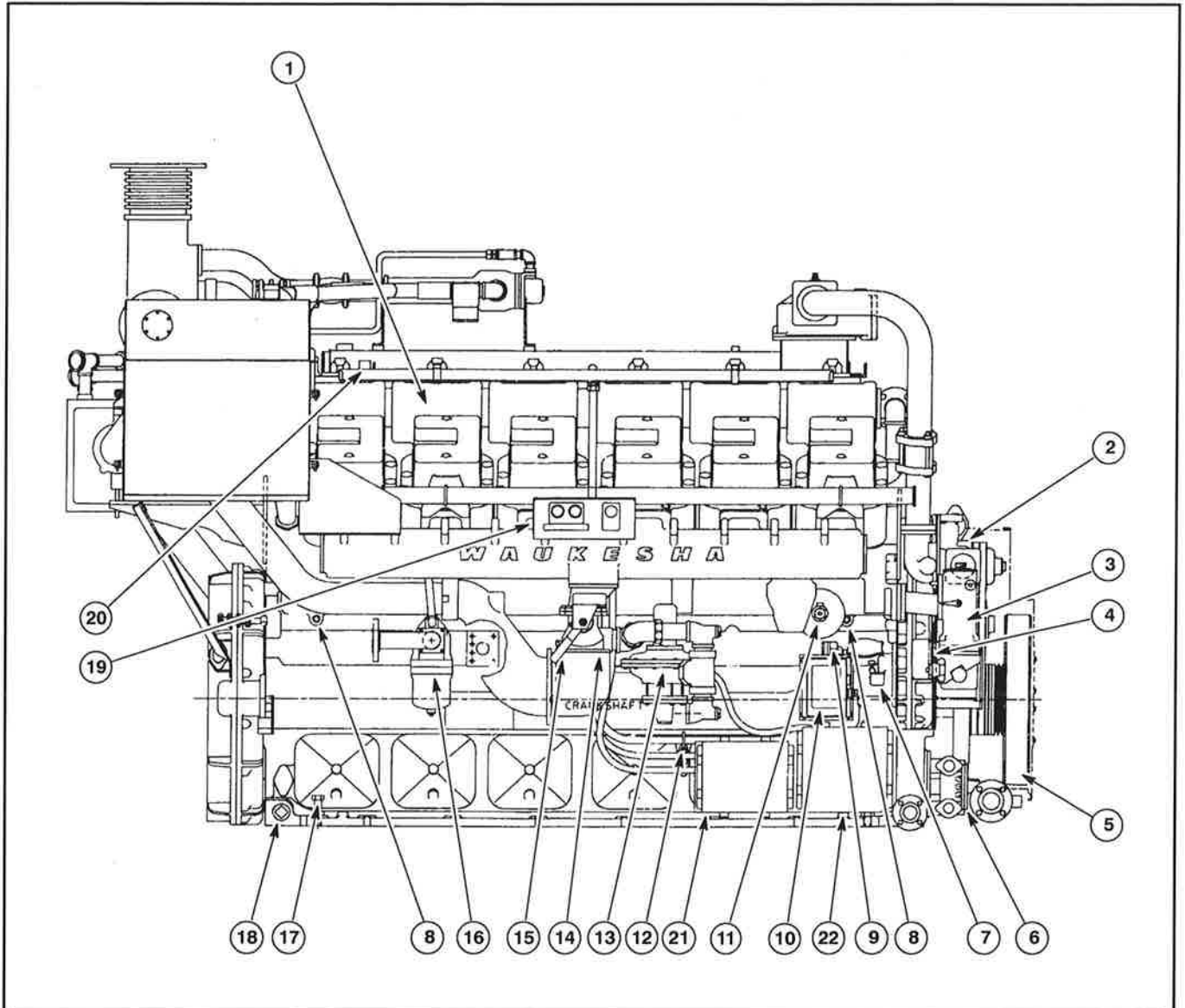
NOTE: Front guard shown removed for clarity.



1. Water Inlet Flange
2. Vibration Damper
3. Auxiliary Water Pump
4. Auxiliary Water Inlet
5. Governor

Figure 1.15-10. Front View - 5115GL

TWELVE CYLINDER GL VIEWS



- | | |
|--|--|
| 1. Exhaust Manifold Assembly, (Right Bank) | 12. Lube Oil Dipstick (Right Bank) |
| 2. Jacket Water Pump | 13. Regulator, Gas (Right Bank) |
| 3. Governor | 14. Carburetor (Right Bank) |
| 4. Governor Speed Control Hand Lever | 15. Manual Shutdown Lever |
| 5. Vibration Damper | 16. Lube Oil Strainer |
| 6. Lube Oil Pump | 17. Engine Leveling Bolts (Right Bank) |
| 7. Magneto Drive | 18. Lube Oil Drain (Right Bank) |
| 8. Water Drains (Right Bank) | 19. Control Panel (Right Bank) |
| 9. Magneto Adapter | 20. Exhaust Thermocouple Assembly |
| 10. CEC Ignition Module | 21. Engine Ignition Power 24 Volt DC |
| 11. Regulator, Prechamber Manifold | 22. Thermocouple Control Box/
CEC Ignition Junction Box |

Figure 1.15-11. Right Side View - 12 Cylinder VHP GL

GENERAL INFORMATION

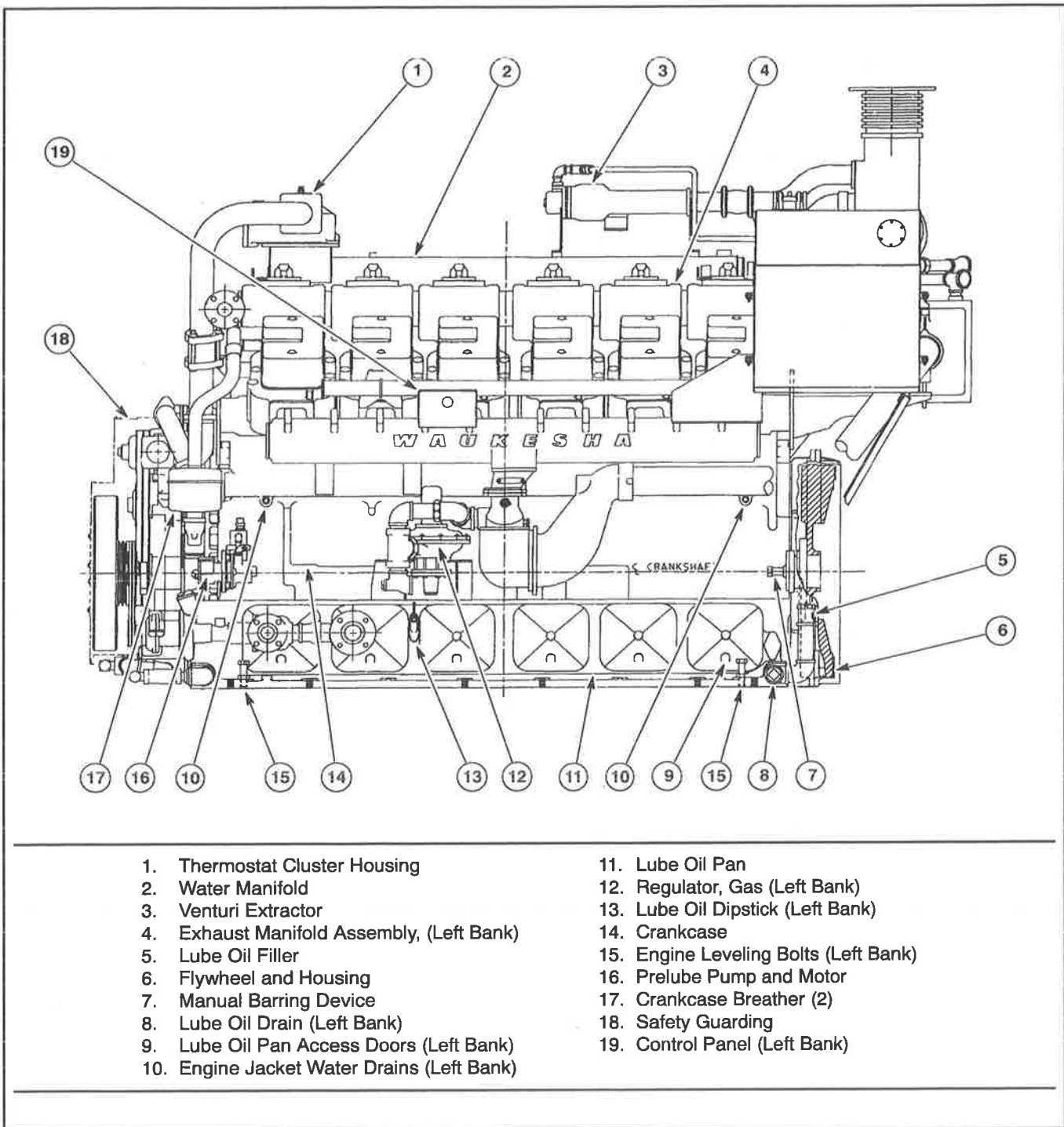
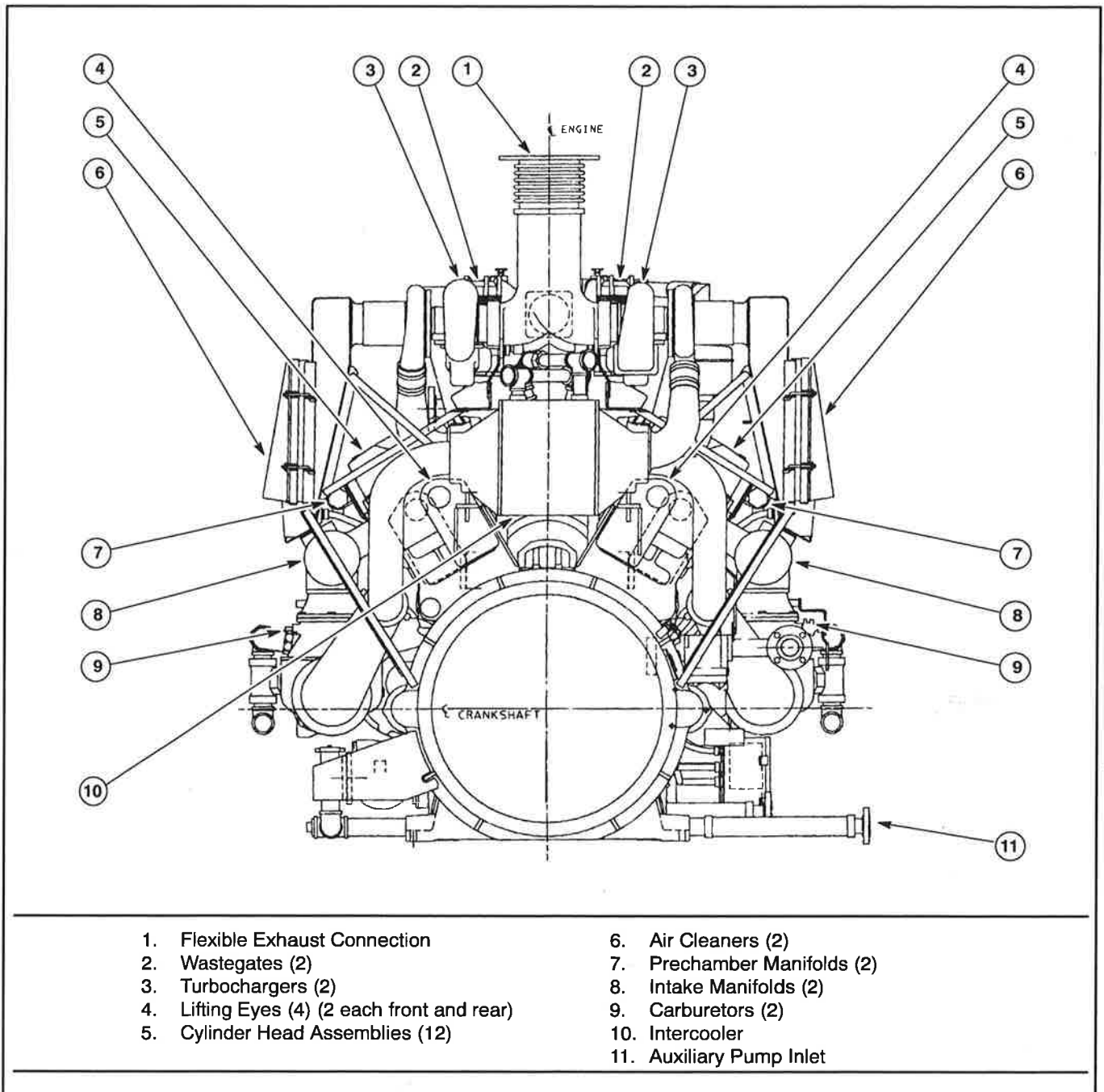


Figure 1.15-12. Left Side View - 12 Cylinder VHP GL



- 1. Flexible Exhaust Connection
- 2. Wastegates (2)
- 3. Turbochargers (2)
- 4. Lifting Eyes (4) (2 each front and rear)
- 5. Cylinder Head Assemblies (12)

- 6. Air Cleaners (2)
- 7. Prechamber Manifolds (2)
- 8. Intake Manifolds (2)
- 9. Carburetors (2)
- 10. Intercooler
- 11. Auxiliary Pump Inlet

Figure 1.15-13. Rear View - 12 Cylinder VHP GL

GENERAL INFORMATION

SIXTEEN CYLINDER GL VIEWS

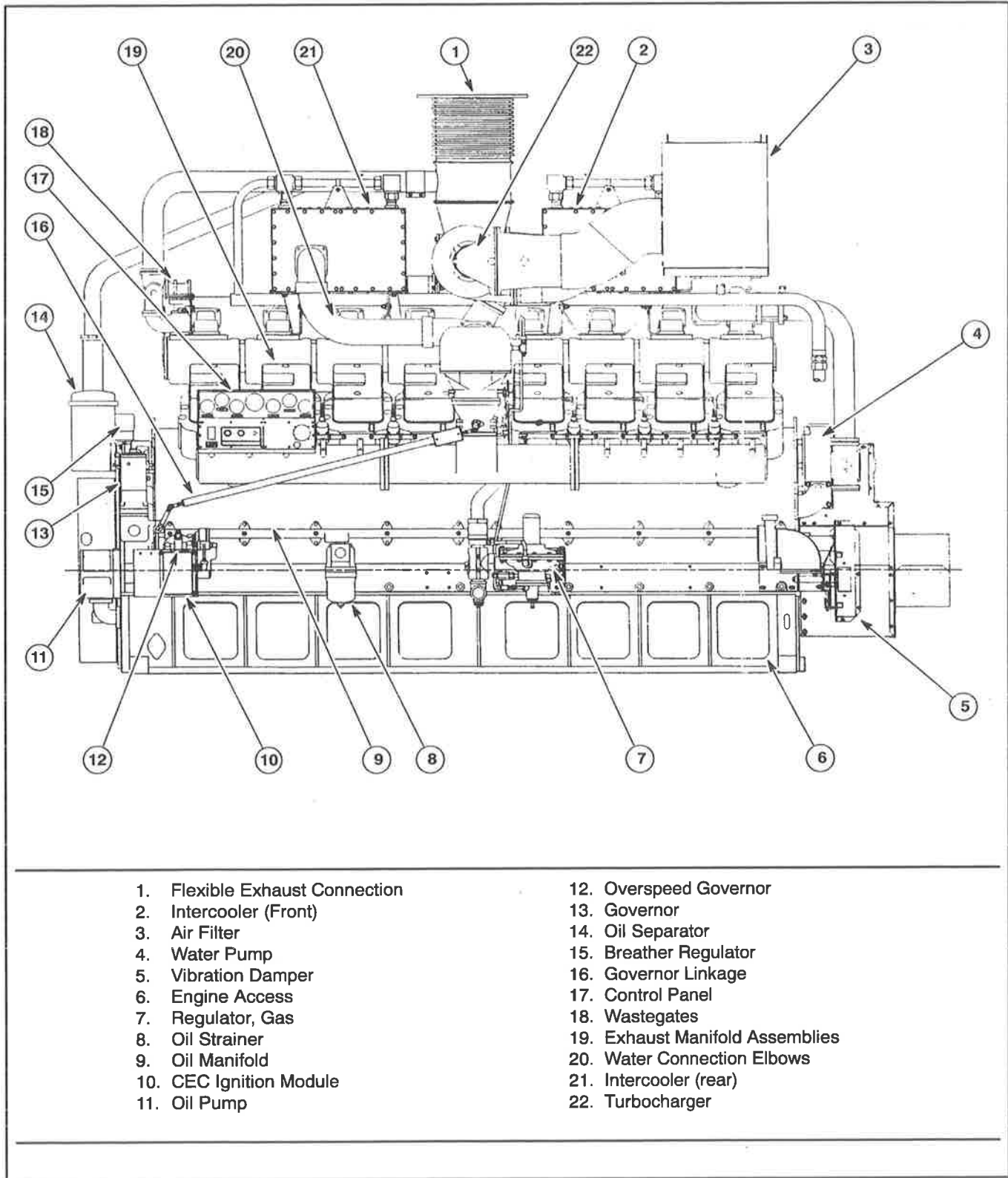


Figure 1.15-14. Right Side View - 16 Cylinder VHP GL

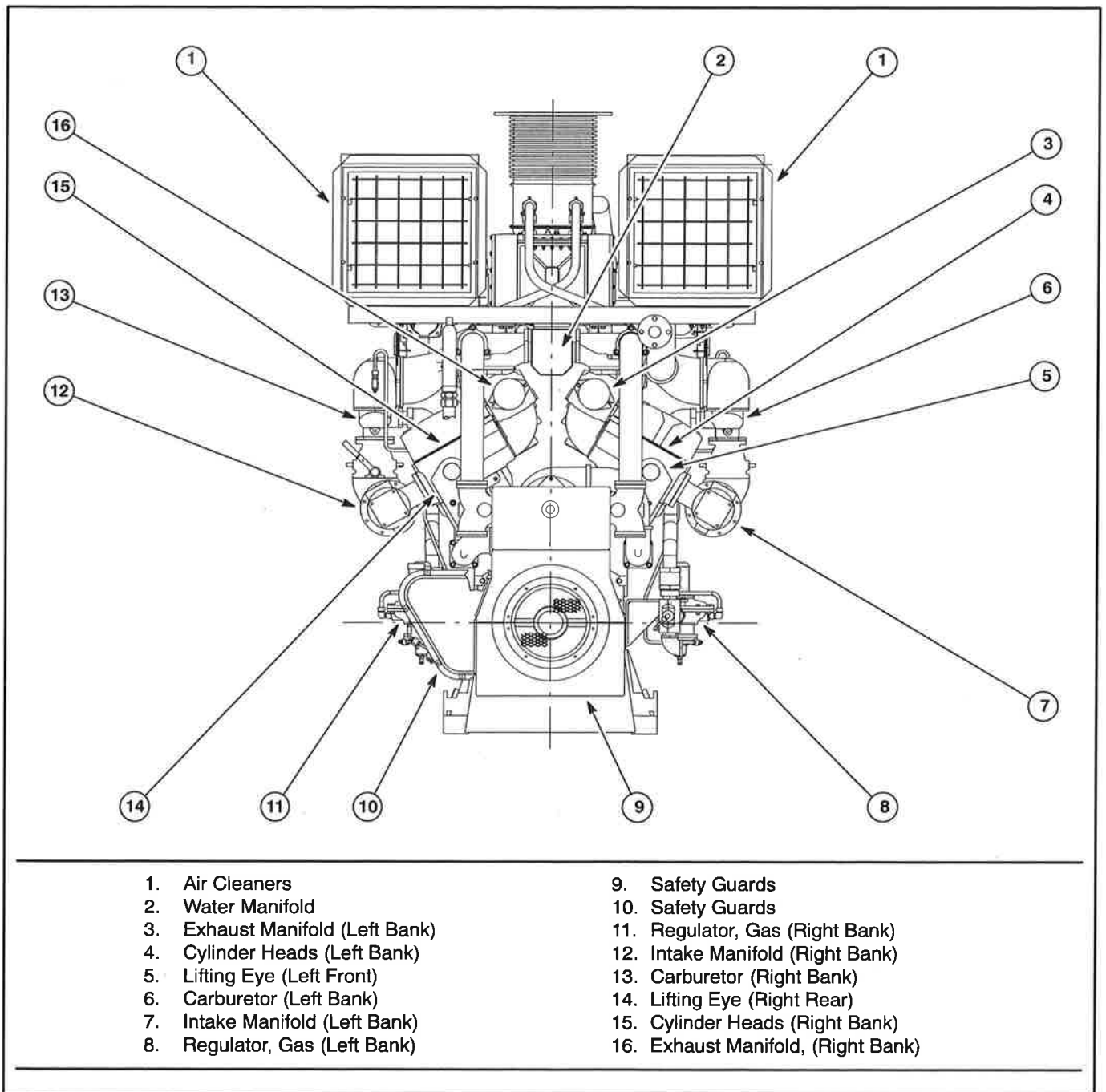


Figure 1.15-15. Front View - 16 Cylinder VHP GL

GENERAL INFORMATION

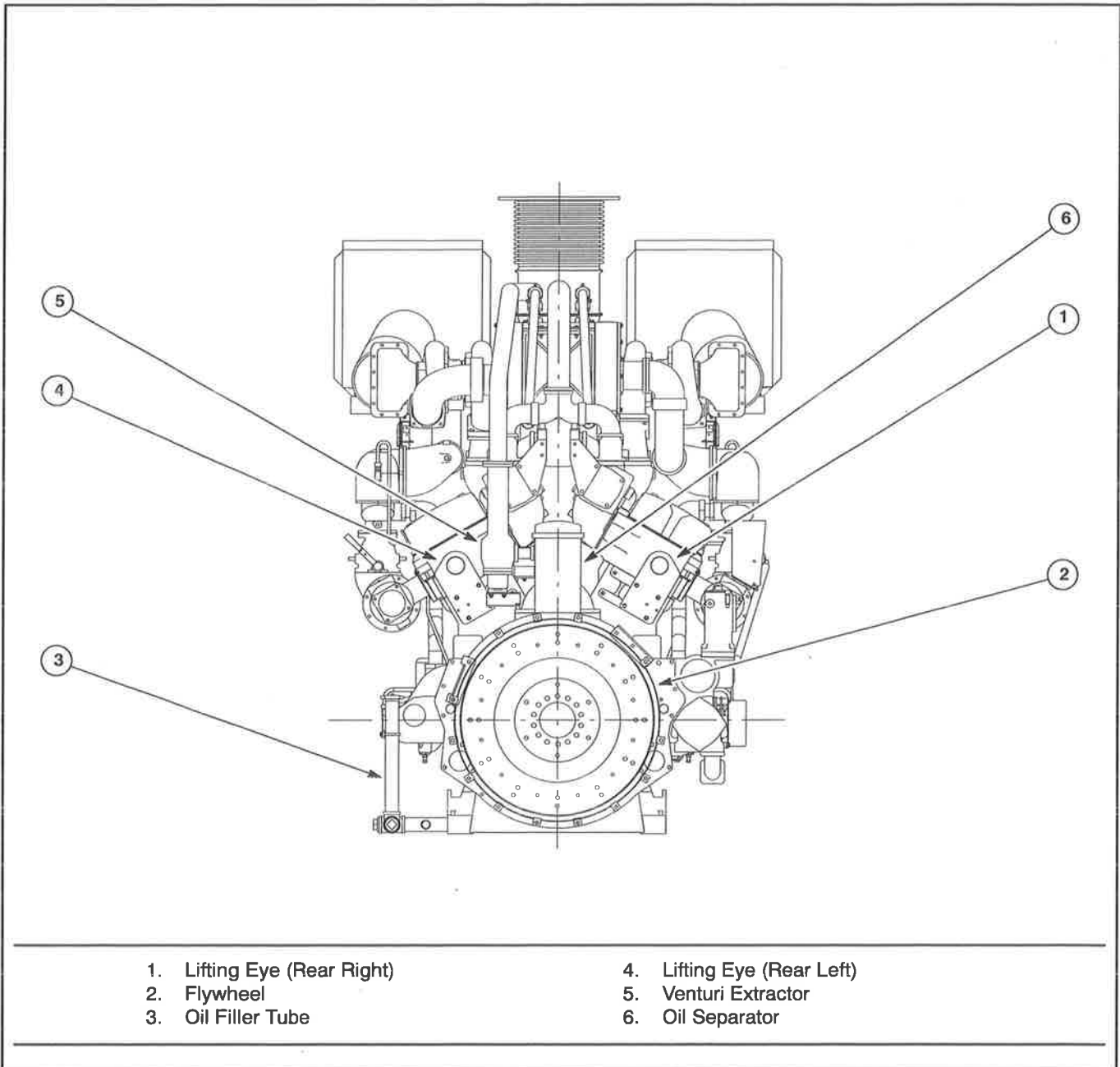


Figure 1.15-16. Rear View - 16 Cylinder VHP GL

ENGINE SPECIFICATIONS

CAUTION Alarm and shutdown valves are based on dry natural gas (900 Btu/cu. ft. SLHV). Refer to Gaseous Fuel Specification Sheet S7884C and Lube Oil Recommendations Sheet S1015Y or latest revisions for typical changes in operation temperatures for jacket water and lube oil when running on landfill or digester gas fuels. Disregarding this information could result in product damage.

Table 1.15-2. VHP Specifications

GENERAL SPECIFICATIONS				
Engine Model	6 Cylinder	12 Cylinder ³	5115GL	16 Cylinder
Type	4-cycle			
Aspiration, G	Naturally aspirated		-	Naturally aspirated
Aspiration, GSI	Turbocharged, intercooled		-	Turbocharged, intercooled
Aspiration, GL	Turbocharged, intercooled, and lean burn		Turbocharged, intercooled, and lean burn	Turbocharged, intercooled, and lean burn
Number of cylinders	Inline-6, 4-valves per cylinder	V-12, 4-valves per cylinder	V-12, 4-valves per cylinder	V-16, 4-valves per cylinder
Bore x stroke	2895 8.50 x 8.50 in. (216 x 216 mm) 3521 9.375 x 8.50 in. (238 x 216 mm)	5108 8.50 x 7.50 in. (216 x 191 mm) 5790 8.50 x 8.50 in. (216 x 216 mm) 7042 9.375 x 8.50 in. (238 x 216 mm) 9390 9.375 x 8.50 in. (238 x 216 mm)	8.50 x 7.50 in. (216 x 191 mm)	9.375 x 8.50 in. (238 x 216 mm)
Displacement	2895G, GSI, GL 2894 cu. in. (47 litres) 3521G, GSI 3520 cu. in. (58 litres) 3521GL 3521 cu. in. (58 litres)	5108G, GSI, GL 5108 cu. in. (83.7 litres) 5790G, GSI 5790 cu. in. (115 litres) 5790GL 5788 cu. in. (95 litres) 7042G, GSI, GL 7040 cu. in. (115 litres) 9390G, GSI, GL 9388 cu. in. (154 litres)	5108 cu. in. (83.7 L)	9388 cu. in. (154 L)
Compression ratio G, GSI	2895G, GSI 8:1 optional 10:1 2895GL 10.5:1 3521G, GSI 8:1 optional 10:1 3521GL 10.5:1	5108 10:1 5790 8.2:1 7042 8.2:1	---	8:1
Compression ratio GL	2895GL 10.5:1 3521GL 10.5:1	5108 10.5:1 5790 10.5:1 7042 10.5:1	10.5:1	10.5:1
Speed range	700 - 1200 rpm (see engine nameplate)		1250 - 1500 rpm (see engine nameplate)	700 - 1200 rpm (see engine nameplate)
Low idle	450 rpm	450 rpm	450 rpm	450 rpm
Lubrication System				
Sump capacity, including filter and cooler*	72 gallons (272.5 litres)	99 gallons (375 litres)	99 gallons (376 litres)	165 gallons (625 litres)
Oil pan (Low level mark)	35 gallons (132.5 litres)	35 gallons (132.5 litres)	35 gallons (132.5 litres)	80 gallons (303 litres)
Oil pan (High level mark)	45 gallons (170.3 litres)	45 gallons (170.3 litres)	54 gallons (204.4 litres)	110 gallons (416 litres)

(Continued)

GENERAL INFORMATION

GENERAL SPECIFICATIONS				
Engine Model	6 Cylinder	12 Cylinder ³	5115GL	16 Cylinder
Lubrication System (continued)				
Lube oil filter capacity	20 gallons (75.7 litres)	36 gallons (136.3 litres)	36 gallons (136.3 litres)	45 gallons (170 litres)
Oil cooler capacity	(8 in.) 6.9 gal. (26.1 L) (10 in.) 10 gal. (37.8 L)	(8 in.) 6.9 gal. (26.1 L) (10 in.) 10 gal. (37.8 L)	9.0 gallons (34.1 litres)	10 gallons (38 litres)
Main filter	15 micron at @ 90% efficiency	15 micron at @ 90% efficiency	15 micron at @ 90% efficiency	15 micron at @ 90% efficiency
Strainer screen	74 micron	74 micron	74 micron	74 micron
Normal lube oil pressure	40 - 55 psi (275 - 380 kPa)	40 - 55 psi (275 - 380 kPa)	40 - 55 psi (275 - 380 kPa)	35 - 50 psi 240 - 345 kPa
Low oil pressure alarm setpoint	30 psi (207 kPa)	30 psi (207 kPa)	30 psi (207 kPa)	25 psi (173 kPa)
Low oil pressure shutdown setpoint	20 psi (138 kPa)	20 psi (138 kPa)	25 psi (172 kPa)	15 psi (103 kPa)
Minimum oil pressure at turbo	10 psi (69 kPa)	10 psi (69 kPa)	10 psi (69 kPa)	10 psi (69 kPa)
Prelube duration	5 minutes			
Postlube duration	5 minutes after operation			
Normal oil header temperature	180° F (82° C)	180° F (82° C)	180° F (82° C)	180° F (82° C)
Oil header temperature alarm setpoint	195° F (91° C)	195° F (91° C)	195° F (91° C)	195° F (91° C)
Oil header temperature shutdown setpoint	205° F (96° C)	205° F (96° C)	205° F (96° C)	205° F (96° C)
Governor And Air Starter Capacities				
UG8 governor oil reservoir	1.5 quart (1.1 litre)	1.5 quart (1.1 litre)	1.5 quart (1.1 litre)	1.5 quart (1.1 litre)
Air starter oil reservoir for one shot lubricator	2.0 pint (0.9 litre)	2.0 pint (0.9 litre)	2.0 pint (0.9 litre)	2.0 pint (0.9 litre)
Air motorized pre-lube motor, in-line lubricator	0.5 pint (0.2 litre)	0.5 pint (0.2 litre)	0.5 pint (0.2 litre)	0.5 pint (0.2 litre)
Cooling System (Jacket Water And Auxiliary System)				
Normal charge air cooler inlet temperature		130° F (54° C)		
Jacket water capacity, engine only	8.5 in. bore 52.5 gal. (198.7 L) 9.375 in. bore 48.5 gal. (183.6 L)	8.5 in. bore 107 gal. (405 L) 9.375 in. bore 100 gal. (387 L)	107 gallons (405 litres)	148 gallons (560 litres)
Surge tank capacity (optional)	23 gallons (87 litres)	45.5 gallons (183 litres)	45.5 gallons (183 litres)	45.5 gallons (183 litres)
Intercooler water capacity	2.75 gallon (10.4 litres)	5.50 gallons (20 litres)	5.5 gallons (20 litres)	11 gallons (42 litres)
Oil cooler water capacity	6 in. diameter 3.4 gal. (12 L) 8 in. diameter 5.5 gal. (20 L) 10 in. diameter 9.4 gal. (34 L)	6 in. diameter 3.4 gal. (12 L) 8 in. diameter 5.5 gal. (20 L) 10 in. diameter 9.4 gal. (34 L)	5.0 gallons (18.9 litres)	9.4 gallons (35.6 litres)
Total system capacity	Add appropriate options to obtain total capacity			
Exhaust System				
Maximum permissible backpressure @ rated load and speed			See Table 4.35-1 <i>Maximum Allowable Exhaust Backpressure And Reductions For Speed And Load</i> in Section 4.35 <i>Exhaust System Maintenance</i>	
Crankcase Breather System				
Crankcase vacuum	0 to -1 (negative) in. (0 to -25.4 mm (negative)) H ₂ O			

(Continued)

GENERAL INFORMATION

GENERAL SPECIFICATIONS			
Engine Model	6 Cylinder	12 Cylinder ³	5115GL
Jacket Water Outlet Temperature			
Standard Cooling System	Normal:	180° F (82° C) for continuous rating 200° F (93° C) for intermittent rating	
	Alarm:	10° F (5.5° C) above normal/design temperature	
	Shutdown:	20° F (11° C) above normal/design temperature	
Elevated Temperature Solid Water Cooling System	Normal:	210° - 235° F (99° - 113° C) solid water	
	Alarm:	5° F (3° C) above normal/design temperature ¹	
	Shutdown:	10° F (5.5° C) above normal/design operating temperature ¹	
Ebullient Cooling System	Normal:	212° - 250° F (100° - 121° C)	
	Alarm:	See Note ² below	
	Shutdown:	See Note ² below	
Intake Manifold Temperature			
GSI & GL Engines	Normal:	Up to 10° F (5.5° C) above design intercooler water inlet temperature	
	Alarm:	15° F (8.5° C) above design intercooler water inlet temperature	
	Shutdown:	20° F (11° C) above design intercooler water inlet temperature	
Intake Manifold Pressure			
Contact Waukesha Engine Application Engineering Department			
Fuel System			
Natural gas pressure at regulator "G" Models		5 - 10 psi (34.5 - 69 kPa)	
Natural gas pressure at regulator "GSI" Models		20 - 25 psi (138 - 172 kPa)	
Natural gas pressure at regulator "GL" Models		35 - 50 psi (241 - 345 kPa)	
Natural gas pressure at regulator Draw-thru models		GSI - 6 in. (152 mm) of water column GL - 6 in. (152 mm) of water column at regulator and 30 psig (206.8 kPa) prechamber fuel supply	
Air Induction System			
Maximum permissible restriction @ rated load and speed			15 in. (381 mm) of H ₂ O
Required filtering efficiency (coarse dust test per SAE726C)			99.7%
Starting System			
Electric starting	24 volts DC		
Air pressure starting	150 psi (1043 kPa)(MAX) Pressure is based on 50° F (10° C) lube oil temperature		
Miscellaneous			
Park plug gap	See Table 1.15-4 and Table 1.15-5		
Engine timing	Refer To Engine Name Plate		
Main bearing temp shutdown	250° F (121° C)		
Overspeed shutdown	10% over governed speed		
Valve Train			
Valve Clearance - Hydraulic lifters 6, 12, and 16 cylinder engines - excluding 5115GL	Not applicable - 0.000		
Valve Clearance - 5115GL engines Only, non-hydraulic lifters Intake Exhaust	0.016 in (0.406 mm) (5115GL only) 0.036 in (0.914 mm) (5115GL only)		

NOTE: *Total capacity of lube oil system. Fill oil pan, filter, cooler, etc., run engine, then add oil as required to bring oil level in oil pan back to high mark. Record total amount for future reference.

¹ Waukesha Power Systems Code 1105, 1105A, or equivalent shutdown system recommended when jacket water temperature exceeds 210° F (99° C).

² Waukesha Power Systems Code 1106, 1106A, or equivalent shutdown system is recommended for ebulliently cooled engines.

³ Does not include 5115GL model.

GENERAL INFORMATION

TORQUE VALUES

Table 1.15-3 lists the torque values needed for the basic maintenance of VHP engines.

Table 1.15-3. Torque Values

DESCRIPTION	ft-lb	N-m
Spark Plugs CAUTION 13/16 inch reach spark plugs must be used with 13/16 inch reach carriers and 1/2 inch reach spark plugs must be used with 1/2 inch reach carriers. Mixing carrier and spark plug components will cause damage to equipment.	40 - 45 (dry)	54 - 61 (dry)
Spark Plug Carriers CAUTION Stainless steel prechamber seal (P/N 209562D) must be used with the prechamber cup when torquing the spark plug carrier to 275 - 280 ft-lb (373 - 380 N-m) (with FEL-PRO® C5-A®, P/N 51005 anti-seize compound applied to threads) or damage to equipment will result.	275 - 280 (with FEL-PRO® C5-A®, P/N 51005 anti-seize compound applied to threads)	373 - 380 (with FEL-PRO® C5-A®, P/N 51005 anti-seize compound applied to threads)
Gas Admission Valve (P/N 211587A used with stainless steel washer P/N 28357)	65 - 70	88 - 95
Rocker Arm Support Capscrews 1/2-13	55 - 60	75 - 81
Fixed Valve Lifter Screws	55 - 60	75 - 81
Rocker Arm Cover Capscrews	30 - 35	41 - 47
Oil Pan Access Covers (Current P/N E200224 with two capscrews)	18 - 20	24 - 27
Pressure Relief Valve Equipped Oil Pan Access Covers	18 - 20	24 - 27
Previous Oil Pan Access Covers (with one capscrew)	18 - 20	24 - 27

NOTE: All torques oiled unless specified.

CAUTION 1/2 inch reach spark plugs must be used with 1/2 inch reach spark plug carriers. Mixing spark plug carrier and spark plug components will cause damage to equipment.

Table 1.15-4. 1/2 Inch Reach Spark Plugs (Used On G and GSI, and 1/2 Inch Reach Spark Plug Carriers on GL Only)

COMPONENT	P/N	REMARKS
SPARK PLUG CARRIERS		
Carrier 1/2 inch plug reach	209567J*	Used on 5108GL only
Carrier 1/2 inch plug reach	209567E*	Used on 2895GL, 3521GL, 7042GL, 9390GL
SPARK PLUGS		
Standard	60999F (Nickel) (Gap 0.020 in. (0.508 mm))	G,GSI - Used with P/N 208338A spark plug recess cover and P/N 69694 "Blue coil"
	60999M (Nickel) (Gap 0.010 in. (0.254 mm))	GL - Used with P/N 208338A spark plug recess cover and P/N 69694 "Blue coil"
CSA (Shielded)	60999H (Nickel) (Gap 0.020 in. (0.508 mm))	CSA G,GSI - Use with P/N 208338B spark plug recess cover, P/N 69772A extension and current P/N 60615F coil
	60999R (Nickel) (previous production - see Table 1.15-5 for current production) (Gap 0.010 in. (0.254 mm))	CSA GL - Used with P/N 69694D (previous production CSA "long coil") and P/N 208338B spark plug recess cover
SPARK PLUG EXTENSIONS		
Extension	211357H (current) A211357 (previous)	G,GSI,GL - Use with P/N 208338A spark plug recess cover and P/N 69694 "Blue coil"
Extension CSA	69772A (current production)	CSA G,GSI - Use with P/N 208338B spark plug recess cover and current P/N 60615F coil
Boot **	740011	Replace boot as required

NOTE: * 1/2 inch reach spark plugs are used with 1/2 inch reach spark plug carriers only.

** Service P/N 211357H spark plug connectors with P/N 740011 Boot.

CAUTION VHP GL 13/16 inch reach spark plugs must be used with 13/16 inch reach spark plug carriers. Mixing spark plug carrier and spark plug components will cause damage to equipment.

Table 1.15-5. VHP GL 13/16 Inch Reach Spark Plugs (Used With 13/16 Inch Reach Spark Plug Carriers Only)

COMPONENT	P/N	REMARKS
SPARK PLUG CARRIERS		
Carrier 13/16 inch plug reach	209567M*	Used on 5108GL and 5115GL only
Carrier 13/16 inch plug reach	209567K*	Used on 2895GL, 3521GL, 7042GL, 9390GL
Carrier 13/16 inch plug reach (CSA)	209567S - (CSA)*	Used on 5108GL and 5115GL (CSA) Used with current CSA spark plug carrier, coil adapter and P/N 69694G Blue CSA flanged coil
Carrier 13/16 inch plug reach (CSA)	209567R - (CSA)*	Used on 2895GL, 3521GL, 7042GL, 9390GL (CSA) Used with current CSA spark plug carrier, coil adapter and P/N 69694G Blue CSA flanged coil
SPARK PLUGS		
Standard	60999S (4 ground) (Nickel) (Gap 0.010 in. (0.254 mm))	Used with P/N 69694 "Blue coil"
	60999W (J-Type) (Platinum) (service option) (Gap 0.010 in. (0.254 mm))	Used with P/N 69694 "Blue coil"
	60999T*** (J-Type) (Iridium/Platinum) (service option and CSA and Non - CSA current production) (Gap 0.010 in. (0.254 mm))	Used with P/N 69694 "Blue coil" in Non CSA applications, and current CSA spark plug carrier, coil adapter and P/N 69694G Blue CSA flanged coil in CSA applications
	60999X*** (J-Type) (Iridium/Platinum) (5115GL current production) (Gap 0.010 in. (0.254 mm))	5115GL used with P/N 69694 "Blue coil" Non CSA applications and and current CSA spark plug carrier, coil adapter and P/N 69694G Blue CSA flanged coil in CSA applications
CSA (Shielded)	60999U (4 ground)(Nickel) (service option) (Gap 0.010 in. (0.254 mm))	Used with P/N 69766A (previous production CSA "long coil") and 208338B spark plug recess cover
SPARK PLUG EXTENSIONS		
Extension	211357H (current production)	G,GSI,GL - Use with P/N 208338A spark plug recess cover and P/N 69694 "Blue coil"
Extension CSA	211357P (current production)	CSA GL - Use with P/N 208338A spark plug recess cover and current CSA spark plug carrier, coil adapter and P/N 69694G Blue CSA flanged coil in CSA applications
Boot **	740011	Replace boot as required


NOTE: * 13/16 inch reach spark plugs are used with 13/16 inch reach spark plug carriers only.

** Service P/N 211357H and P/N 211357P spark plug connectors with P/N 740011 Boot.

*** P/N 60999X spark plugs can be used in place of P/N 60999T spark plugs, but P/N 60999T spark plugs **cannot** be used in place of the P/N 60999X spark plugs on 5115GL engines, because of manufacturing differences.

GENERAL INFORMATION

ENGINE TIMING DATA

 **CAUTION** Detonation is NOT allowed at any time during engine operation, regardless of the specified timing. If detonation occurs at the specified timing, a timing adjustment must be made to retard the ignition timing until NO audible detonation exists. Engine damage may result if detonation occurs.

Refer to the engine nameplate for the proper engine timing value.

NOTE: Changing the engine timing will also change the exhaust emissions and fuel economy.

WAUKESHA KNOCK INDEX™ (WKI™) The WKI™, developed by Waukesha Engine, represents a major leap forward in field gas analysis. This new method replaces the Octane Method analysis method previously used.

The WKI™ greatly improves the accuracy of calculating fuel knock resistance of field gas, natural gas, and low Btu gases. In addition, the WKI™ is able to account for the “knock improver” characteristics of inert gases which are often found in gaseous fuels. When used in conjunction with the Waukesha Custom Engine Control® Detonation Sensing Module, Waukesha is often able to maximize power ratings and optimize performance on poor quality fuels while maintaining an adequate knock safety margin.

SERVICE TOOLS LIST

You will need the following special tools to perform the operator tasks on VHP engines (see Table 1.15-6). In some instances, substitute items may be used but only if specifically approved by Waukesha. To order these special tools, contact your local Waukesha Engine Distributor.

Table 1.15-6. Service Tools

WAUKESHA TOOL P/N	TOOL DESCRIPTION
167164D	Spark Plug Socket/Ext. (1 inch socket with 10 inch extension, for Shielded, CSA w/F.M. coils)
474016	VHP V- Belt Tester
474022	Timing Tool
475006	Spark Plug Spreading Tool
475037	Spark Plug Socket (NEW) (7/8 inch Socket 15-1/2 inch long w/rubber O-ring insert)
475028	Digital Manometer/Calibrator Kit
475029	O-Ring Lube
494087	Spark Plug Thread and Seat Cleaner (18 mm) for 1/2 inch reach spark plug bores
475065	Spark Plug Thread and Seat Cleaner (18 mm) for 13/16 inch reach spark plug bores
494227	Explosion Proof Timing Light
494258	Slack Tube Manometer
494287	Valve Adjusting Wrench
494338	Induction Timing Light
494421	Spark Plug Gapping Tool - 0.010 - 0.013 in. (0.254 - 0.330 mm)(4 prong)(not recommended for gapping used plugs)
494422	Spark Plug Gapping Tool - 0.018 - 0.022 in. (0.457 - 0.559 mm)(4 prong)(not recommended for gapping used plugs)
475033	Spark Plug Gapping Kit (4 prong) Contains gap setting tool for closing the gaps, a gap spreading tool, and two gap setting tools, 0.011 in. (0.279 mm) and 0.020 in. (0.508 mm)
489341	KRYTOX® GPL-206 grease - for spark plug boot and extension

CONTENTS

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SECTION 2.05 - FUEL SYSTEM DESCRIPTION

SECTION 2.10 - IGNITION SYSTEM DESCRIPTION

SECTION 2.15 - AIR INTAKE SYSTEM DESCRIPTION

SECTION 2.20 - TURBOCHARGER SYSTEM DESCRIPTION

SECTION 2.25 - COOLING SYSTEM DESCRIPTION

SECTION 2.30 - LUBRICATION SYSTEM DESCRIPTION

SECTION 2.35 - EXHAUST SYSTEM DESCRIPTION

SECTION 2.40 - CRANKCASE BREATHER SYSTEM DESCRIPTION

**SECTION 2.45 - PRELUBE AND STARTING SYSTEM
DESCRIPTION**

**SECTION 2.50 - ENGINE PROTECTION SHUTDOWN SYSTEM
DESCRIPTION**

SECTION 2.00

SPEED GOVERNING SYSTEM DESCRIPTION

SPEED GOVERNING SYSTEM DESCRIPTION

The engine speed governing system consists of the following components. Components may vary with the engine model:

- Governor Options
 - Woodward UG-8L Governor
 - Woodward UG-8 Dial Governor
 - Woodward UG-Actuator
 - Woodward EG-3P Electronic Governor
- Governor Linkage
- Magnetic Pickup (for electronic governors)
- Control Panels (for electric units)
- Overspeed Governor (optional)

WOODWARD UG-8L GOVERNOR

The Woodward UG-8L Governor, capable of isochronous operation (will maintain the same engine speed regardless of engine load) is a mechanical-hydraulic device (see Figure 2.00-1).

WOODWARD UG-ACTUATOR GOVERNOR

The Woodward UG-Actuator Governor, is a proportional electric/hydraulic actuator. The UG-Actuator converts an electrical input signal to a proportional hydraulic output-shaft position to control engine fuel flow. The UG-Actuator provides the advantages of electronic control while using the same linkages as the UG-8 governors. The UG-Actuator is outwardly similar to the UG-8L governor.

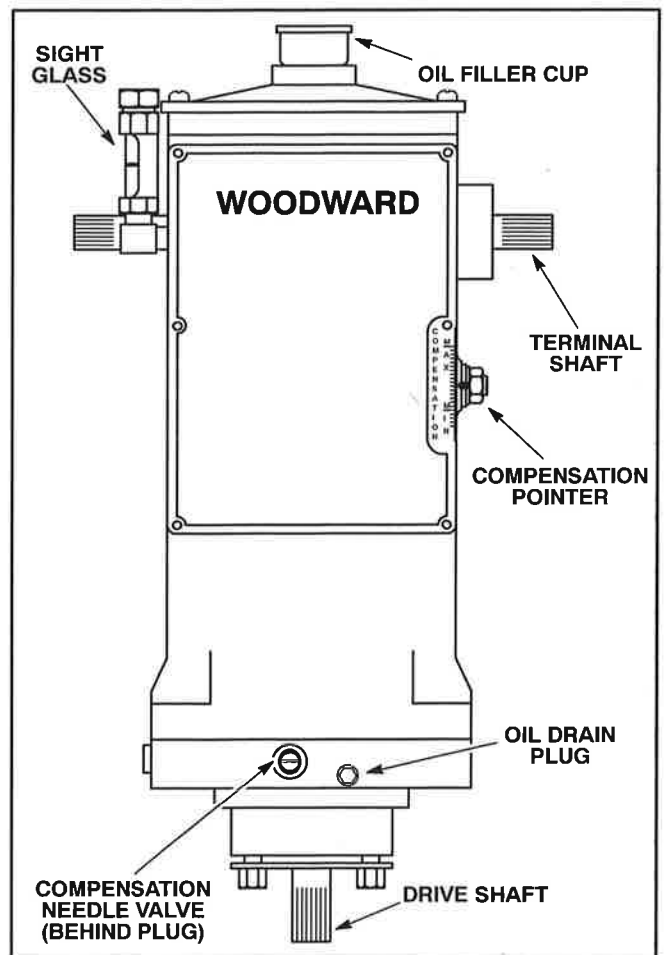


Figure 2.00-1. Woodward UG-8L Governor

WOODWARD UG-8 DIAL GOVERNOR

The Woodward UG-8 Dial Governor, is a mechanical-hydraulic device mechanically linked to the fuel system. The governor operates isochronously (will maintain the same engine speed regardless of engine load), except during transient load conditions. The UG-8 Dial Governor has dial adjustments on the face of the gear (see Figure 2.00-2). These dials are the Speed Droop control knob, the Load Limit control knob, the Synchronizer, and the Syn. Indicator. The speed droop control can be set to

SPEED GOVERNING SYSTEM DESCRIPTION

automatically divide and balance the load between engines driving the same shaft, or paralleled in an electrical system.

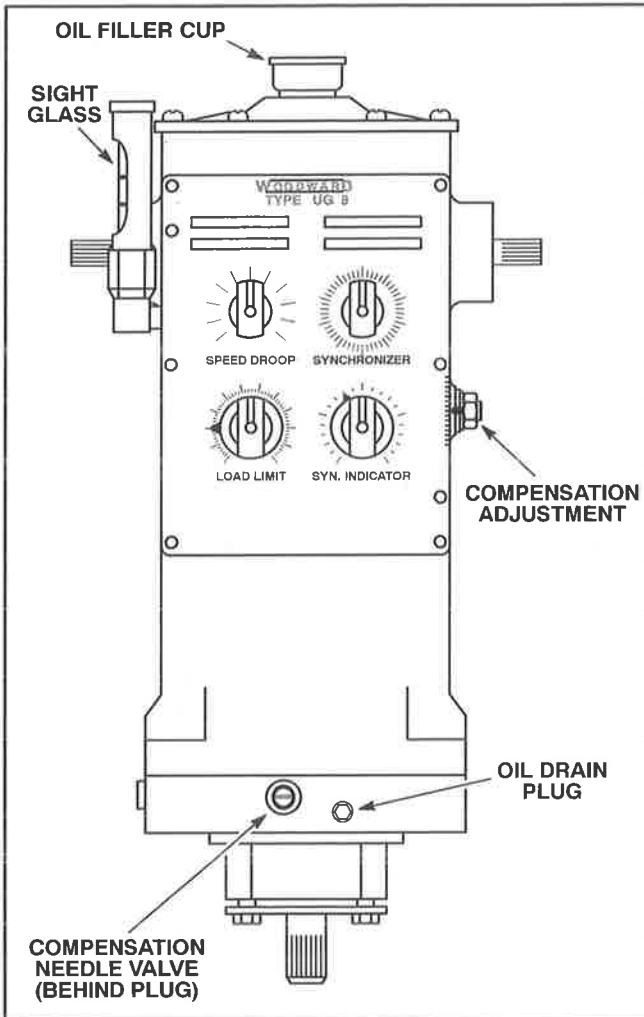


Figure 2.00-2. Woodward UG-8 Dial Governor

WOODWARD EG-3P ELECTRONIC GOVERNING SYSTEM

The Woodward EG-3P electronic governing system (see Figure 2.00-3) consists of three components, the magnetic pickup, the control unit and the actuator. The system is capable of isochronous operation (will maintain the same engine speed regardless of engine load). The control unit is off-engine mounted and is usually in the control room. It is the device that interrupts the signal that is sent from the magnetic pickup. The control unit then compares the the magnetic signal through circuitry and makes the proper adjustments through the actuator. The governor actuator is engine mounted, and is the mechanical device that physically moves the carburetor butterflies. The governor actuator is driven from the accessory drive gear.

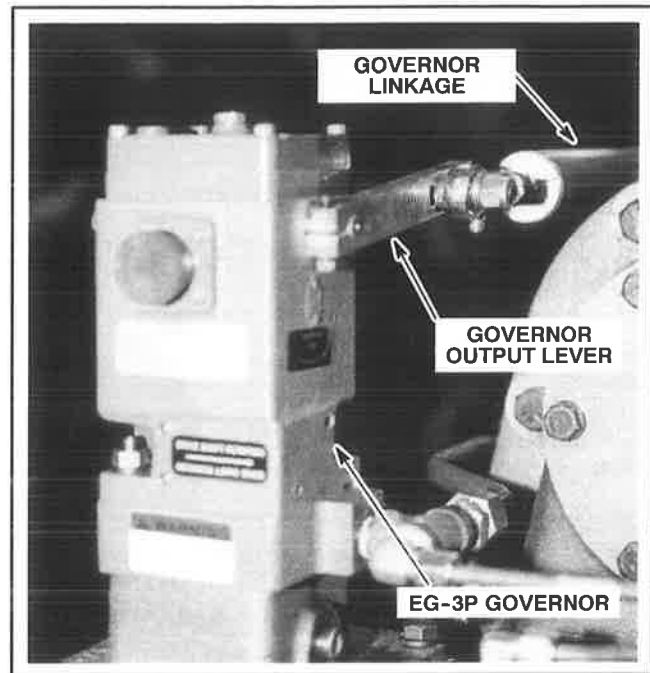


Figure 2.00-3. EG-3P Governor - 6 Cylinder Shown

OVERSPEED GOVERNOR

The overspeed governor is a safety device that protects the engine from overspeed damage (see Figure 2.00-4). The overspeed governor is activated when the engine speed rises approximately 10 percent above the maximum high idle speed. The overspeed governor functions only if the regular governor fails to operate.

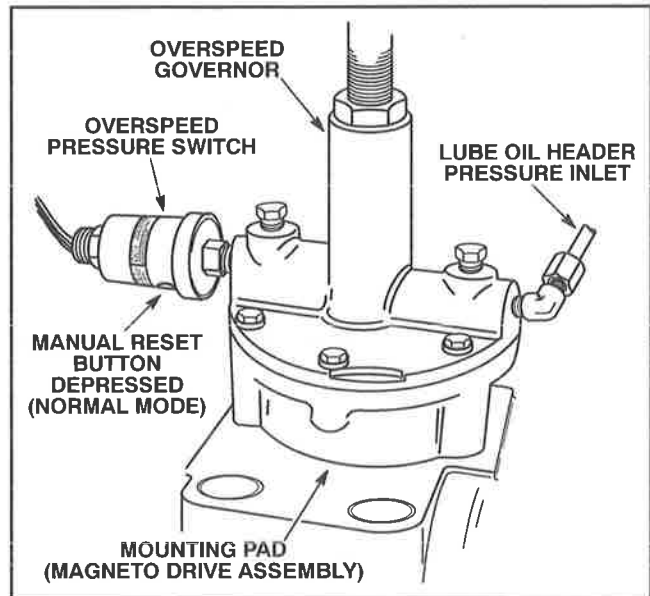


Figure 2.00-4. Overspeed Pressure Switch

GOVERNOR LINKAGE

The governor linkage (see Figure 2.00-3) connects the governor output shaft with the carburetor butterfly shaft. UG-8L governors (see Figure 2.00-5) have a hand lever on the side of the governor to manually set engine speed. UG-8 dial governors (see Figure 2.00-2) manually control engine speed with a dial control. All engines have a manual shutdown lever (see Figure 2.00-6) added to the linkage on the carburetor side, that enables the operator to manually return the engine to idle in the event of an emergency.

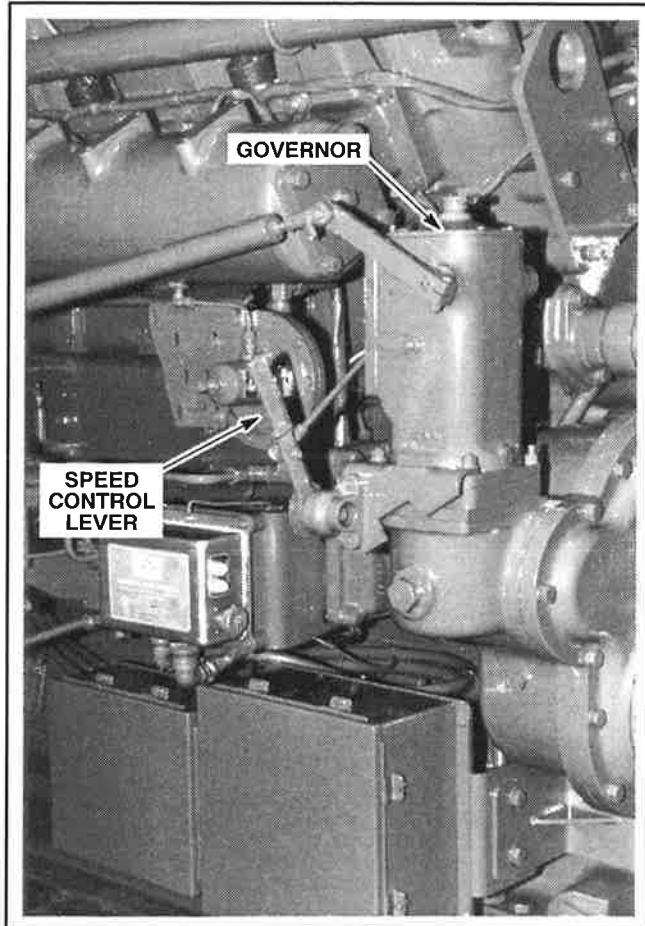


Figure 2.00-5. Governor Speed Control Lever - 5115GL

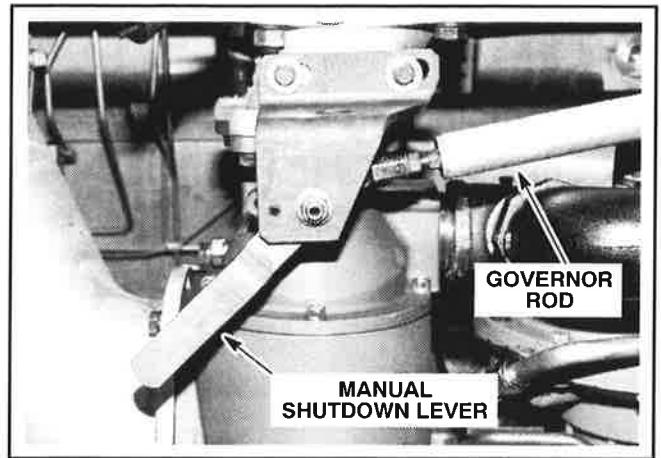


Figure 2.00-6. Manual Shutdown Lever - 5115GL

MAGNETIC PICKUP

The engine speed is detected by a magnetic pickup threaded into the flywheel housing above the flywheel ring gear.

SPEED GOVERNING SYSTEM DESCRIPTION

CONTROL PANEL

A control unit (see Figure 2.00-7 and Figure 2.00-8), used with electric units, is off-engine mounted, usually in the control room, and is the device that receives the signal that is sent from the magnetic pickup. The control unit then compares the magnetic pickup signal to the predetermined engine rpm signal through circuitry and makes the proper adjustments through the actuator. The engine rpm is set with the rated speed potentiometer located on the control unit, or by the optional external speed trim potentiometer. The rpm setting voltage is

compared at the control unit between the control amplifier voltage and the rpm voltage. The control amplifier sends an appropriate voltage to the actuator. For example, if the speed was greater than the speed setting, the control amplifier would decrease its output and the actuator would decrease fuel to the engine. Load sharing between two or more engine-generator sets is accomplished via the load sensing circuitry. Each generator's load is electronically measured continuously to other units on the same bus via parallel lines. Continuous correction to control loop gives load sharing.

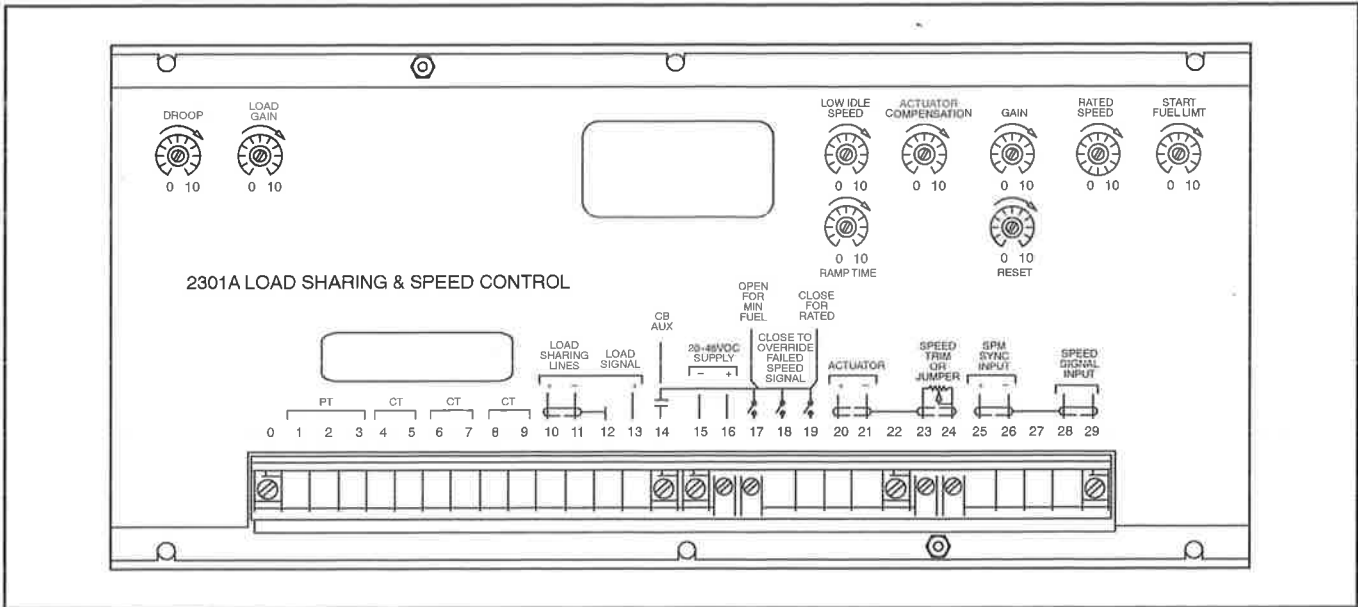


Figure 2.00-7. 2301A Load Sharing And Speed Control

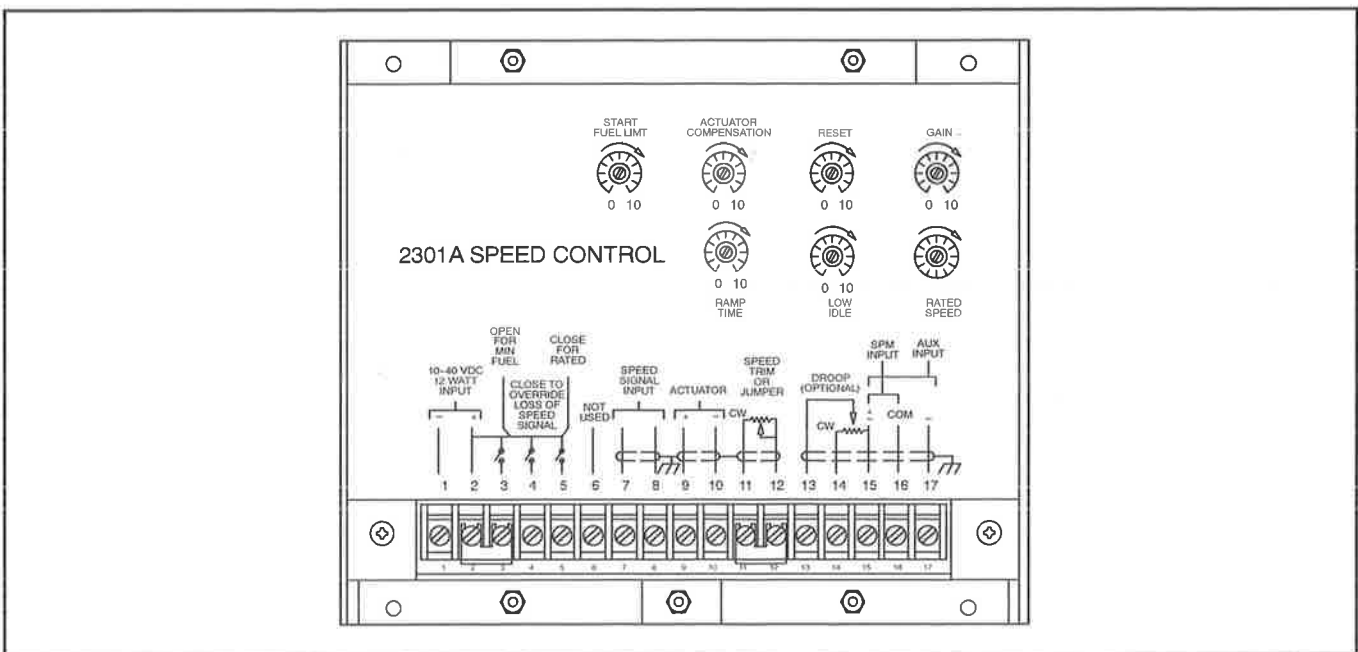


Figure 2.00-8. 2301A Speed Control

SECTION 2.05

FUEL SYSTEM DESCRIPTION

FUEL SYSTEM DESCRIPTION

The function of the fuel system is to maintain a constant air/fuel ratio throughout the load range of the engine and to deliver the air/fuel mixture in the proper quantities. See following components and Figure 2.05-1 for G/GSI/GL engine fuel components. See *Draw-thru Engines* in this Section, for draw-thru components.

- Main Fuel Gas Pressure Regulator(s)
- Carburetor(s)
- Pilot-Operated Prechamber Gas Valve (GL engines)
- Prechamber Gas Safety Shutdown Valve (GL engines)
- Prechamber Regulator (GL engines)
- Prechamber Manifolds (2) (GL engines)
- Fuel Admission Valves (one per cylinder) (GL engines)
- Custom Engine Control[®] Air/Fuel Module (AFM) System (Optional)

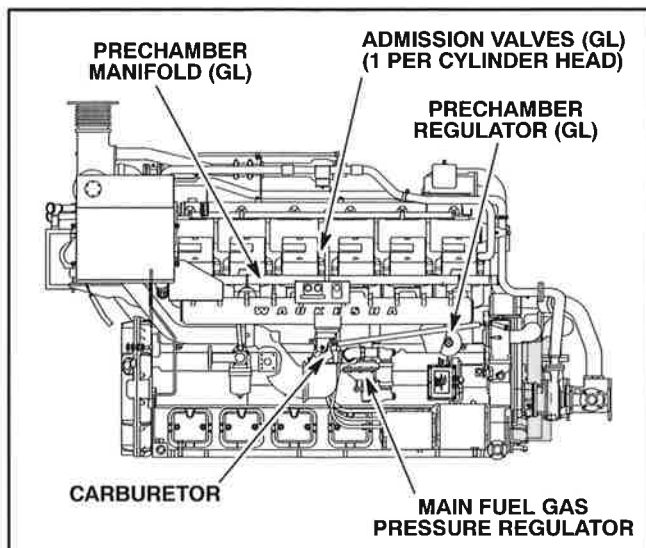


Figure 2.05-1. 5115GL Right Side Engine View

MAIN FUEL GAS PRESSURE REGULATORS

To ensure a steady fuel supply to the carburetor(s), all engines have one main fuel gas pressure regulator for each bank (see Figure 2.05-2).

The main fuel gas pressure regulator(s) reduce the incoming fuel supply pressure to the carburetor(s).

NOTE: The actual carburetor inlet fuel pressure will depend on the heating value of the fuel.

From the main fuel gas pressure regulator(s) the fuel flows into the carburetor(s) where it is mixed with air to provide a very lean mixture to the combustion chambers.

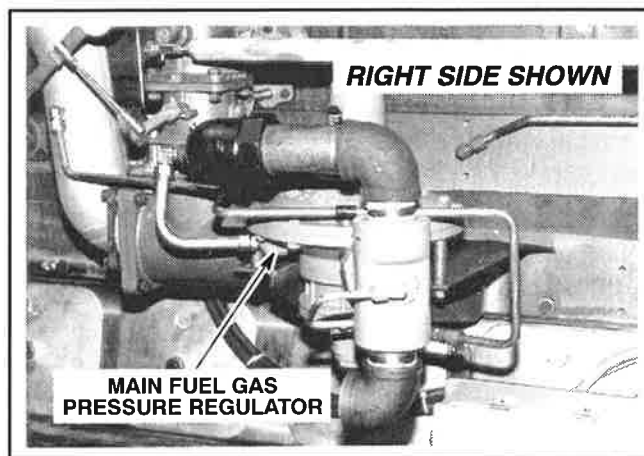


Figure 2.05-2. Fisher 99 Main Fuel Gas Pressure Regulator - 12 Cylinder GSI

FUEL SYSTEM DESCRIPTION

CARBURETOR(S)

All engines have a carburetor, mounted just below the center of each intake manifold (see Figure 2.05-3).

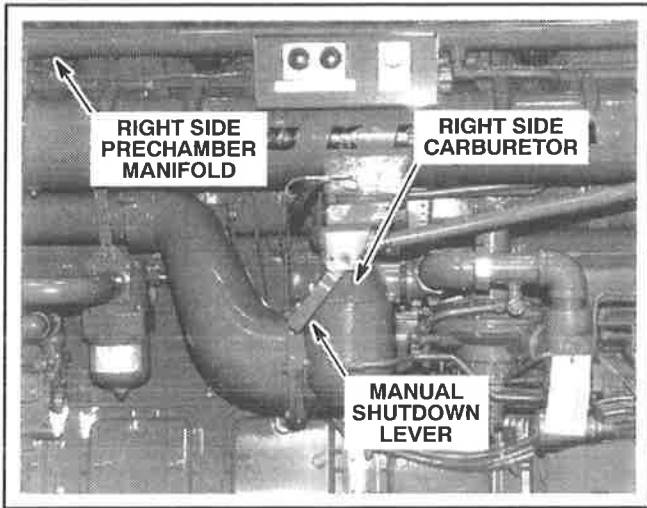


Figure 2.05-3. Carburetor - 5115GL Right Side View

The carburetor(s) produce a combustible mixture by automatically mixing air and fuel in the proper proportions.

PRECHAMBER REGULATOR

On GL engines, the prechamber regulator (see Figure 2.05-4) controls the amount of fuel available to the prechamber manifolds. The flow to the prechamber manifolds is fuel only. All of the air needed for combustion is pushed into the prechamber by the piston on its compression stroke.

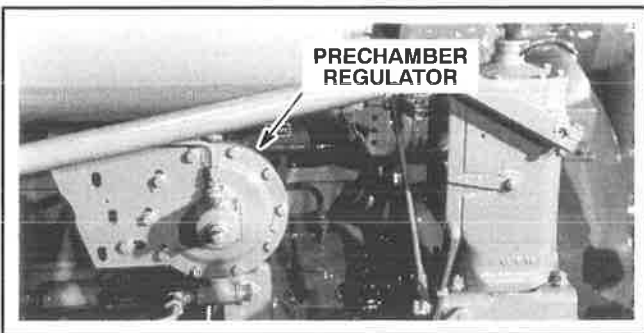


Figure 2.05-4. Prechamber Regulator 5115GL

PRECHAMBER GAS VALVE

On GL engines, the prechamber gas valve (see Figure 2.05-5), located on a line off the main fuel gas pressure regulator gas inlet pipe tee, admits high pressure gas to the prechamber fuel regulator.

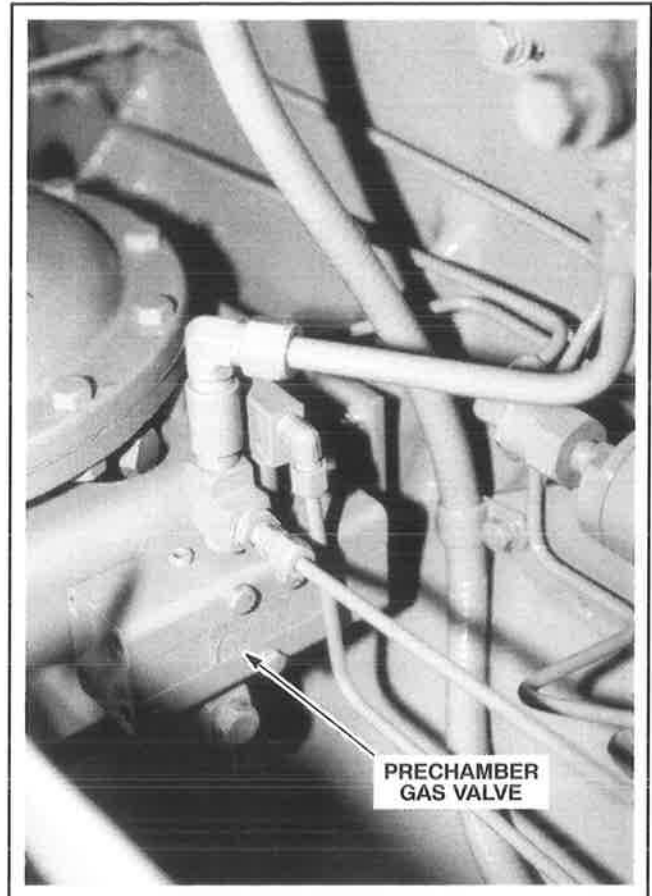


Figure 2.05-5. Prechamber Gas Valve - 6 Cylinder GL Engine Shown

PRECHAMBER GAS SAFETY SHUTDOWN VALVE

On GL engines, the prechamber gas safety shutdown valve (see Figure 2.05-6) admits gas pressure once engine lube oil pressure reaches or exceeds 20 psi (138 kPa). Lube oil pressure continues to admit gas to the prechamber regulator, while the engine is running.

If the engine stops, loss of engine oil pressure automatically causes the prechamber gas safety shutdown valve to stop the flow of gas to the prechamber gas valve, which shuts off the supply of gas to the prechamber regulator.

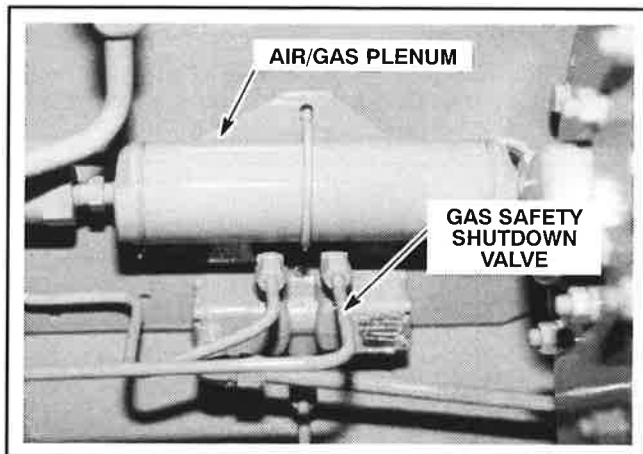


Figure 2.05-6. Prechamber Gas Safety Shutdown Valve - 6 Cylinder Engine GL Shown

ADMISSION VALVE ASSEMBLIES

On GL engines, each admission valve assembly (1 per cylinder head) is mounted at a 45 degree angle on the side of each cylinder head (see Figure 2.05-7). The admission valve directs the flow of fuel to the prechamber (see Figure 2.05-8). During the compression stroke, the air/fuel mixture flows into the prechamber through the prechamber torch holes and mixes with the prechamber gas. The spark plug ignites the near stoichiometric mixture.

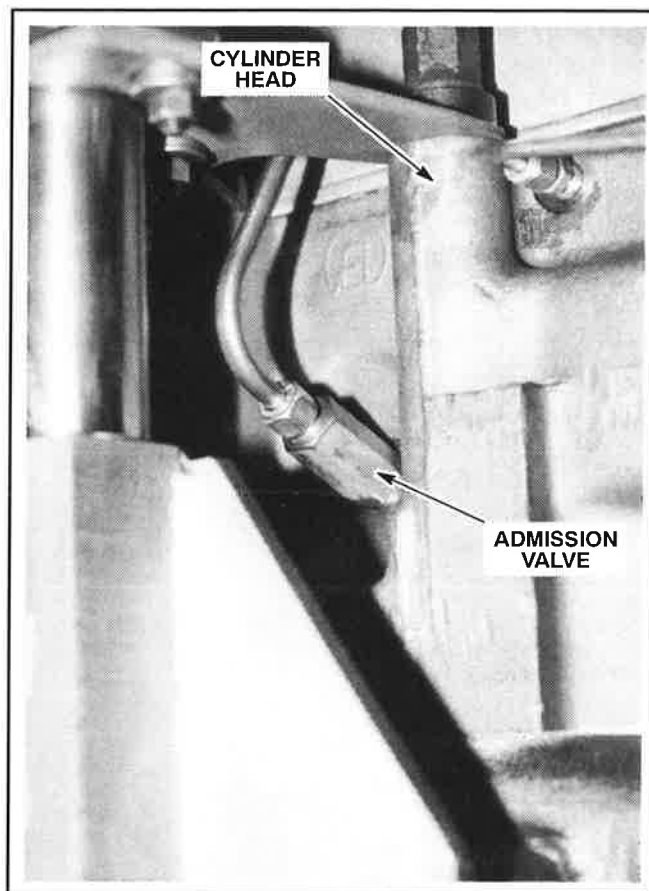


Figure 2.05-7. Admission Valves - 6 Cylinder GL Shown

FUEL SYSTEM DESCRIPTION

PRECHAMBERS AND SPARK PLUG CARRIERS

On GL engines, the air/fuel mixture in the main combustion chamber is so lean that it can't be ignited with a spark plug alone. With the prechamber design, the prechamber receives a rich fuel mixture that is easily ignited. The resulting flame ignites the lean mixture in the main chamber.

The top half of the prechamber is located in the bottom of the spark plug carrier. The lower portion of the prechamber is a separate piece with a six-hole nozzle (see Figure 2.05-8). The prechamber is filled with the rich air/fuel mixture through the admission valve. The prechamber fuel charge is leaned out by air flow into the prechamber during the compression stroke. This process is designed to be highly turbulent, ensuring good mixing of each prechamber charge. The spark plug then ignites the prechamber mixture, which directs a flame torch through the nozzle holes into the lean mixture in the main combustion chamber. The main chamber fuel charge then ignites.

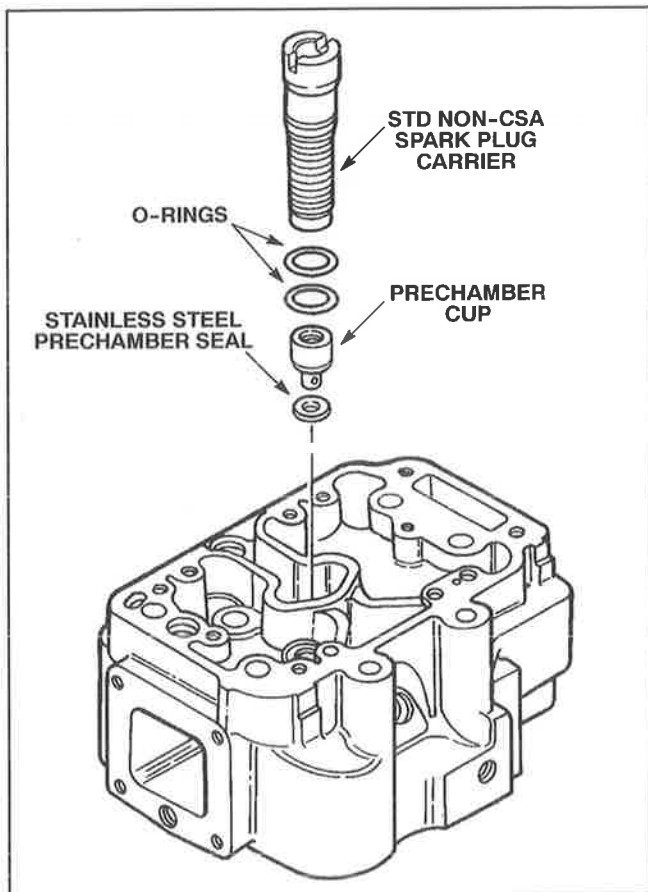


Figure 2.05-8. Prechamber/Spark Plug Carrier Assembly GL Engines

CUSTOM ENGINE CONTROL[®] AIR/FUEL MODULE SYSTEM

The Custom Engine Control[®] (CEC) Air/Fuel Module (AFM) system is designed to control the air/fuel ratio of Waukesha's gaseous fueled, industrial engines (see Figure 2.05-9). An engine's air/fuel ratio defines the amount of air in either weight or mass in relation to a single amount of fuel supplied to an engine for combustion. Air/fuel ratio influences engine power, emissions, and fuel economy. By controlling an engine's air/fuel ratio with the AFM system, you will benefit in fuel savings, emissions control, and/or peak engine performance. The AFM system regulates and maintains the engine's air/fuel ratio even with changes in engine load, speed, fuel pressure, and fuel quality.

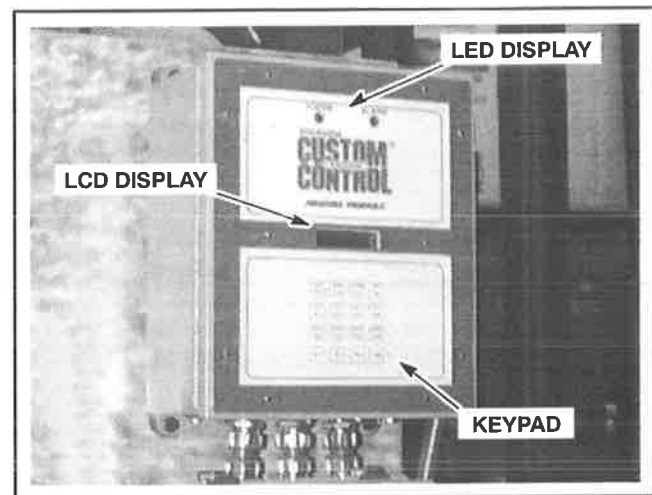


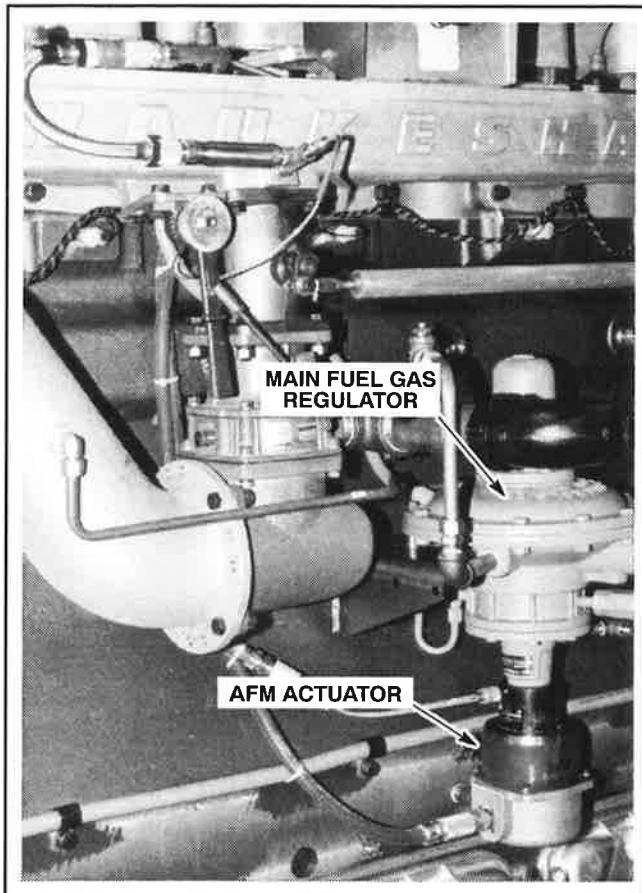
Figure 2.05-9. Air/Fuel Module Front Panel

The AFM system is programmed at the engine site and is customized for the engine based on site specific information with a personal computer (PC). Form 6263, *AFM Custom Engine Control[®] Air/Fuel Module Second Edition*, provides information on the operation and programming of the AFM.

The basic AFM system consists of an oxygen sensing system, intake manifold pressure transducer (catalyst and lean burn only), electronic control module (AFM module), actuator (see Figure 2.05-10), and exhaust thermocouple. The oxygen sensor continually reports the concentration of oxygen in the exhaust to the AFM module. Based on this signal, the AFM module then determines if a correction to the air/fuel ratio is required. If a change is needed, a command is sent to a stepper motor (installed on the fuel regulator) which influences the fuel flow to the engine. The exhaust thermocouple ensures exhaust temperatures are high enough to permit correct system operation.

The AFM module is equipped with several features to inform site personnel of system status. These features include:

- “Power” and “Alarm” lights (LED display) on the front panel of the AFM module (see Figure 2.05-9)
 - The green “Power” LED is lit any time power is applied to the AFM module
 - The yellow “Alarm” LED is lit any time the AFM system’s diagnostic functions are activated or when AFM execution has been stopped by the operator (such as during the saving of a data-set)
- An alpha-numeric liquid crystal display (LCD display) visible from the front of the AFM module allows the operator to monitor important system parameters
- A sealed membrane keypad located on the front of the AFM module

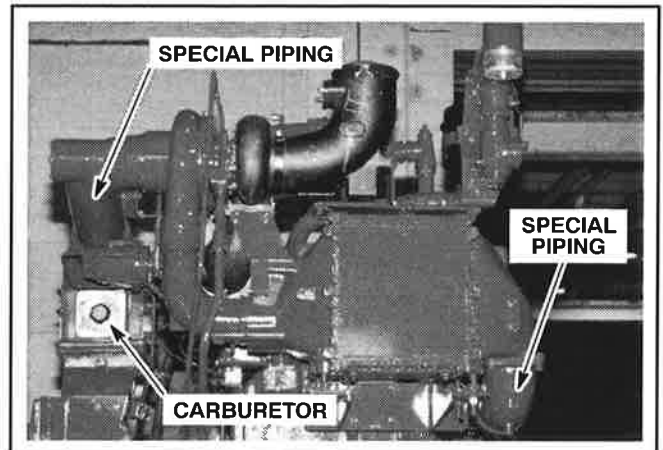


**Figure 2.05-10. AFM Actuator -
6 Cylinder Engine Shown**

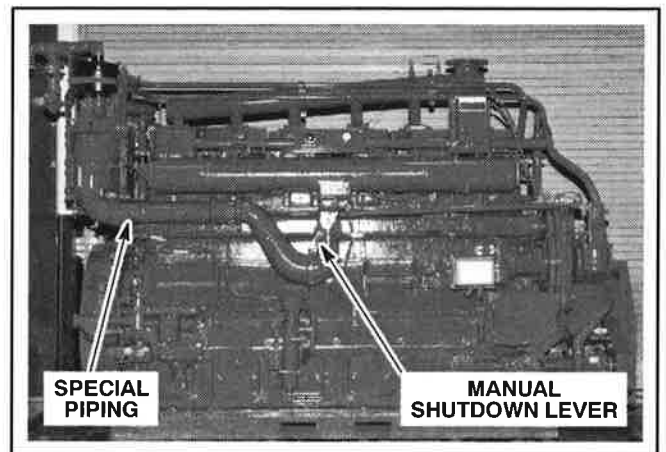
DRAW-THRU ENGINES

Draw-thru engines are capable of using low pressure fuel. Characteristic that are unique to these engines are listed below:

- Main Fuel Gas Pressure Regulator(s) mounted off engine
- Carburetor(s) mounted in plenum(s) on top of the air filter housing(s) (see Figure 2.05-11)
- Special piping that allows the air fuel mixture to be delivered to the intake manifold (see Figure 2.05-12)



**Figure 2.05-11. Draw-thru Engine -
6 Cylinder Engine Shown**



**Figure 2.05-12. Draw-thru Engine -
6 Cylinder Engine Shown**

FUEL SYSTEM DESCRIPTION

SECTION 2.10

IGNITION SYSTEM DESCRIPTION

IGNITION SYSTEM DESCRIPTION

The ignition system consists of the following components:

- Custom Engine Control® (CEC) Ignition Module (Standard) used with the following components:
 - Magnetic Timing Disc
 - Hall-effect Pickup Sensor
 - Cable Assemblies
- Spark Plugs (One per cylinder) and Spark Plug Carriers (GL)
- Spark Plug Connectors (One per cylinder)
- Ignition Coils (one per cylinder)
- Custom Engine Control® Detonation Sensing Module (Also described in this Section with *Engine Protection Equipment*)
- Wiring
- Magneto Ignition System (Optional)
- CSA Ignition (Optional)

SPARK PLUGS, SPARK PLUG CARRIERS, AND CONNECTORS

CAUTION 13/16 inch reach spark plugs must be used with 13/16 inch reach carriers, and 1/2 inch reach spark plugs must be used with 1/2 inch reach carriers. Mixing carrier and spark plug components will cause damage to equipment and/or personal injury.

One spark plug is provided for each of the cylinders. On G and GSI engines, 1/2 inch reach spark plugs are used. On these engines, the spark plug is threaded directly into the cylinder head. GL engines may be equipped with either 1/2 inch or 13/16 inch reach spark plugs and spark spark plug carriers (one per cylinder), however 1/2 inch reach spark plugs must be used with 1/2 inch reach spark plug carriers and 13/16 inch reach spark plugs must be used with 13/16 inch reach spark plug carriers. The spark plug carriers (see Figure 2.10-1), are stamped to identify the spark plug reach. If a Waukesha spark plug carrier is not marked, it is 1/2 inch reach. The spark plug carriers are threaded directly into the cylinder head and the spark plug is threaded into the spark plug carrier. The GL engines use spark plug carriers because of the special combustion characteristics of these engines (see Figure 2.10-2).

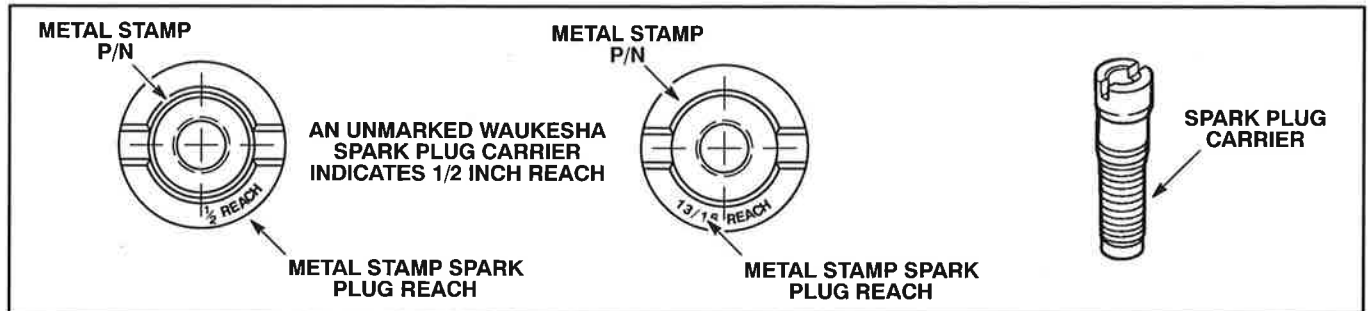


Figure 2.10-1. Spark Plug Carriers

IGNITION SYSTEM DESCRIPTION

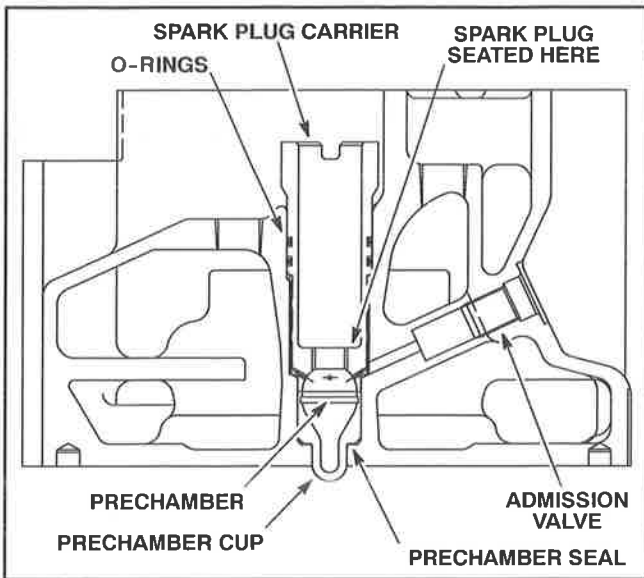


Figure 2.10-2. Spark Plug Carrier And Prechamber Design - GL Engine Cylinder Head Cutaway View

Spark plug connectors, (made of white Teflon, except for G, GSI and previous GL CSA engines) extend from the spark plug to above the rocker arm covers (see Figure 2.10-3).

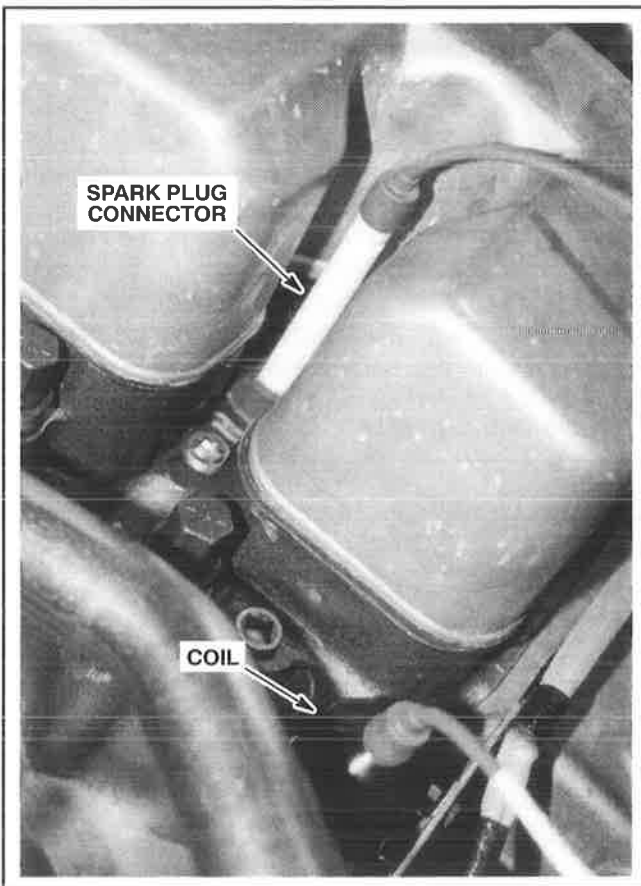


Figure 2.10-3. Spark Plug, Connector, And Ignition Coil - Standard Ignition

IGNITION COILS

One ignition coil is provided for each of the cylinders. Each coil is attached to a base that is securely mounted between the intake manifold runners (see Figure 2.10-2 and Figure 2.10-3).

CUSTOM ENGINE CONTROL® IGNITION MODULE

The Custom Engine Control® (CEC) Ignition Module (IM) (see Figure 2.10-4) and its associated components are described in the following paragraphs. Refer to Form 6253 (Previous Model) or Form 6272 (Current Model) *IM Custom Engine Control® Ignition Module Installation Operation And Maintenance* for further information concerning the IM.

The current IM is equipped with three diagnostic LEDs on front of the die cast IM housing: "Power," "Pickup," and "Application" (see Figure 2.10-4). These LEDs give operators visual confirmation on (1) incoming power, (2) Hall-effect pickup signal, and (3) proper application settings. The previous IM did not have diagnostic LEDs.

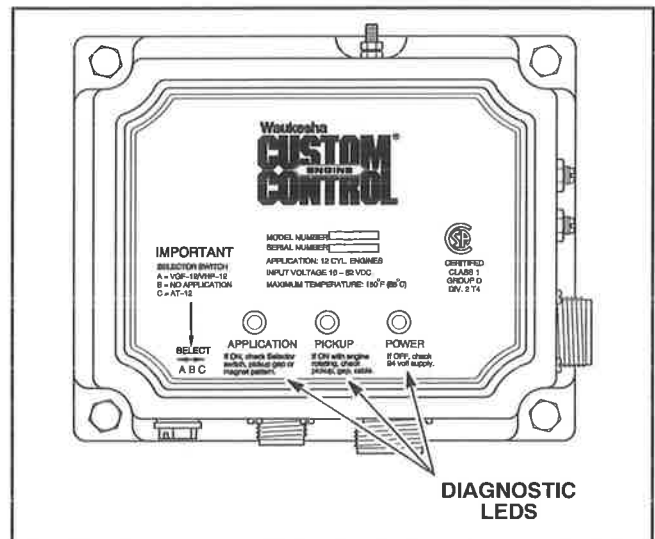


Figure 2.10-4. IM Diagnostic LEDs

The Custom Engine Control® (CEC) Ignition Module functions by using a Hall-effect pickup to read magnetic reference marks on a timing disc to determine the exact position of the crankshaft (see Figure 2.10-5, Figure 2.10-6, and Figure 2.10-7). The signals sent from the Hall-effect pickup to the IM, allow the IM to tell the correct cylinder, exactly when to fire. Your engine may be equipped with the Custom Engine Control® Detonation Sensing Module (DSM). The DSM system is connected to the IM system by a cable connector. The two systems, when connected together, provide defense against combustion detonation, which can lead to severe engine damage.

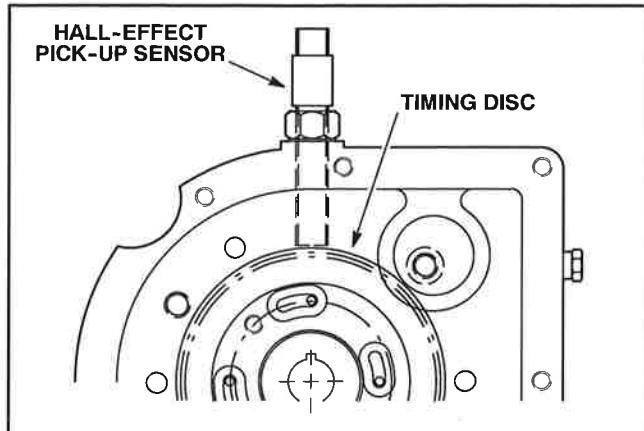


Figure 2.10-5. Hall-effect And Timing Disc - Internal View 5115GL

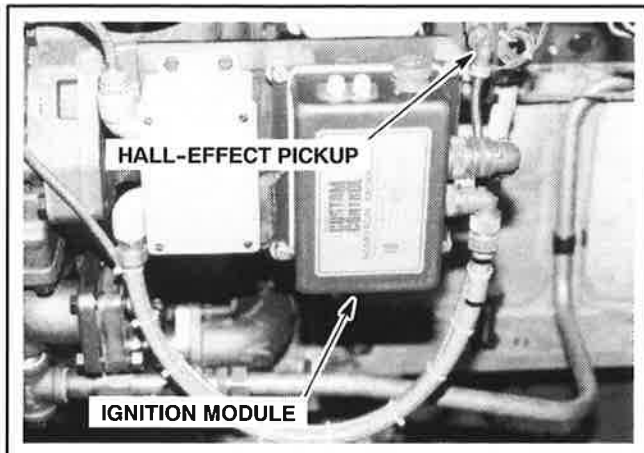


Figure 2.10-6. Hall-effect Sensor And Timing Disc - P9390

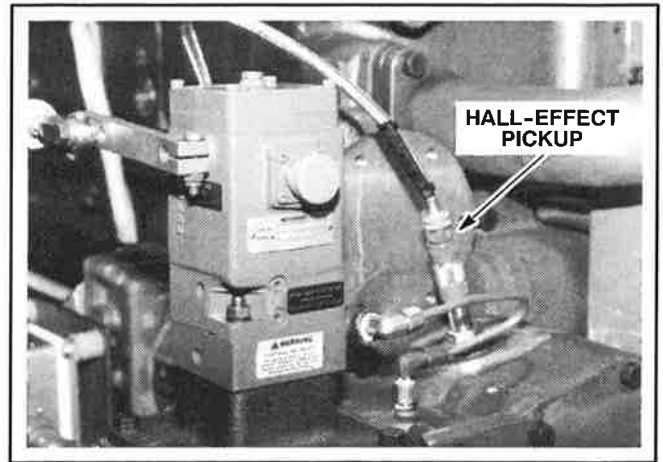


Figure 2.10-7. Hall-effect Pickup Location - 6 and 12 Cylinder Engines - 12 Cylinder Shown

On 5115GL and P9390 engines, the timing disc is located in the magneto adaptor housing attached to the governor drive gear hub. The Hall-effect pickup sensor is installed in the magneto adaptor housing with the 5115GL mounted vertically and the P9390 mounted horizontally. On all other models the timing disc is located in the governor drive housing and the Hall effect pickup is located next to the governor.

The ignition module can be set for dual fuel applications, two distinct fuel gases, or load conditions. Refer to Form 6253 (Previous Model) or Form 6272 (Current Model) *IM Custom Engine Control® Ignition Module Installation Operation And Maintenance* for further information concerning the IM.

IGNITION SYSTEM DESCRIPTION

MAGNETO IGNITION SYSTEM

The magneto ignition system consists of the following components:

- Magneto
- Spark Plugs (One per cylinder) and Spark Plug Carriers (GL)
- Spark Plug Connectors (One per cylinder)
- Ignition Coils (one per cylinder)
- Wiring

The magneto is driven from the accessory (magneto) drive gear (see Figure 2.10-8). The magneto uses solid state electronic components. Self-generated alternating current is rectified to direct current and stored within a capacitor. Silicon controlled rectifiers (SCR's) function as switches to release the stored energy to the ignition coils. A trigger coil arrangement produces the voltage needed to turn the SCR on.

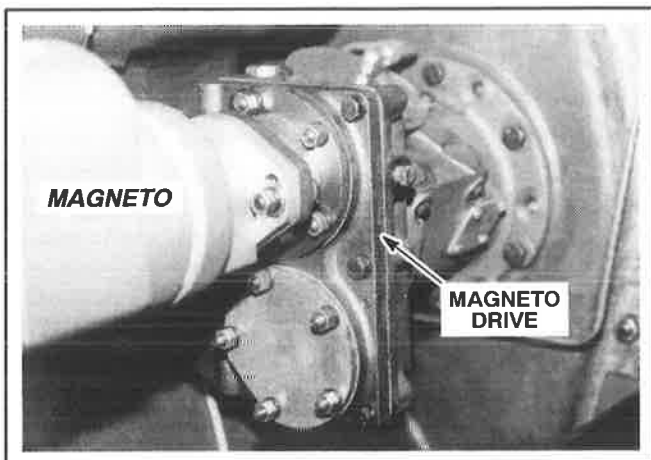


Figure 2.10-8. Magneto

CSA IGNITION SYSTEM

Engines may be equipped with special sealed CSA ignition systems. These units have special sealed switches and wiring. G and GSI engines have a special coil that is installed in place of the standard spark plug connector (see Figure 2.10-9). GL engines have a special longer spark plug carrier that has the ignition coil mounted directly to it (see Figure 2.10-10).

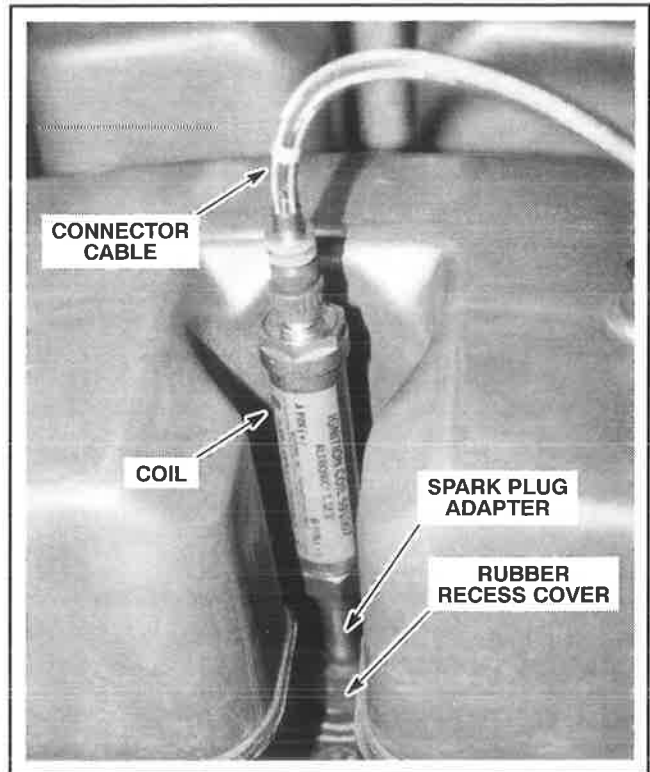


Figure 2.10-9. CSA Spark Plug Adapter And Coil - G, GSI

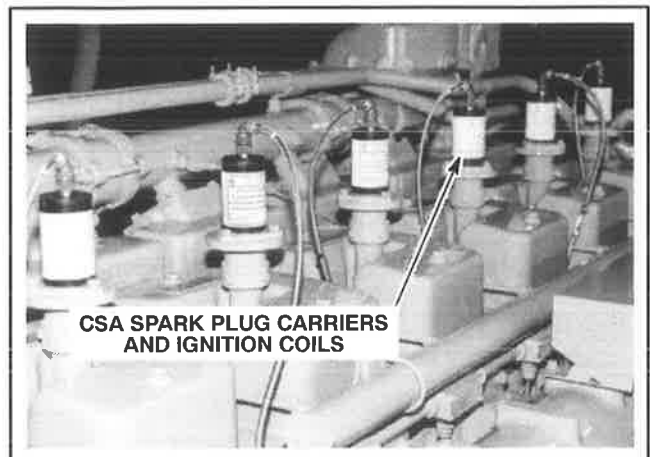


Figure 2.10-10. CSA Ignition - GL Engines - 6 Cylinder Shown

CUSTOM ENGINE CONTROL® DETONATION SENSING MODULE

To prevent detonation from occurring, Waukesha Engine has developed an electronic Custom Engine Control® Detonation Sensing Module (DSM) system that is designed to function with Waukesha spark ignited AT and VHP engines (see Figure 2.10-11 and Form 6268, *DSM Custom Engine Control® Detonation Sensing Module Installation Operation And Maintenance*). The DSM system protects Waukesha spark ignited gas engines from damage due to detonation on an individual cylinder basis.

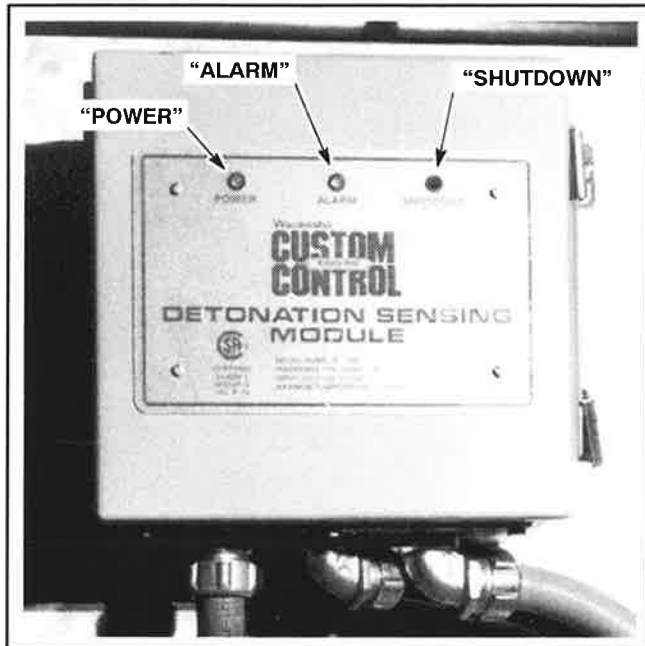


Figure 2.10-11. Detonation Sensing Module Front Panel

The DSM, and its related system, must function with a CEC Ignition Module with a 14 pin DSM expansion port. The DSM system also includes a Waukesha designed electronic filter, a detonation sensor mounted at each engine cylinder, and a number of interconnecting cables and harnesses that may vary depending on the application.

The DSM system is customized for each application with a personal computer. Refer to Form 6268, *DSM Custom Engine Control® Detonation Sensing Module Installation Operation And Maintenance* for further programming information.

The DSM module is equipped with several features to inform site personnel of system status. These features include:

- "Power", "Alarm", and "Shutdown" lights (LED display) on the front panel of the DSM module (see Figure 2.10-11)

- a liquid crystal display (LCD) located inside the DSM module which continually shows the current status of the system through diagnostic codes (see Figure 2.10-11)
- the capability to drive remote alarms or lights

For example, the DSM module can detect if a sensor has been damaged or disconnected. In either event, a default timing value is imposed for the cylinder associated with the lost signal. In addition to imposing the default timing, the DSM module will also illuminate the yellow alarm LED on the front cover, provide a signal for a remote alarm, and will display the error code on the LCD within the DSM module.

IGNITION SYSTEM DESCRIPTION

SECTION 2.15

AIR INTAKE SYSTEM DESCRIPTION

AIR INTAKE SYSTEM DESCRIPTION

The air intake system consists of the following components:

- Carburetor(s) G,GSI,GL
- Intake Manifold(s) G,GSI,GL
- Air Filtration System (Air Cleaner(s))
- Turbocharger(s) GSI,GL
- Intercooler(s) GSI,GL

CARBURETOR(S) AND INTAKE MANIFOLD(S)

Both the carburetor(s) and air intake manifold(s) are mounted to the outside of the cylinder bank(s). The carburetor produces a combustible mixture by automatically mixing air and fuel in the proper proportions (see Figure 2.15-1, Figure 2.15-2, and Figure 2.15-3).

Intake manifold(s) connect the intake ports of the cylinders and equally distribute the air/fuel mixture to each.

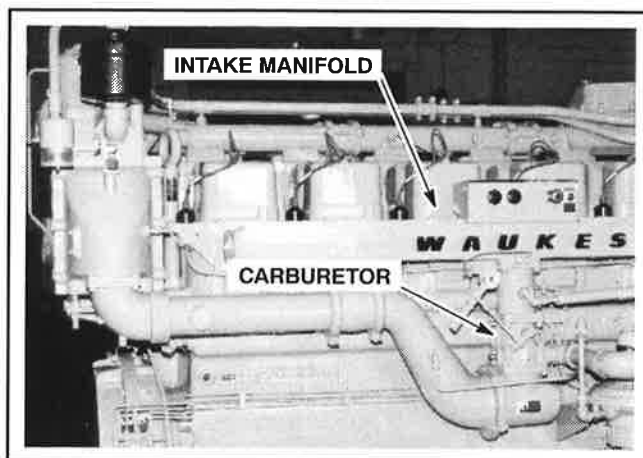


Figure 2.15-1. 6 Cylinder GSI

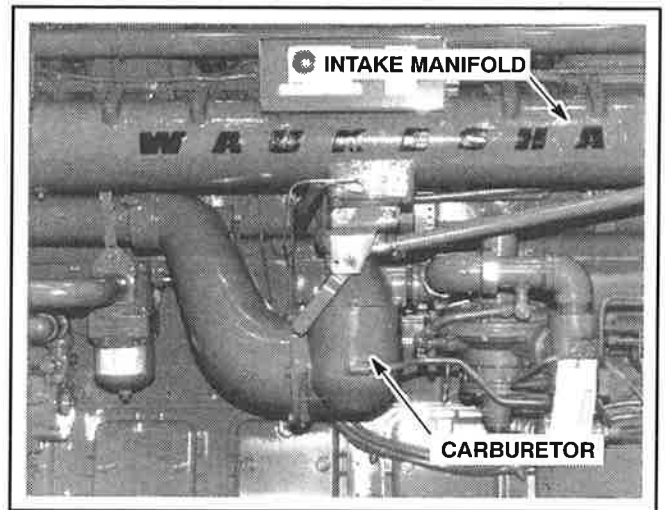


Figure 2.15-2. 12 Cylinder GL

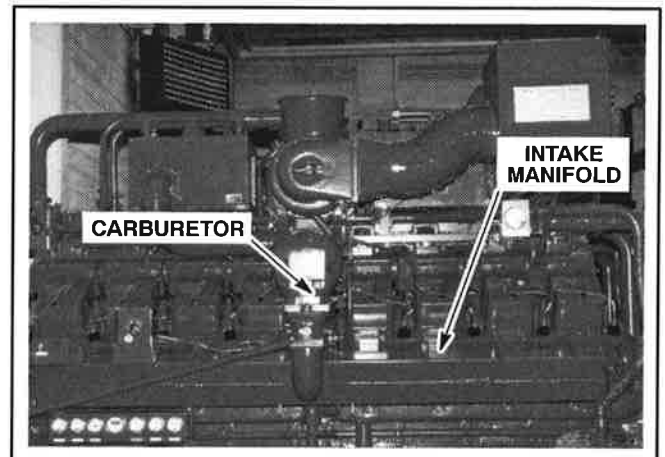


Figure 2.15-3. 16 Cylinder GSI

AIR CLEANER(S)

6 cylinder engines have one air cleaner (see Figure 2.15-4), while 12 and 16 cylinder engines have two air cleaners (see Figure 2.15-5 and Figure 2.15-6). Each air cleaner consists of the air filter frame, main air filter element, prefilter pad, air intake restriction indicator and rain shield.

AIR INTAKE SYSTEM DESCRIPTION

The air restriction indicator on 6 and 12 cylinder engines, will "pop red" if the air intake restriction is 15 in. (381 mm) of water. This indicates a clogged or dirty main air filter element and/or clogged or dirty precleaner element. On 16 cylinder engines, gauges mounted on each air cleaner register the condition of the air filters. The air restriction gauge must show in the green, for both the prefilter and final filter. A toggle switch allows the operator to select the filter reading desired.

TURBOCHARGER(S)

6 cylinder GSI and GL engines have one turbocharger (see Figure 2.15-4), all other VHP GSI and GL engines have two turbochargers, one for each bank (see Figure 2.15-5 and Figure 2.15-6).

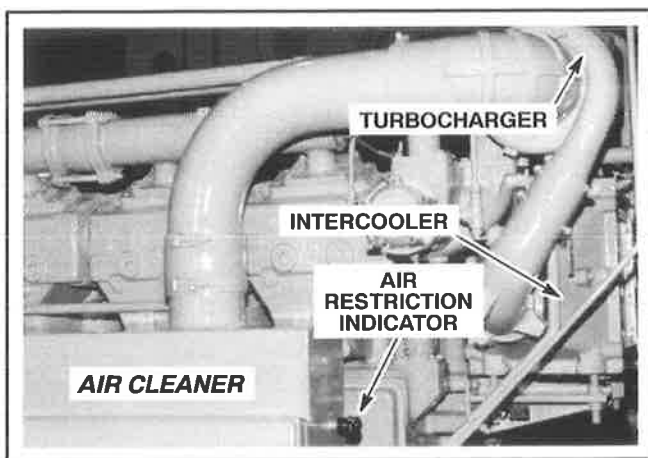


Figure 2.15-4. 6 Cylinder GSI - Rear View

INTERCOOLER(S)

Box-type intercooler(s), used on GSI and GL engines, are mounted on the rear of the engine on 6 and 12 cylinder models (see Figure 2.15-4 and Figure 2.15-5) and on top of the engine, on 16 cylinder models (see Figure 2.15-6). Heated compressed air from the turbocharger(s) enters the intercooler(s) and flows over a series of tubes through which the auxiliary water system coolant is circulated. The temperature of the compressed air is reduced, which makes it denser.

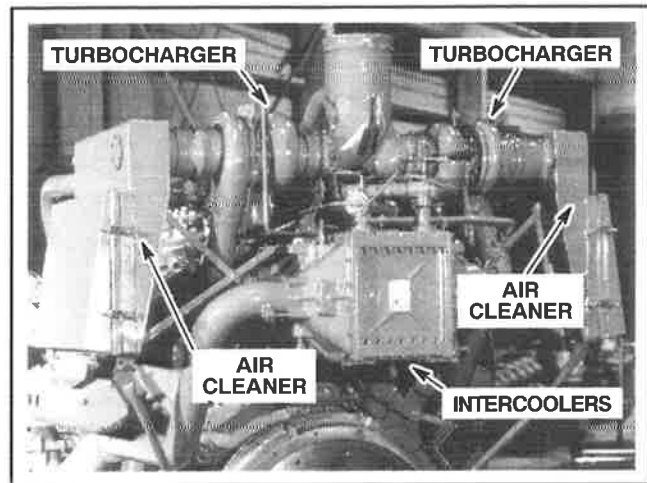


Figure 2.15-5. 12 Cylinder GL - Rear View

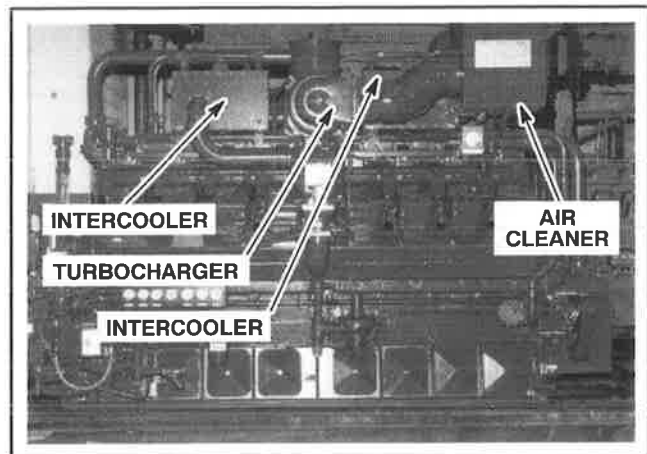


Figure 2.15-6. 16 Cylinder GSI

SECTION 2.20

TURBOCHARGER SYSTEM DESCRIPTION

TURBOCHARGER SYSTEM DESCRIPTION

GSI and GL engines are turbocharged. The turbocharger system consists of the following components:

- Turbocharger(s)
- Connecting Hose(s)
- Connecting Piping

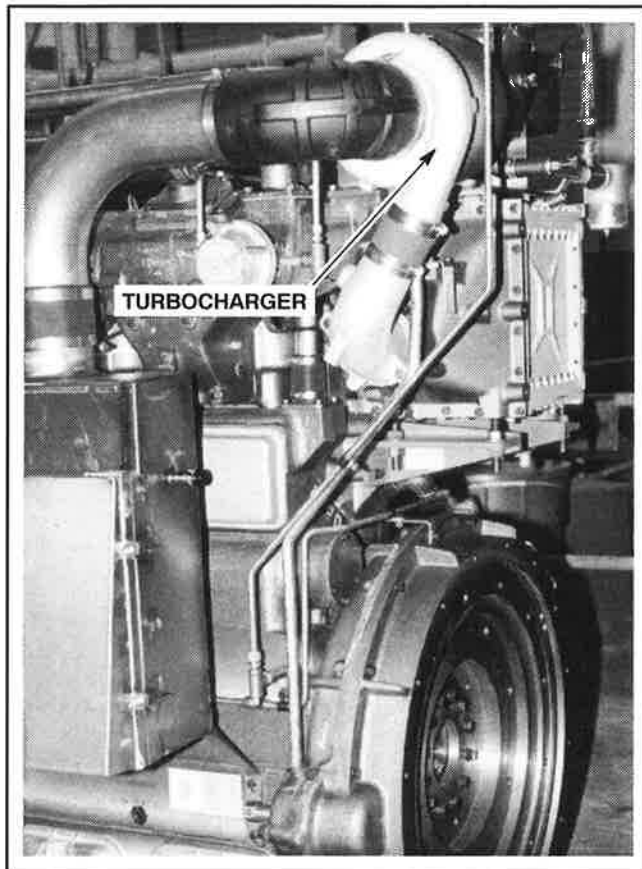


Figure 2.20-1. Turbocharger - 6 Cylinder Rear View

TURBOCHARGER(S)

6 cylinder GSI and GL engines have one turbocharger (see Figure 2.20-1), all other VHP GSI and GL engines have two turbochargers, one for each bank

(see Figure 2.20-2 and Figure 2.20-3). While the turbine side of each turbocharger is part of the exhaust system, the compressor side is part of the air intake system; a shaft connects the two. When the turbine is caused to spin from the expansion of exhaust gases exiting the engine, the movement of the compressor wheel causes the air passing through the air cleaner enroute to the carburetor, to be compressed.

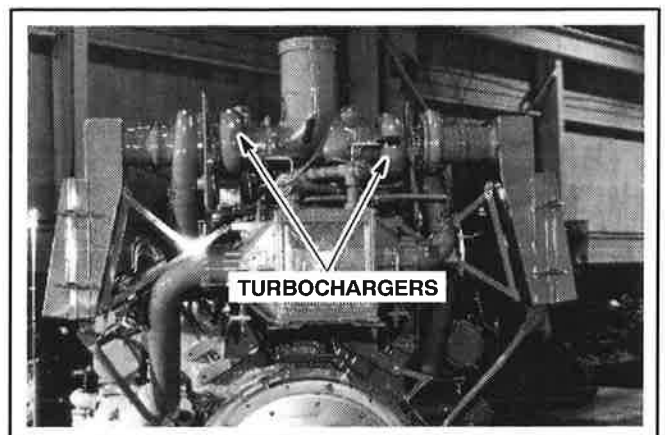


Figure 2.20-2. Turbochargers - 12 Cylinder GL Rear View

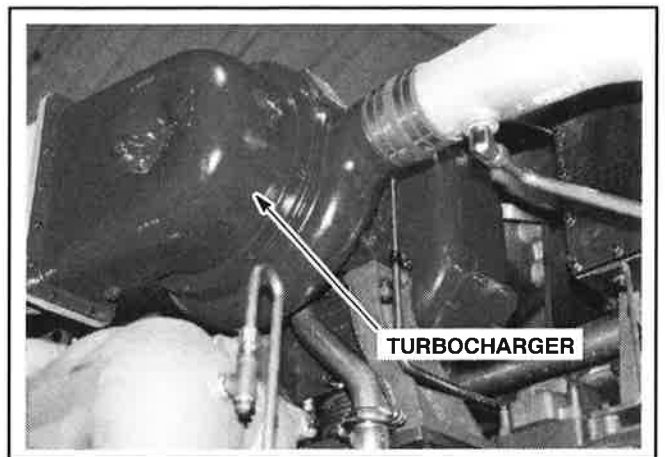


Figure 2.20-3. Turbochargers - 16 Cylinder GSI Side View

TURBOCHARGER SYSTEM DESCRIPTION

SECTION 2.25

COOLING SYSTEM DESCRIPTION

COOLING SYSTEM DESCRIPTION

The cooling system consists of the following components:

Jacket Water Circuit

- Jacket Water Header/Jacket Water
- Exhaust Manifold
- Jacket Water Pump
- Water Manifold
- Jacket Water Temperature Control Valve
- Surge Tank (Optional)
- Remote Heat Transfer Device (Customer Supplied)

Auxiliary Cooling Water Circuit

- Auxiliary Water Pump
- Intercoolers
- Oil Cooler
- Auxiliary Water Temperature Control Valve
- Auxiliary Water Heat Transfer Device (Customer Supplied)

JACKET WATER HEADER/JACKET WATER

The cooling water passageways in both the crankcase and cylinder heads comprise the jacket water system. The jacket water header is integrally cast within the crankcase. Cooling water circulates around the cylinder sleeves inside the cylinder block. Water flows up through the water passage openings in the deck of each cylinder head, flows around the valve seats and exhaust guides, and up to the water-cooled exhaust manifold(s).

EXHAUST MANIFOLD

From each cylinder head, water passes up through the water outlet elbow connection (see Figure 2.25-1) to one segment of the water-jacketed exhaust manifold(s) and exits through the water outlet port, to the water manifold. (see Figure 2.25-2 and Figure 2.25-3). Each exhaust manifold assembly is comprised of individual water-cooled segments.

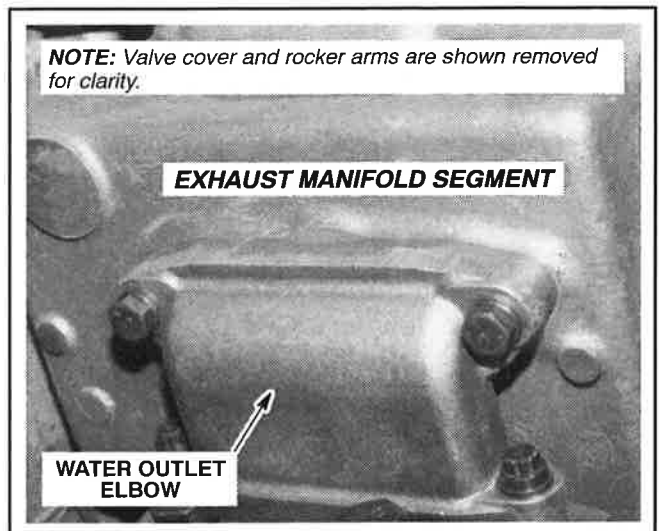


Figure 2.25-1. Water Outlet Elbows

COOLING SYSTEM DESCRIPTION

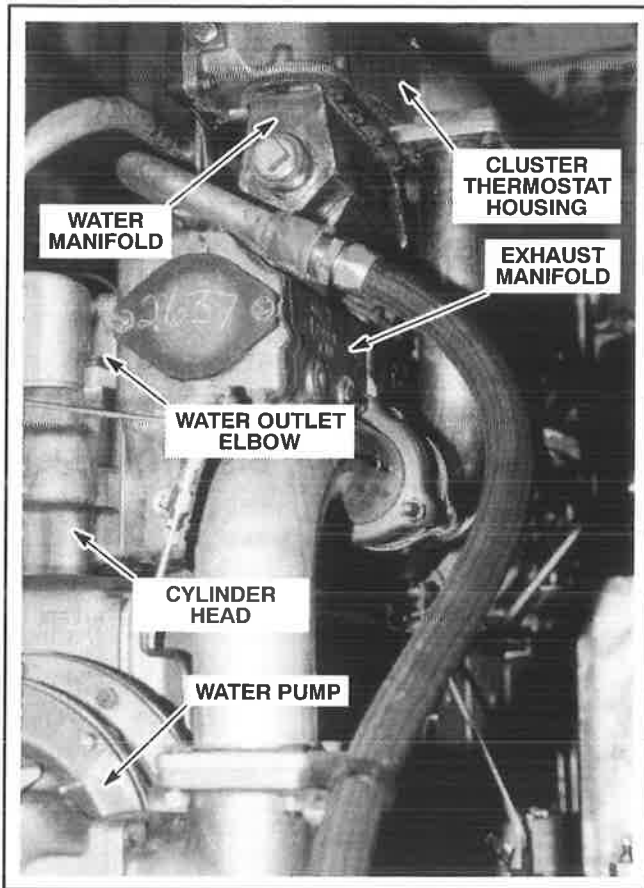


Figure 2.25-2. 6 Cylinder Engine Cooling Components

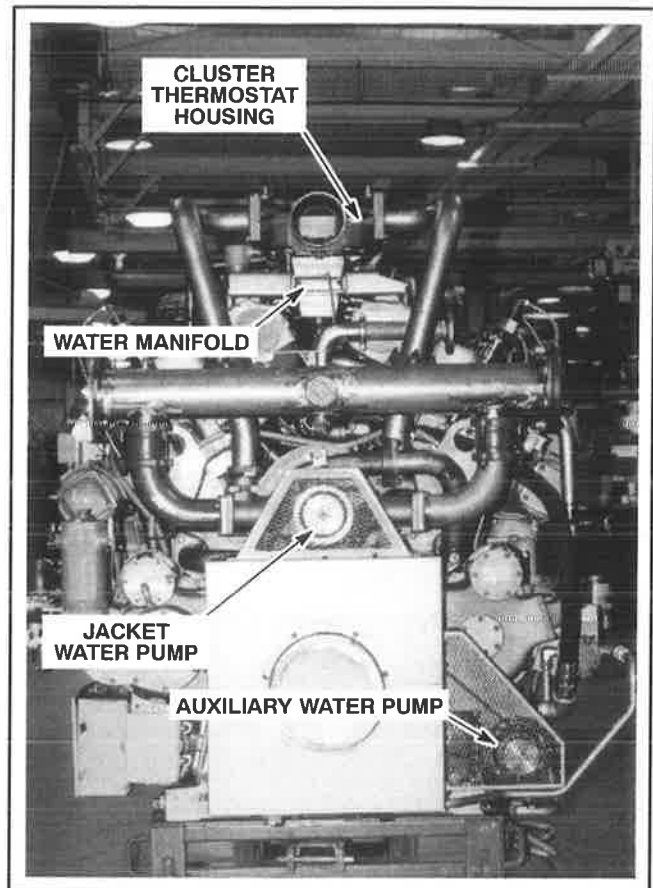


Figure 2.25-3. 12 Cylinder Engine Cooling Components

JACKET WATER PUMP

On 5115GL engines (see Figure 2.25-4), a gear driven water pump is mounted at the left side (as viewed from the flywheel end of the engine) of the gear cover. On 6, 12, and 16 cylinder engines (see Figure 2.25-3, and Figure 2.25-5) a belt driven water pump is mounted on the front of the engine. Cooling water exiting the pump is piped to the jacket water headers.

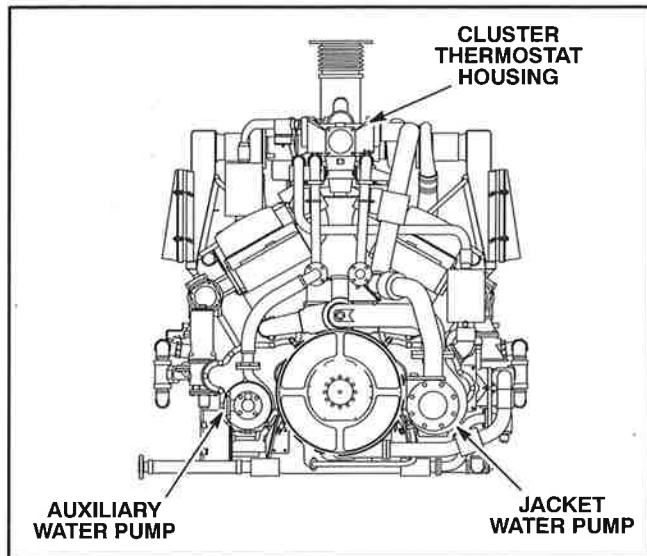


Figure 2.25-4. 5115GL Engine Cooling Components

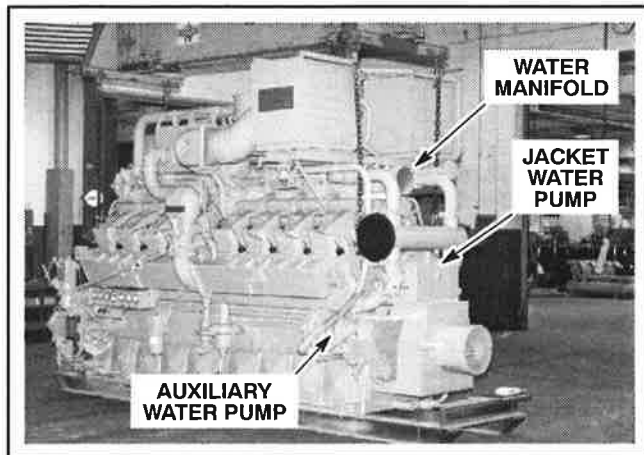


Figure 2.25-5. 16 Cylinder Engine Cooling Components

WATER MANIFOLD

The water manifold (see Figure 2.25-2, Figure 2.25-3, and Figure 2.25-5) receives the cooling water flowing out of each segment of the exhaust manifold and routes it to the cluster thermostat housing on 6 and 12 cylinder engines. On 16 cylinder engines, the thermostats are located in the connector elbows between the exhaust manifold segments and the water manifold.

CLUSTER THERMOSTAT HOUSING

The thermostatic valves are enclosed in the cluster thermostat housing at the outlet end (front) of the water manifold on 6 and 12 cylinder engines (see Figure 2.25-2, Figure 2.25-3, and Figure 2.25-4) and on 16 cylinder engines, located in the connector elbows between the exhaust manifold segments and the water manifold. By regulating the circulation of coolant, the thermostatic valves, control the jacket water temperature. The thermostatic valves remain closed while the engine is warming up, so cooling water is circulated through the engine water jacket only.

The thermostats start to open as the engine warms up to its normal operating temperature. A portion of the coolant is diverted to the remote heat transfer device, which absorbs the heat and directs the coolant back to the jacket water pump. The coolant supply from the heat transfer device mixes with that portion of the coolant that continues to flow down the bypass tube(s) to provide a blend that is within the normal range.

COOLING SYSTEM DESCRIPTION

SURGE TANK

The optional surge tank provides a coolant reservoir for the engine. A sight gauge on the side of the surge tank allows the operator to easily view the coolant level (see Figure 2.25-6).

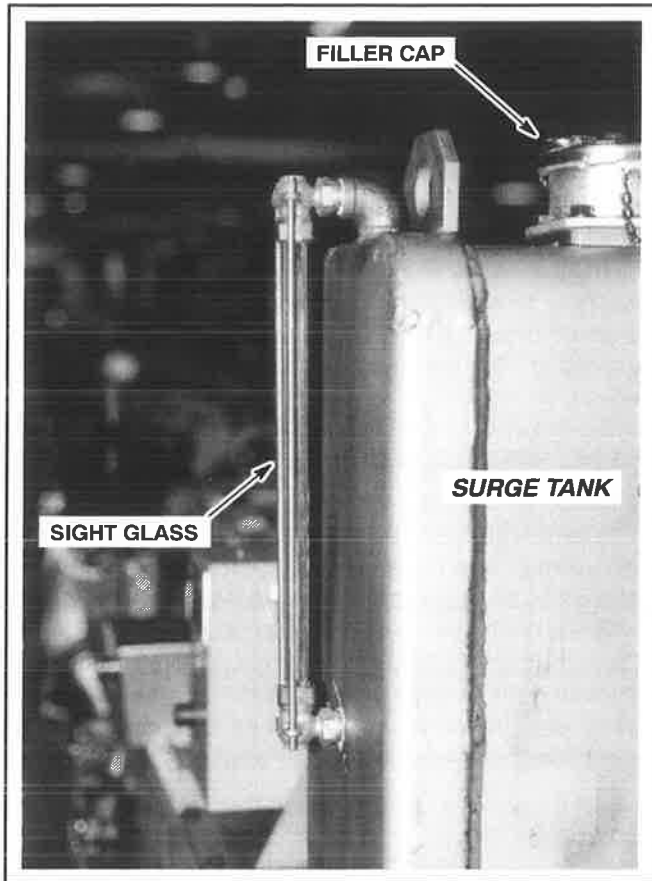


Figure 2.25-6. Surge Tank (Optional)

REMOTE HEAT TRANSFER DEVICE

The remote heat transfer device may be a radiator, cooling fan, cooling tower, heat exchanger or some other device.

AUXILIARY WATER PUMP

On 5115GL engines the gear driven auxiliary water pump is mounted at the right front of the gear cover (see Figure 2.25-4). All other VHP engines are belt driven. The 6 cylinder and 16 cylinder engines have the auxiliary water pump located on the lower right front of the engine (see Figure 2.25-2), while 12 cylinder engine auxiliary water pumps are located on the lower right front side (see Figure 2.25-3).

INTERCOOLER(S)

On GSI, and GL models, the intercooler(s) cool the inlet air to the turbochargers, to provide denser air to the turbochargers. The intercooler(s) are located at the rear of the engine on 6 and 12 cylinder engines (see Figure 2.25-7), and on top of the engine on 16 cylinder engines (see Figure 2.25-8).

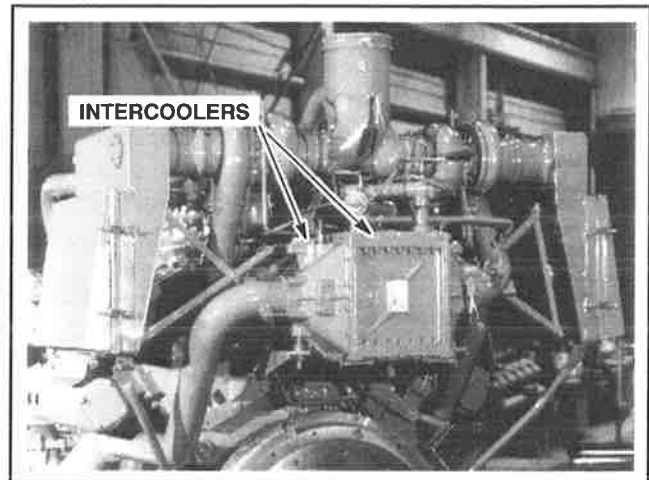


Figure 2.25-7. Intercoolers - 12 Cylinder Engine

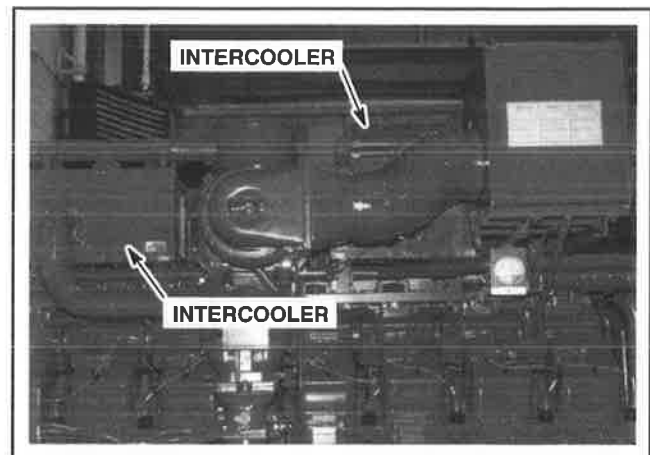


Figure 2.25-8. Intercoolers - 16 Cylinder Engine

OIL COOLER

The coolant flows from the intercooler(s) to the oil cooler. The oil cooler is a tube and baffle type assembly (see Figure 2.25-9). While the coolant flows through a bundle of tubes in the oil cooler, the lube oil circulates around them. Heat from the oil passes through the tubes to the coolant which carries it to a heat transfer device for dissipation. From the heat transfer device, the coolant passes back to the auxiliary water pump to repeat the circuit.

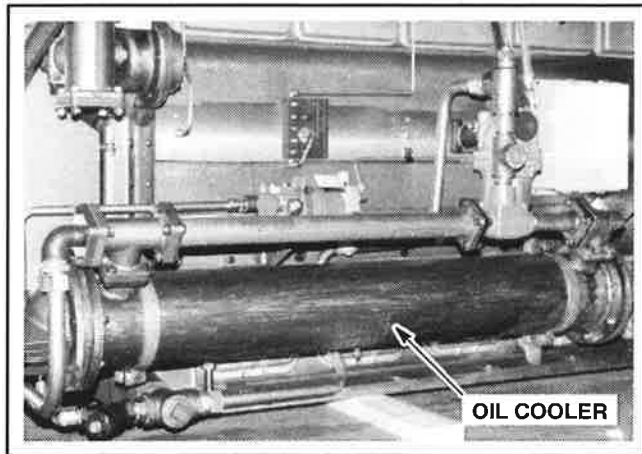


Figure 2.25-9. Oil Cooler - 6 Cylinder Engine Shown

AUXILIARY WATER REMOTE HEAT TRANSFER DEVICE

The auxiliary or secondary heat transfer device, may be a radiator, cooling fan, cooling tower, heat exchanger or some other device. The heat transfer device provides cooling for the auxiliary system coolant.

COOLING SYSTEM DESCRIPTION

SECTION 2.30

LUBRICATION SYSTEM DESCRIPTION

LUBRICATION SYSTEM DESCRIPTION

The lubrication system consists of the following components:

- Oil Pan and Pickup Screen
- Oil Pump
- Oil Cooler
- Temperature Control Valve
- Pressure Regulating Valve
- Full-Flow Lube Oil Filter
- Filter Relief Valve(s)
- Oil Strainer
- External Piping (customer supplied)

PRELUBE SYSTEM COMPONENTS

- Prelube Pump and Prelube Motor
- Prelube Pushbutton Valve
- Pilot-Operated Prelube Valve
- In-line Lubricator
- Oil Pressure Gauge

INTERNAL OIL CONTROL

The main oil header is an integral part of the crankcase casting (see Figure 2.30-1). Internal passages in the crankcase direct the flow of pressurized oil to the main bearings, via drillings in the main bearing saddles.

The flow of oil passes from the main bearing journals into the T-drilled crankshaft and then up through drilled passages in the connecting rods. After lubricating the connecting rod bearing, piston pin bushing and piston pin, the pressurized oil passes through an opening in the top of the rod. The oil spray exiting the rod cools the underside of the piston crown and drains back to the oil pan.

Oil supply tubes tapped off the internal oil passage leading to the front main bearing, supply a continuous spray of oil to the gear train.

Internal passages in the crankcase casting also direct the flow of pressurized oil to the camshaft bearing saddles to provide lubrication of the main camshaft bearings (bushings). Oil flows through holes in the cam bearing caps and down passageways in the valve lifter housing. This lubricates the roller followers and cam lobes, after which it drops back to the oil pan.

An external oil supply line off the main oil header carries oil to a separate external rocker arm oil header. Supply tubes from the rocker arm oil header direct the flow of oil to the rocker arm assemblies and valves.

Excess oil drains down a cored passage in the cylinder head and runs down the outside of the pushrod tubes to a drainage passage in the valve lifter guides. The passage directs the flow of oil to a drainage hole in the valve lifter housing where it flows back to the oil pan via the camshaft recess.

The flow of pressurized oil through the fixed valve lifter screws of the rocker arm assemblies also supplies oil to the lifters, where the excess oil joins the flow from the cored passage in the cylinder head.

The flow of pressurized oil through the external system, is depicted in Figure 2.30-2.

LUBRICATION SYSTEM DESCRIPTION

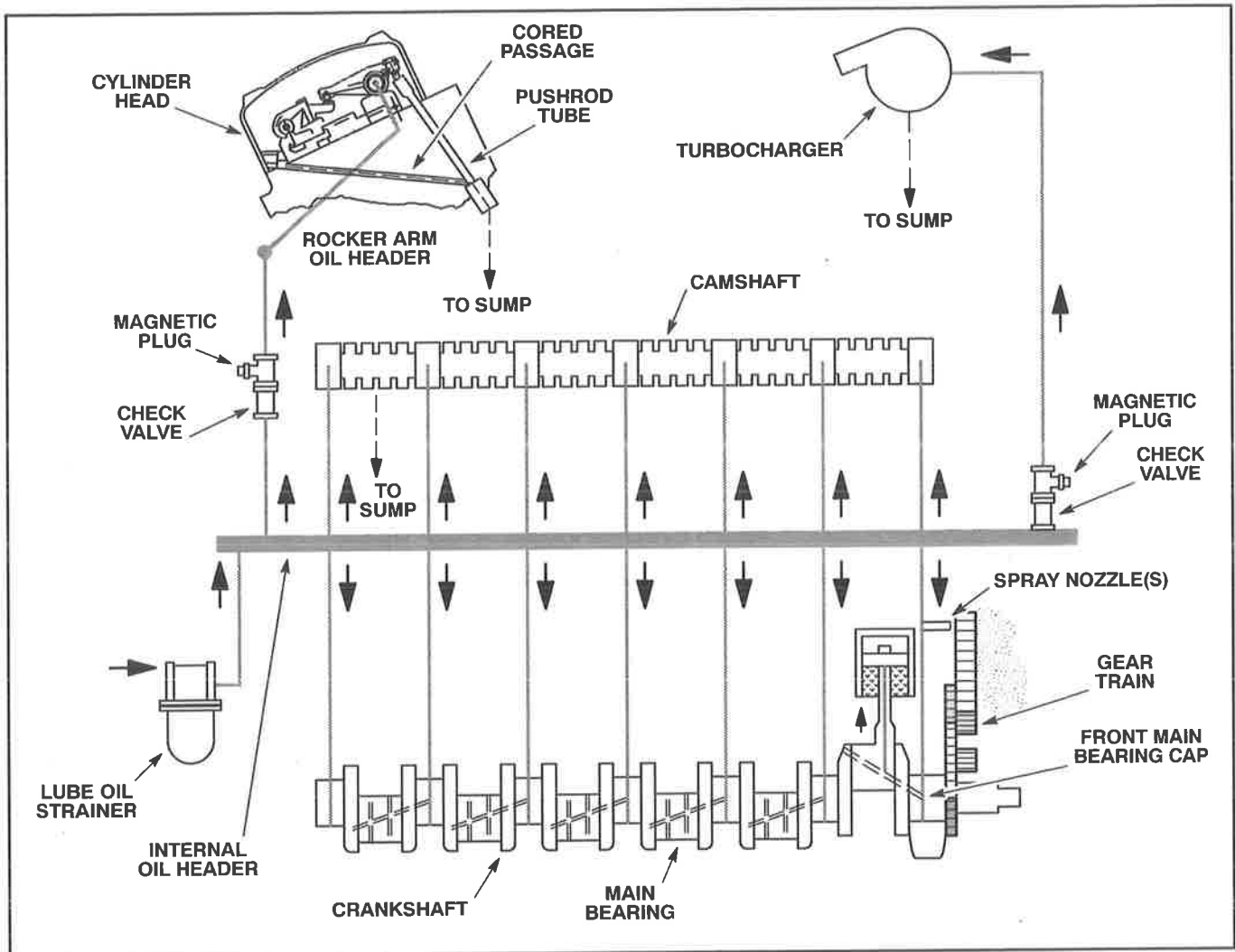


Figure 2.30-1. Internal Oil Flow System

LUBRICATION SYSTEM DESCRIPTION

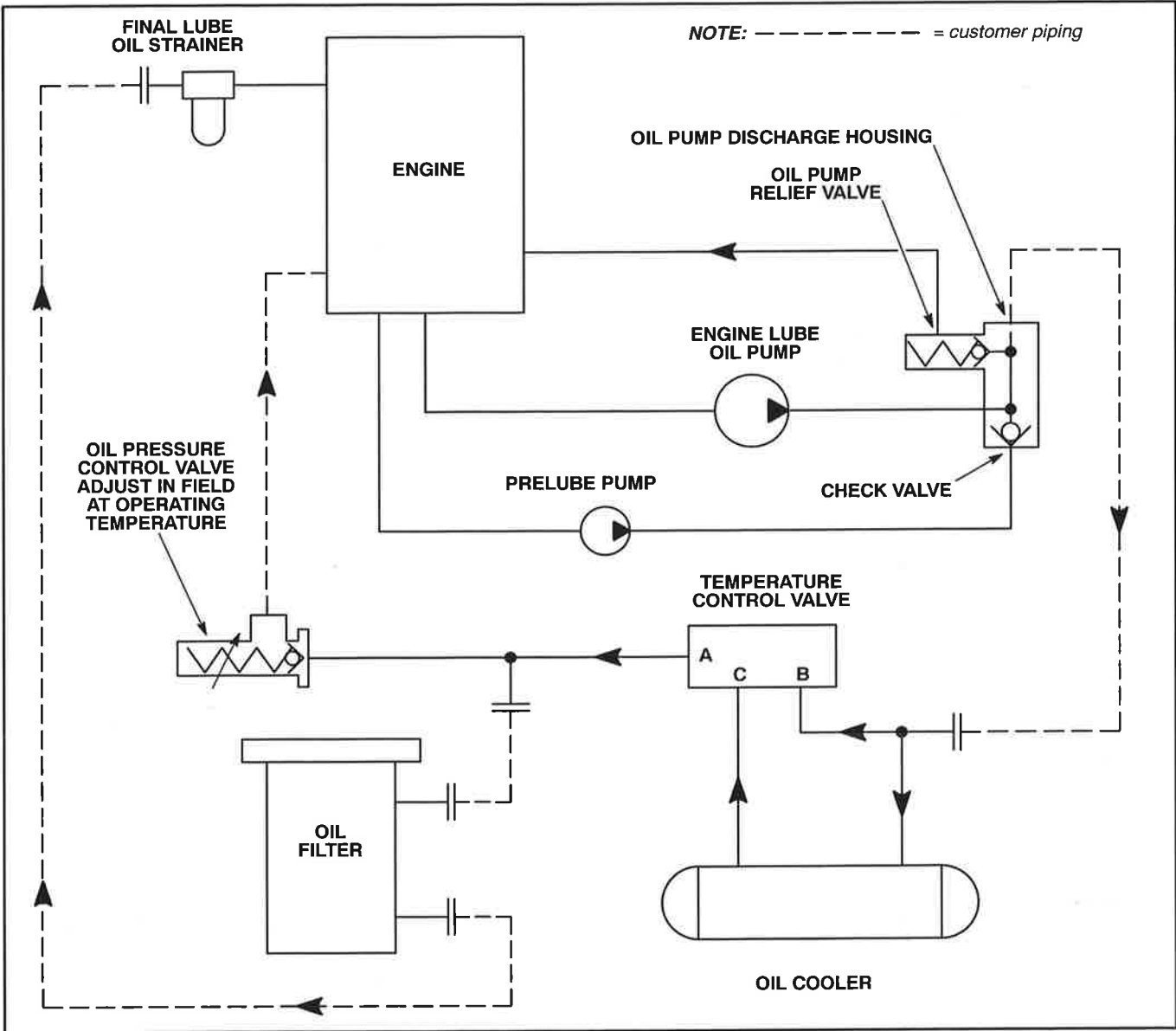


Figure 2.30-2. External Oil System Schematic

LUBRICATION SYSTEM DESCRIPTION

OIL PAN AND PICKUP SCREEN

The bottom of the crankcase is enclosed by the oil pan. The oil pump draws oil from the lowest point in the oil pan and delivers it to the oil cooler. The oil pickup screen (see Figure 2.30-3) prevents foreign material in the oil pan from entering the lube oil circuit.

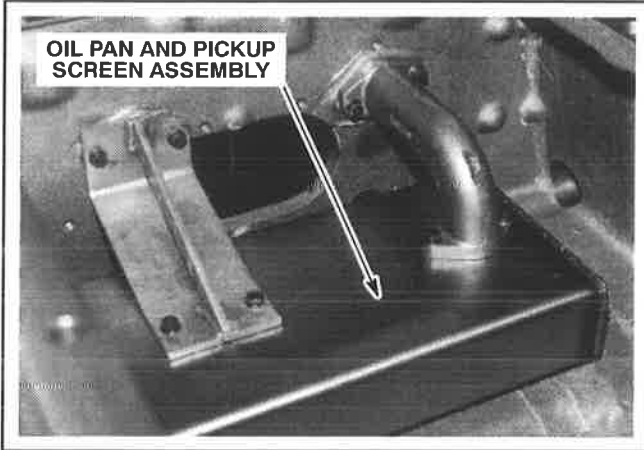


Figure 2.30-3. 6 Cylinder Engine Oil Pan And Pickup Screen Assembly

OIL PUMP

The lube oil pump, gear-driven by the gear train, is externally mounted. On 6 and 12 cylinder engines, the oil pump is located on the front of the engine, below the crankshaft (see Figure 2.30-4). On 5115GL engines, the oil pump is located on the front left side of engine on the back side of the gear housing (see Figure 2.30-5). On 16 cylinder engines, the oil pump is located on the right rear of the engine, mounted on the flywheel housing (see Figure 2.30-6).

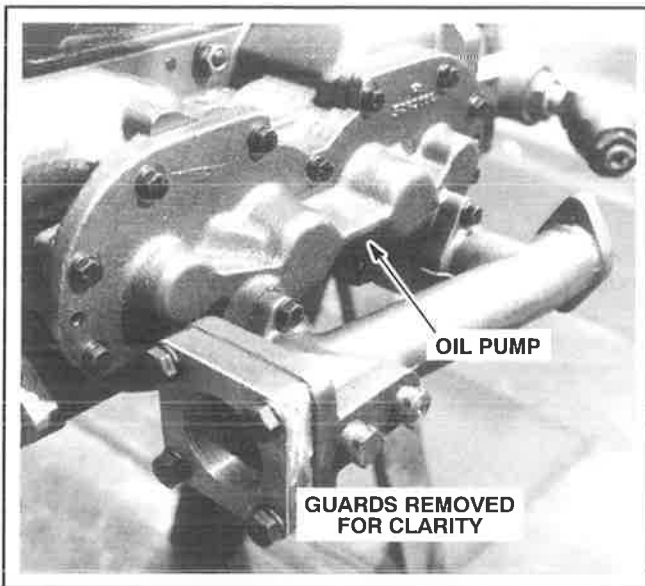


Figure 2.30-4. 6 And 12 Cylinder Engine Oil Pump - 6 Cylinder Shown

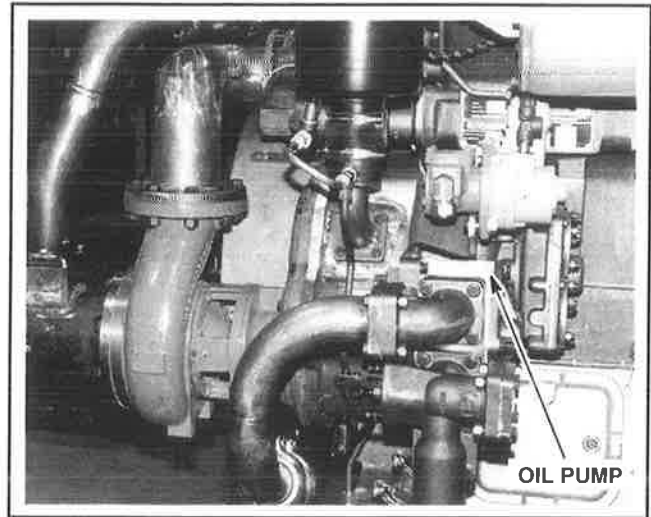


Figure 2.30-5. 5115GL Oil Pump

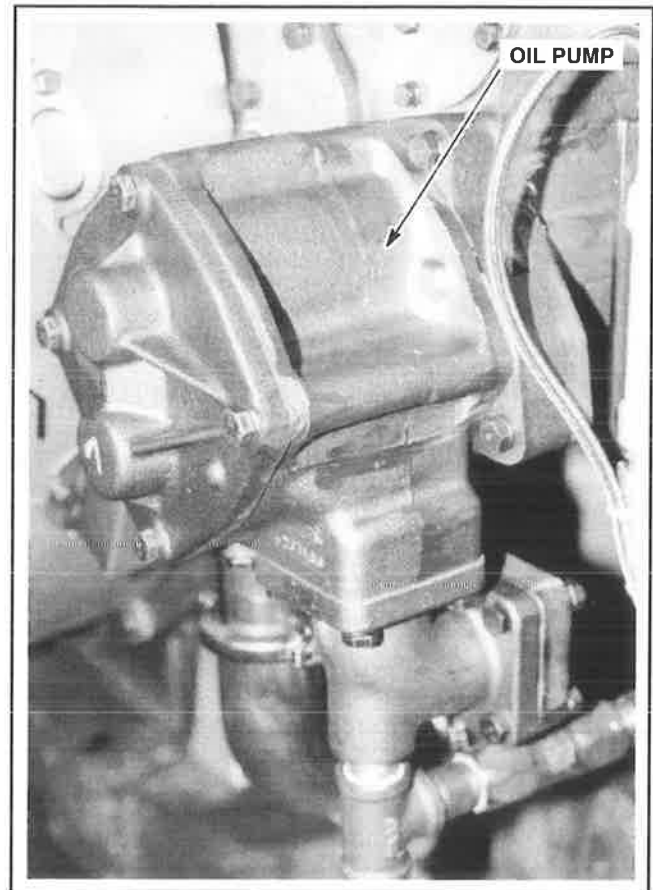


Figure 2.30-6. 16 Cylinder Engine Oil Pump

OIL COOLER

NOTE: The oil cooler assembly is shipped loose on 12 and 16 cylinder engines, and must be either skid or remote mounted by the customer. The assembly consists of the oil cooler, temperature control valve and pressure regulating valve.

The oil cooler (see Figure 2.30-7) is a tube and baffle type assembly. Coolant is pumped through the cooler by the auxiliary water pump. While the coolant flows through a bundle of tubes in the oil cooler, the lube oil circulates around them. Heat from the oil passes through the tubes to the coolant which carries it to a heat transfer device for dissipation.

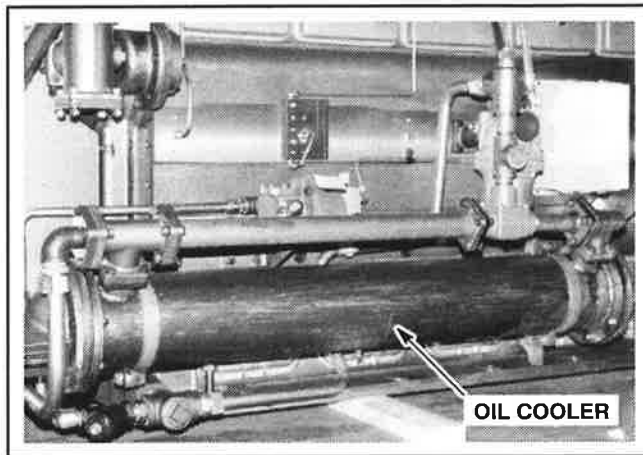


Figure 2.30-7. Oil Cooler - 6 Cylinder Engine Shown

Thermostatic valve(s) are enclosed in a housing mounted at the oil cooler outlet (see Figure 2.30-7).

OIL STRAINER

The lube oil strainer contains one bypass pressure relief valve. A pressure differential of 15 psi (103 kPa) opens the valve and allows the oil flow to bypass the strainer element enroute to the main oil header (see Figure 2.30-8).

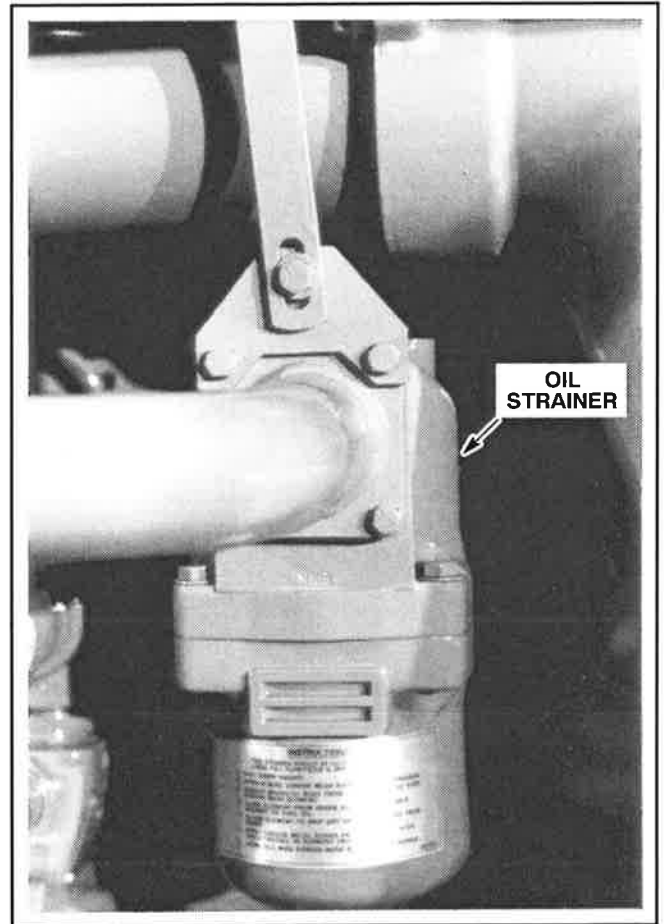


Figure 2.30-8. Lube Oil Strainer - 5115GL Engine Shown

LUBRICATION SYSTEM DESCRIPTION

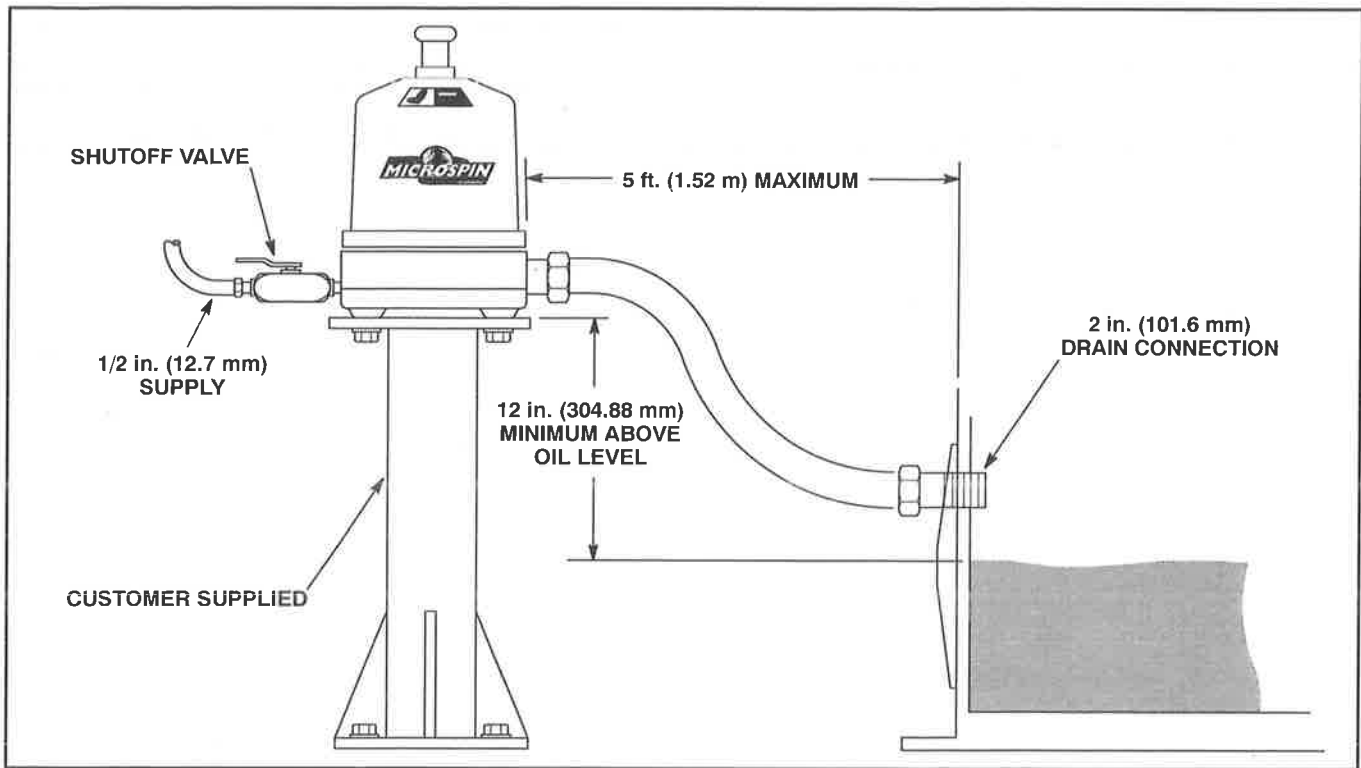


Figure 2.30-9. MICROSPIN™ Centrifuge Assembly

MICROSPIN™ CLEANABLE LUBE OIL FILTERING SYSTEM

The MICROSPIN™ cleanable lube oil filtering system, consists of two major components, cleanable oil filter elements (see Figure 2.30-10), and a centrifuge, using a removable paper insert (see Figure 2.30-9). The MICROSPIN™ system cleanable filter elements, are installed in the existing lube oil filtration canister. The centrifuge is installed as a bypass system, working in conjunction with the cleanable filter elements. The centrifuge is driven by the engine's oil pressure. The spinning action of the centrifuge's internal turbine assembly develops a force that exceeds 2000 G's, which compacts the contaminants against the turbine's housing. The centrifuge will remove oil contaminating particles as small as 0.5 microns. The cleanable filter elements remove remaining particles as small as 25 microns absolute. The MICROSPIN™ system is more environmentally friendly than systems that utilize disposable elements. Cleaning the elements eliminates the expense of replacement elements and the cost of hazardous waste disposal. Refer to Service Bulletin 12-2698B or latest revision, for further information.

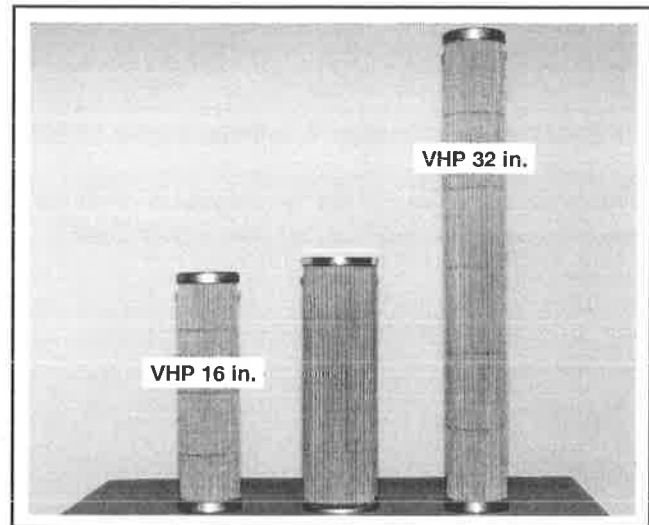


Figure 2.30-10. Cleanable Oil Filter Elements - All VHP, AT, F817G, F1197G, And VGF (Vee) Engines

PRELUBE PUSHBUTTON VALVE

The air/gas supply from the bulkhead is connected to the the pushbutton valve (see Figure 2.30-11). Depressing the prelube pushbutton activates the prelube function.

⚠ WARNING

From the bulkhead, all gas vented from the system must be piped to a safe area in conformance with all applicable codes. Improper venting may result in severe personal injury or death.

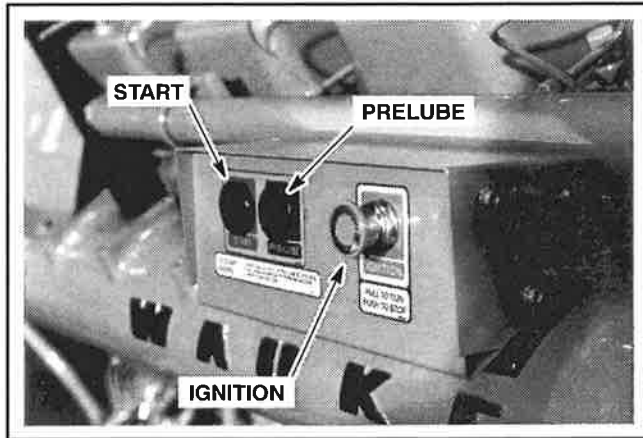


Figure 2.30-11. Prelube Pushbutton Valve

PRELUBE PUMP/MOTOR

⚠ CAUTION Oil drains back into the oil sump after engine shutdown, leaving a minimal amount of oil at key wear points. Since the crankshaft starts to turn before the oil pump begins to circulate oil, failure to prelube the engine will result in “dry” starts, resulting in bearing damage and an accelerated wear rate.

The function of the prelube pump/motor is to purge the lubrication system of air and to ensure that all moving parts, especially the turbochargers, are properly lubricated before the engine is started (see Figure 2.30-12).

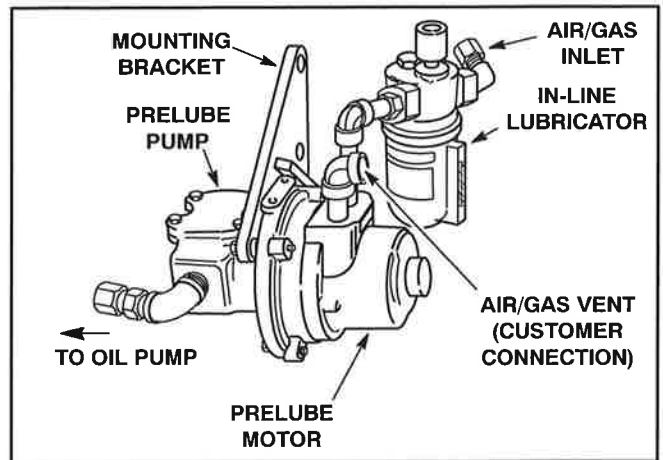


Figure 2.30-12. Prelube Motor/Pump Assembly - Similar All Engines

PRELUBE VALVE

The prelube valve opens to admit air from a branch of the main air/gas supply line, which turns the prelube pump air motor to activate the prelube pump (see Figure 2.30-13).

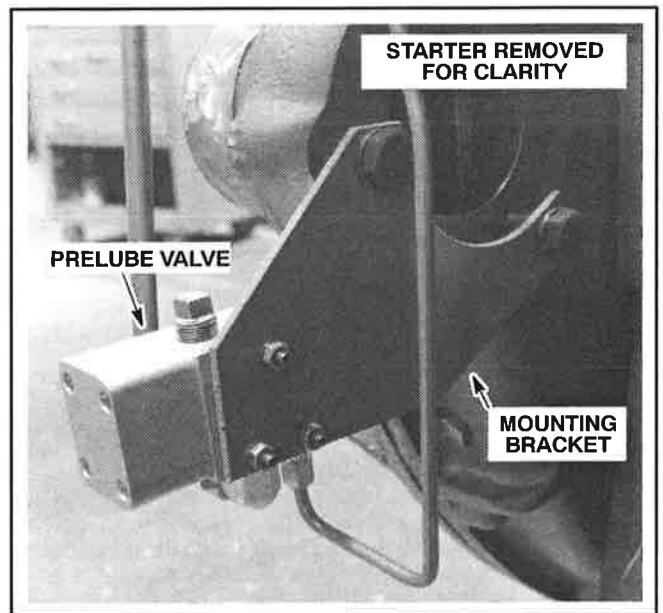


Figure 2.30-13. Prelube Valve - 6 Cylinder Engine Shown

LUBRICATION SYSTEM DESCRIPTION

IN-LINE LUBRICATOR

 **WARNING**

If high pressure gas is used to drive the air/gas prelude pump motor, vent the motor exhaust to a safe area in conformance with all applicable codes. Improper venting may result in severe personal injury or death.

NOTE: The air/gas starting system also has a lubrication reservoir. See Starting Systems for information on this reservoir.

The in-line lubricator injects oil into a stream of compressed air/gas to automatically provide the proper internal lubrication for the vanes of the air/gas operated prelude pump motor (see Figure 2.30-14).

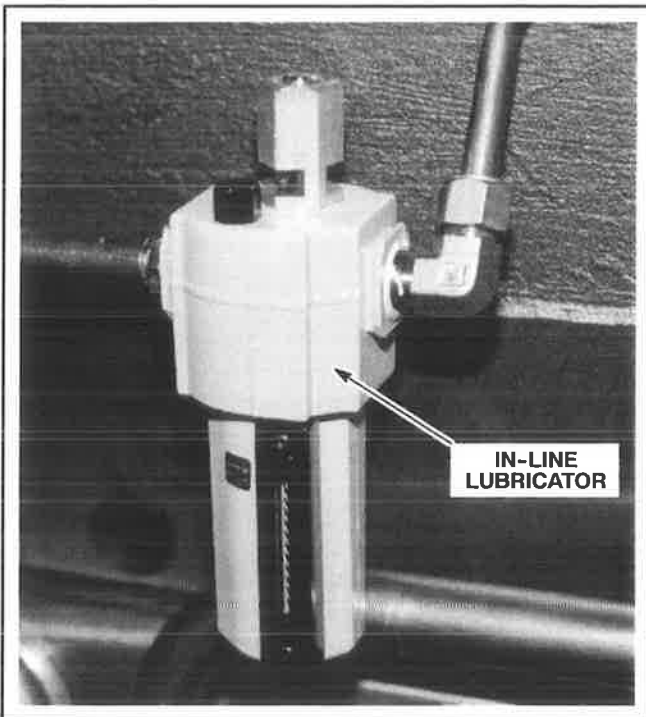


Figure 2.30-14. In-line Lubricator

SECTION 2.35

EXHAUST SYSTEM DESCRIPTION

EXHAUST SYSTEM DESCRIPTION

⚠ WARNING

Do not inhale engine exhaust gases. Do not open exhaust system while the engine is running. Exhaust gases are highly toxic and could cause severe personal injury or death.

The exhaust system consists of the following components (see Figure 2.35-1):

- Exhaust Manifolds
- Turbochargers (GSI and GL engines)
- Exhaust Wastegates (GSI and GL engines)
- Exhaust Piping and Flexible Connections (customer supplied)

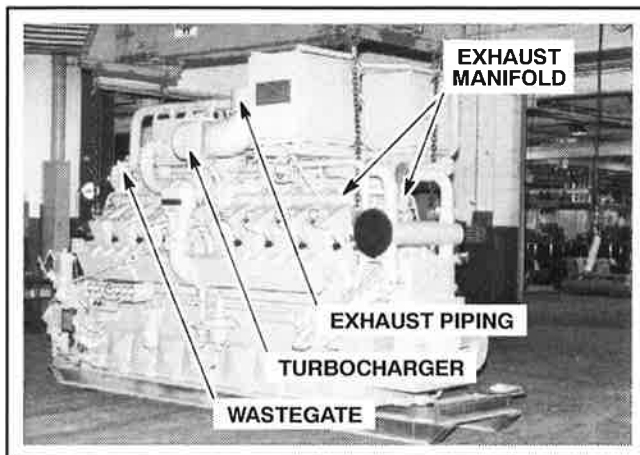


Figure 2.35-1. Exhaust System Components

EXHAUST MANIFOLD(S)

Each water-cooled exhaust manifold assembly is comprised of individual segments (see Figure 2.35-2). The exhaust port of each cylinder head is connected to one water-jacketed segment of the exhaust manifold. Water outlet elbows (see Figure 2.35-2) connect the water outlet hole in each cylinder head with the exhaust manifold segments.

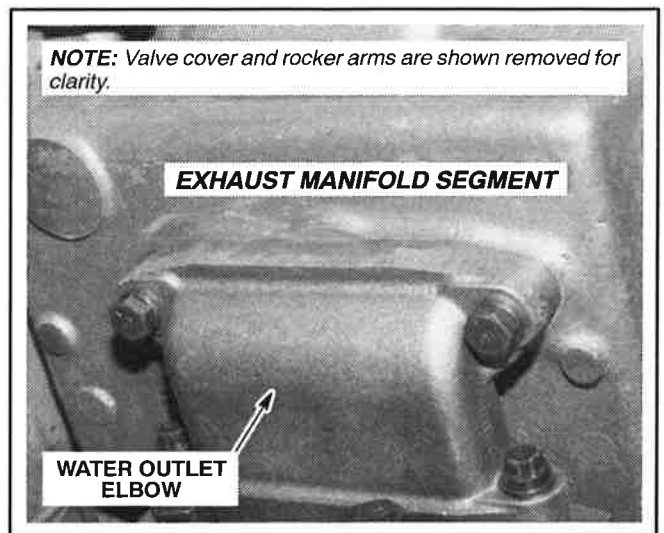


Figure 2.35-2. Water Outlet Elbows

EXHAUST SYSTEM DESCRIPTION

TURBOCHARGERS(S)

A wastegate-controlled turbocharger (see Figure 2.35-3) is provided for each cylinder bank. The compressor side of the turbocharger is part of the air induction system; the turbine side is part of the exhaust system. When the turbine spins through the expansion of exhaust gases exiting the engine, the movement of the compressor wheel causes the air passing through the air cleaner enroute to the carburetor, to be compressed.

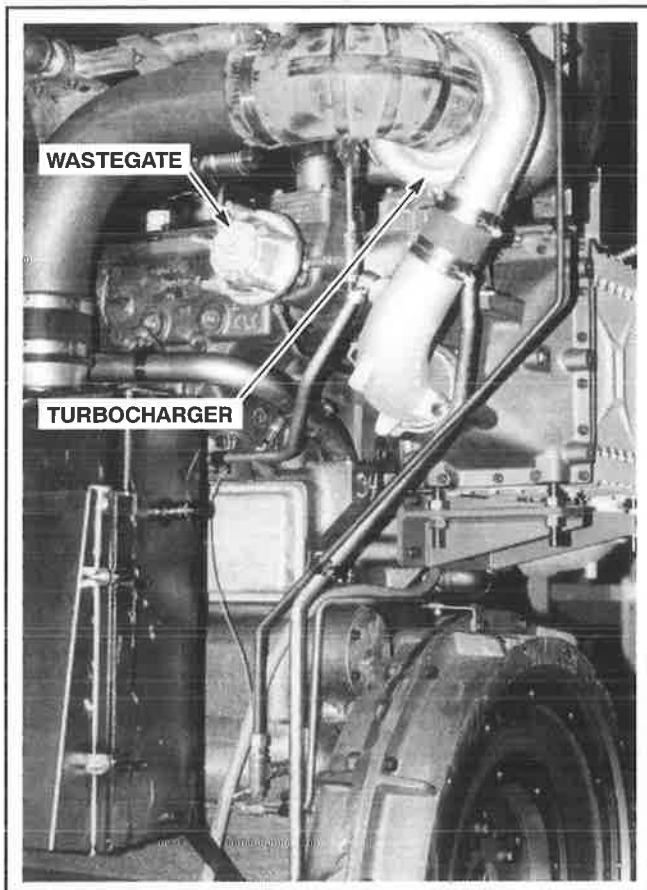


Figure 2.35-3. Turbocharger and Wastegate - 6 Cylinder Engine Shown

WASTEGATE(S)

A water-cooled exhaust wastegate (see Figure 2.35-3) is mounted at the outlet of each exhaust manifold. The wastegate is a load limiting device. At a predetermined point, intake manifold pressure counteracts the tension of a spring, and a valve opens to bypass a portion of the engine exhaust around the turbocharger turbine. In this way, the air intake boost pressure is held within an acceptable range.

Exhaust gases driving (or bypassing) the turbocharger turbine, exit the engine through the exhaust stack. Exhaust gases passing through the flexible exhaust connection, are directed into the atmosphere through customer supplied exhaust piping.

SECTION 2.40

CRANKCASE BREATHER SYSTEM DESCRIPTION

CRANKCASE BREATHER SYSTEM DESCRIPTION

The purpose of the crankcase breather system is to maintain a slight negative pressure in the crankcase. The negative pressure rids the crankcase of harmful water vapors and combustion gases, and helps to prevent sludge buildup and oil contamination. The breather system is also designed to separate the oil from the vapors before the discharge is released into the atmosphere.

All engines are provided with manual crankcase pressure adjustment. The adjustment is accomplished by admitting more or less outside air into the breather system. All manual adjustment devices are externally controlled and easily accessible.

The components of the crankcase breather system are as follows:

- Crankcase Separator Screen (6 and 12 Cylinder Engines)
- Oil Separators
- Vacuum Valve/Choke Valve
- Breather Regulator
- Venturi Extractor
- Crankcase Pressure Relief Valves

SEPARATOR SCREEN MAINTENANCE

6 and 12 cylinder engines have a crankcase separator screen. On six cylinder engines, the separator screen is located in the firing deck of the crankcase at the rear of the engine (see Figure 2.40-1) On 12 cylinder engines, the separator screen is located in the rear right side of the engine on the cylinder firing deck (see Figure 2.40-2). 16 cylinder engines do not have separator screens.

The crankcase separator screen allows vapors to be vented from the crankcase. It also serves to stop a portion of the oil carried by these vapors from reaching the oil separator. As the oil mist and vapors pass out of the crankcase, the expanded metal elements in the separator screen restrict the flow of much of the oil, dropping the surplus back into the oil pan.

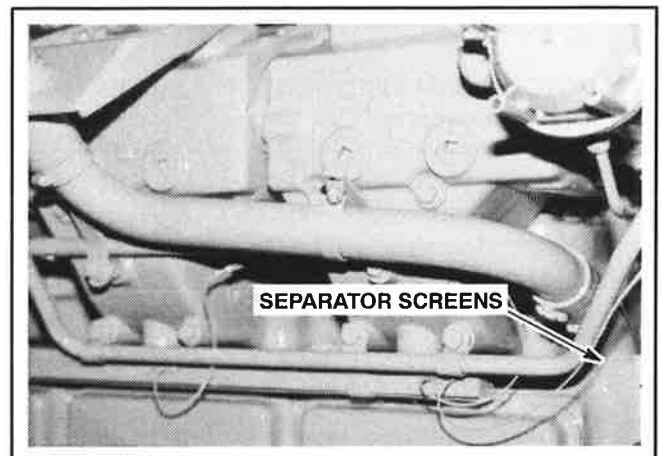


Figure 2.40-1. Crankcase Separator Screen - 6 Cylinder Engine Shown

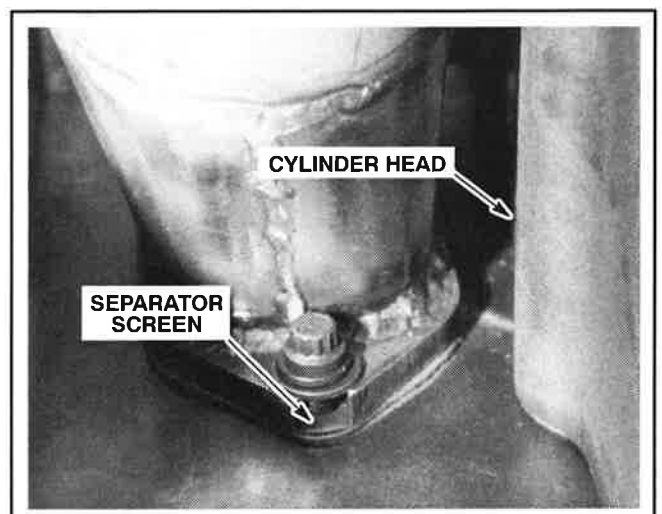


Figure 2.40-2. Crankcase Separator Screen - 12 Cylinder Engine Shown

CRANKCASE BREATHER SYSTEM DESCRIPTION

OIL SEPARATOR(S)

6 cylinder and 12 cylinder G engines, have one oil separator located at the rear of the engine (see Figure 2.40-3).

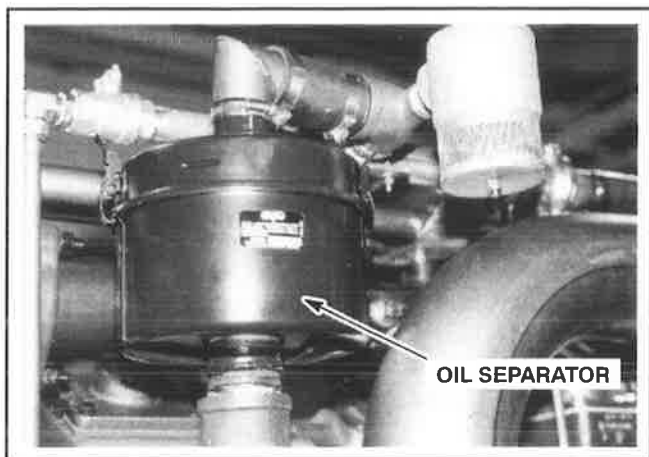


Figure 2.40-3. Oil Separator Assembly - 6 Cylinder Engine Shown

The 5115GL engine, and 12 cylinder GSI and GL engines, have two oil separators. One oil separator is connected by an elbow to the vent in the gear housing cover on the front left side of the engine (see Figure 2.40-5). The second oil separator is mounted above the crankcase at the rear right side of the engine (see Figure 2.40-4). This oil separator is connected by a breather tube to the crankcase separator screen in the top of the crankcase.

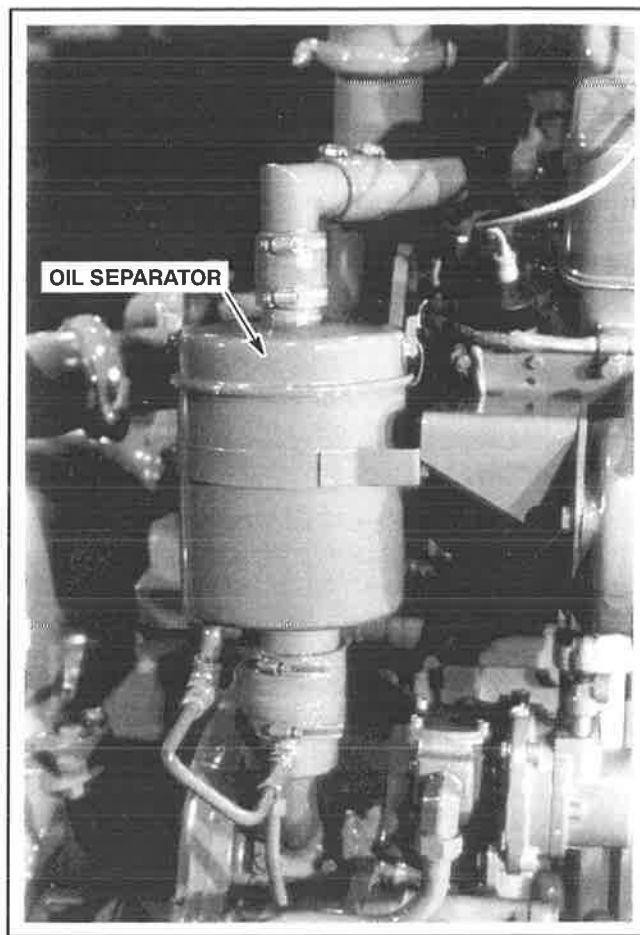


Figure 2.40-5. Oil Separator Assembly - 5115GL Engine Front Left

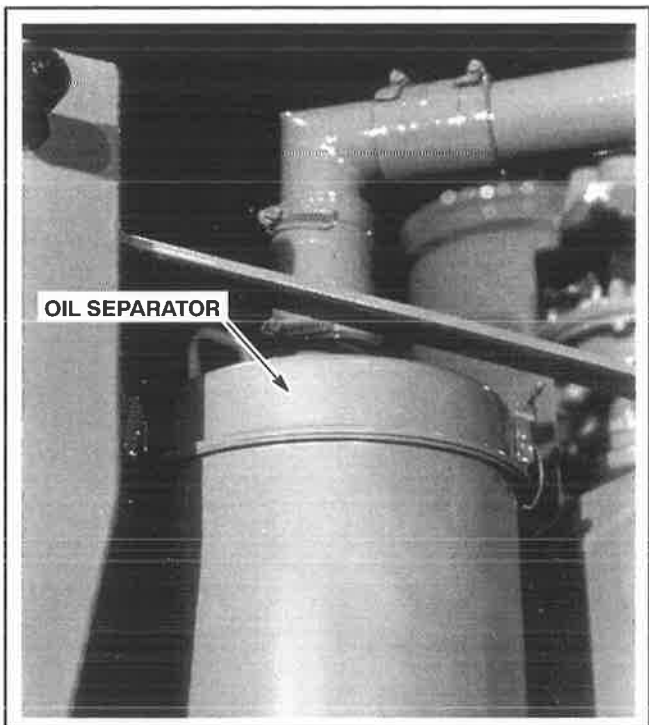


Figure 2.40-4. Oil Separator Assembly - 5115GL Engine Rear Right

CRANKCASE BREATHER SYSTEM DESCRIPTION

16 cylinder engines have one oil separator located on the rear of the engine directly above the flywheel (see Figure 2.40-6).

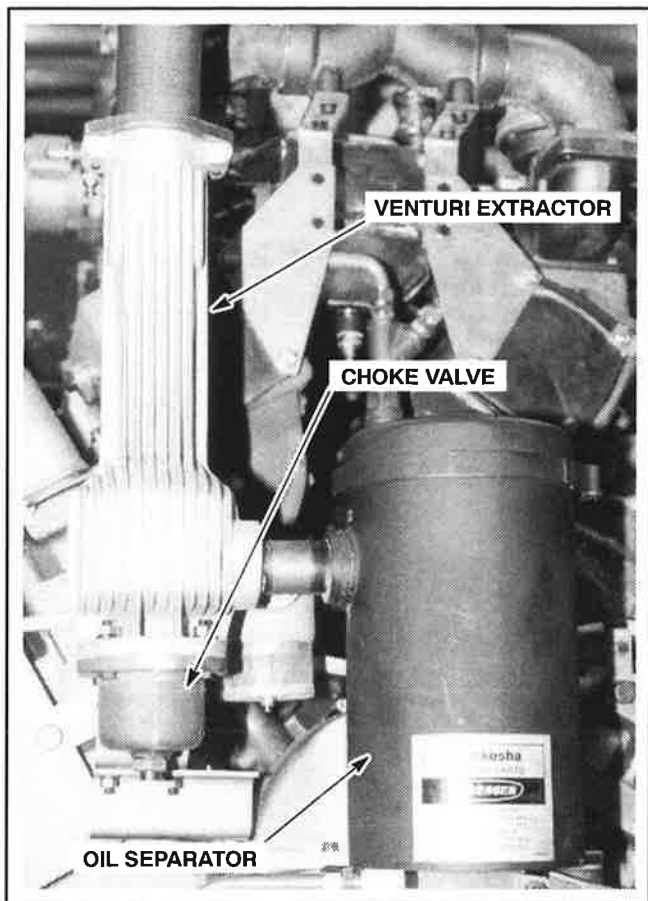


Figure 2.40-6. Oil Separator Assembly - 16 Cylinder Engine Shown

As the crankcase vapors and oil mist pass through the oil separator, much of the oil adheres to the steel mesh element contained in the inlet side of the separator housing. This surplus oil condenses, drops into the base of the separator and returns to the oil pan through a drain tube in the base of the separator housing (see Figure 2.40-7). The crankcase vapors pass into the venturi extractor, where they are drawn into the exhaust stack and discharged into the atmosphere.

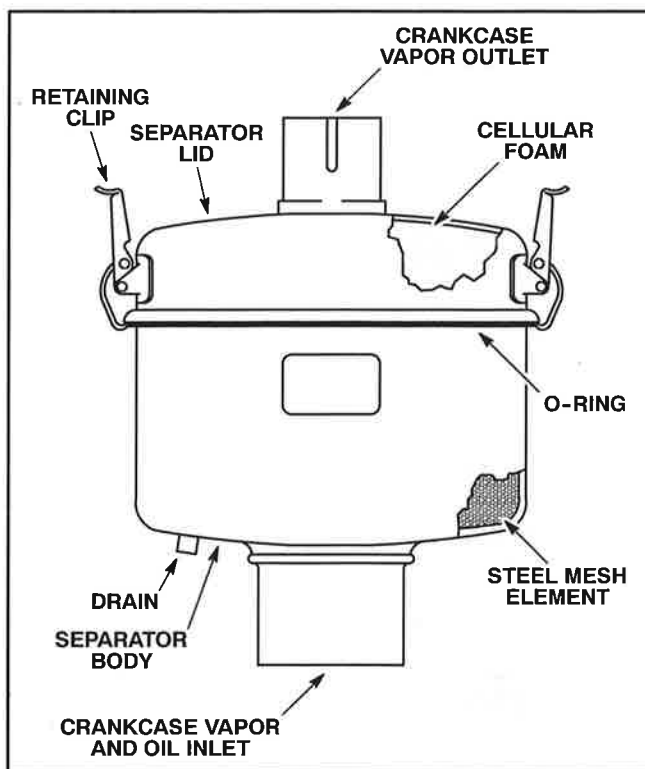


Figure 2.40-7. Oil Separator - 6 And 12 Cylinder Engine

CRANKCASE BREATHER SYSTEM DESCRIPTION

CHOKE VALVE/VACUUM VALVE

The choke valve/vacuum valve, allows the crankcase pressure to be adjusted externally. Refer to *Crankcase Pressure Adjustment* in Chapter 4, for procedures to adjust the crankcase pressure.

On 6 cylinder models, crankcase pressure is adjusted with either a venturi/adjusting screw assembly (see Figure 2.40-8), an ejector breather/adjusting valve assembly (see Figure 2.40-9) or a vacuum valve (see Figure 2.40-10).

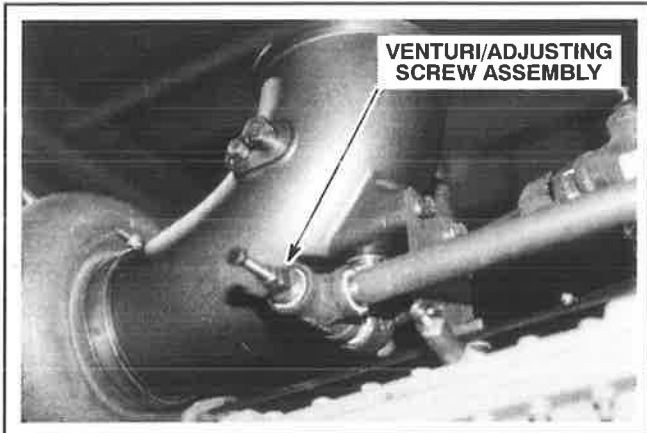


Figure 2.40-8. Venturi/Adjusting Screw Assembly - 6 Cylinder GSI Shown

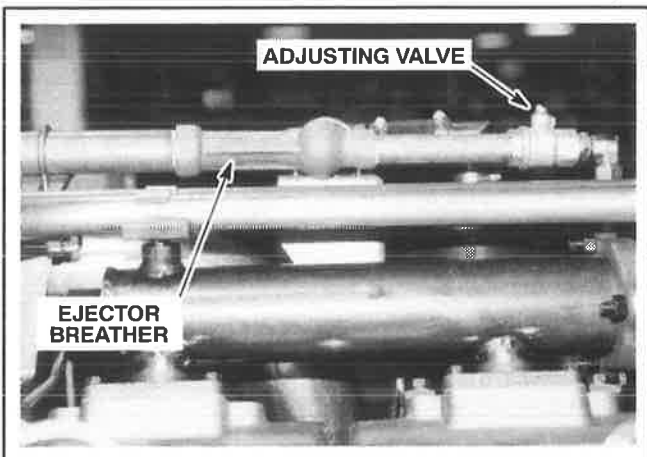


Figure 2.40-9. Ejector Breather/Adjusting Valve Assembly - 6 Cylinder Shown

On 12 cylinder models that are not equipped with venturi extractor, the crankcase pressure is adjusted with a vacuum valve assembly of which there are different configurations. (see Figure 2.40-10 and Figure 2.40-11). On 12 cylinder models equipped with a venturi extractor, the choke valve is located on the end of the venturi extractor (see Figure 2.40-12).

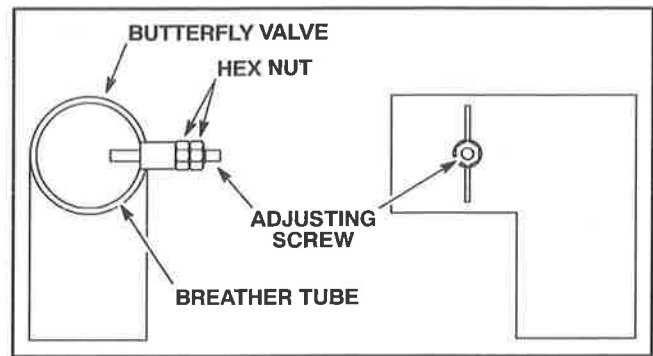


Figure 2.40-10. Vacuum Valve Assembly

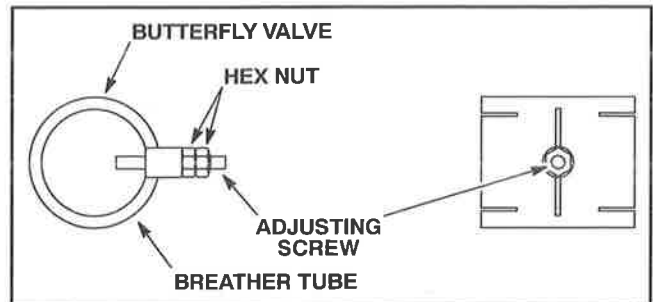


Figure 2.40-11. Vacuum Valve Assembly

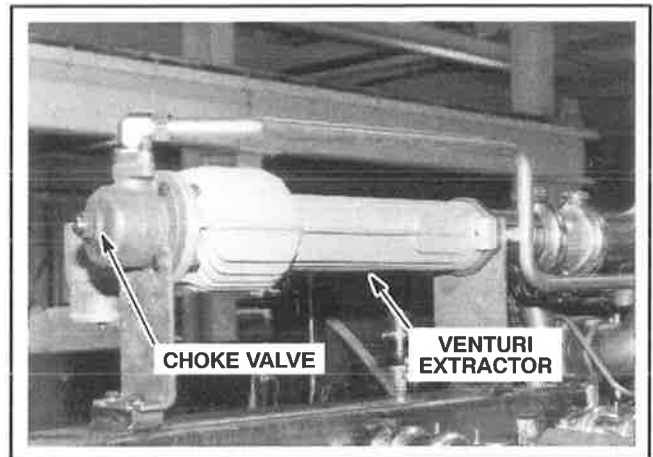


Figure 2.40-12. Venturi Extractor/Choke Valve Assembly - 12 Cylinder GL Shown

On 16 cylinder engines, the crankcase pressure is adjusted with a vacuum valve that is similar in appearance to the valve shown in Figure 2.40-8, or a venturi extractor/choke valve assembly similar to the one shown in Figure 2.40-12.

CRANKCASE BREATHER SYSTEM DESCRIPTION

BREATHER REGULATOR

The crankcase breather regulator assembly (see Figure 2.40-13) automatically performs fine adjustments to maintain a negative crankcase pressure to as the engine changes speed and load. Maintaining a negative crankcase pressure is important to prevent oil leaks and vacate harmful vapors, but too much pressure pulls in environmental dust and dirt. With less load, less vacuum is required to vacate crankcase vapors.

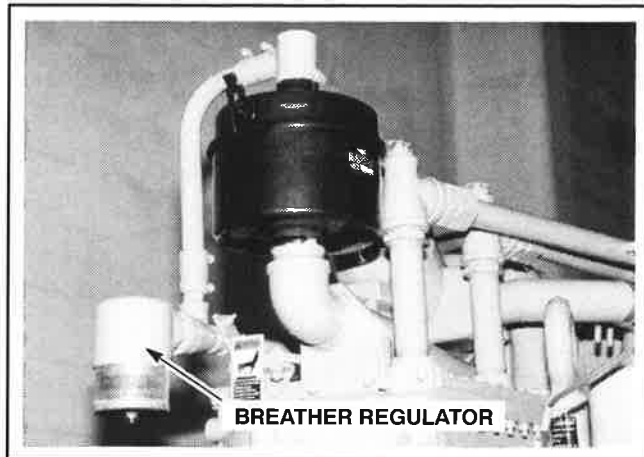


Figure 2.40-13. Breather Regulator

With an increase in load, the amount of compressor discharge air from the turbochargers increases and the plate within the regulator floats up. More outside air is sucked in as the plate rises, which allows the breather system to draw a greater vacuum.

VENTURI EXTRACTOR

Some models are equipped with a venturi extractor (see Figure 2.40-12). The venturi extractor creates a vacuum at the exhaust pipe connection to draw the crankcase vapors from the oil separator(s) into the exhaust stack.

CRANKCASE PRESSURE RELIEF VALVES

Some customers may require crankcase pressure relief valves as a safety precaution, in lieu of the standard oil pan door (see Figure 2.40-14). The valves open fully when the pressure in the crankcase exceeds one pound per square inch and close tightly and quickly to prevent the inflow of air after the internal pressure has been relieved. The possibility of combustion is prevented, since no oxygen is allowed to enter the crankcase to support new combustion. The valves do not prevent crankcase combustion, but only reduce the peak pressures, thereby minimizing damage.

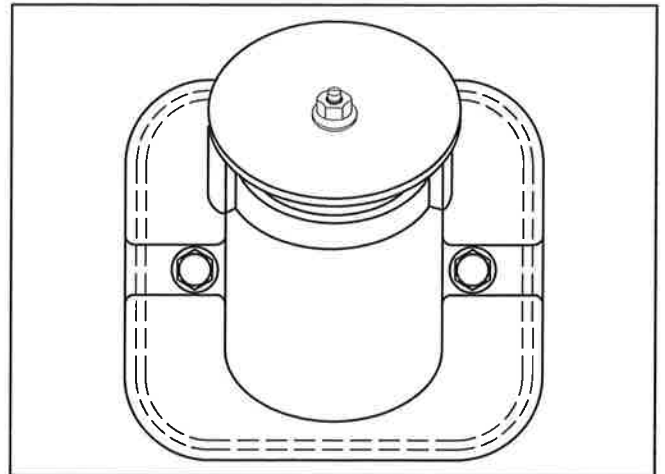


Figure 2.40-14. Crankcase Pressure Relief Valve

The valve incorporates an internal flame trap to retard the emission of flame while the valve is venting. The flame trap is of an oil-wetted wire gauze design. The cooling capacity of the gauze is doubled when oil-wetted, a condition effected by the oil mist that normally exists in the crankcase or by oil spray from the connecting rod bearings. The valve incorporates the flame trap as a single unit and the O-ring construction eliminates oil leakage.

WARNING

The number of pressure relief valves used on the engine depends on the volume of the crankcase. Never operate the engine without all valves on the engine. The ability of the system to function is dependent upon the proper number of relief valves. Operation without the proper type and number of relief valves, or if the relief valves are not properly maintained, can result in severe personal injury or death.

CRANKCASE BREATHER SYSTEM DESCRIPTION

SECTION 2.45

PRELUBE AND STARTING SYSTEM DESCRIPTION

PRELUBE AND STARTING SYSTEM DESCRIPTION

- Prelube Pushbutton Valve
- Prelube Pump And Motor
- In-line Lubricator
- Start Pushbutton Valve
- Starter Motor(s) Air/Gas or Electric

⚠ WARNING

From the bulkhead, all gas vented from the system must be piped to a safe area in conformance with all applicable codes. Failure to comply could result in serious personal injury or death.

PRELUBE PUSHBUTTON VALVE

The PRELUBE pushbutton valve activates the prelude system (see Figure 2.45-1). The prelude system circulates oil through the the engine and turbocharger(s) to provide the engine adequate lubrication during startup.

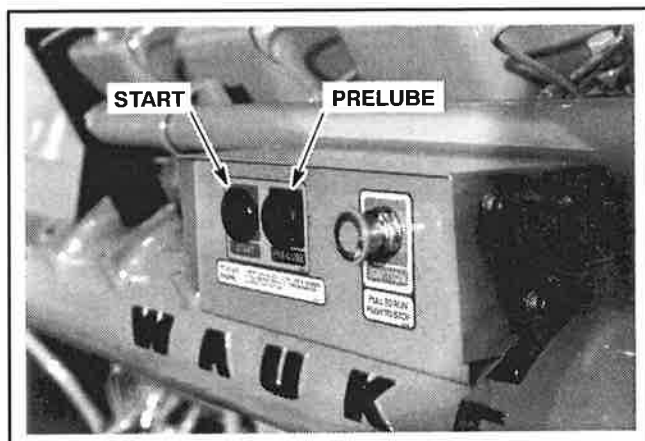


Figure 2.45-1. Start And Prelube Pushbutton Valves

PRELUBE PUMP AND MOTOR

The prelude pump and motor (see Figure 2.45-2) circulate the oil through the engine when the PRELUBE pushbutton is pressed.

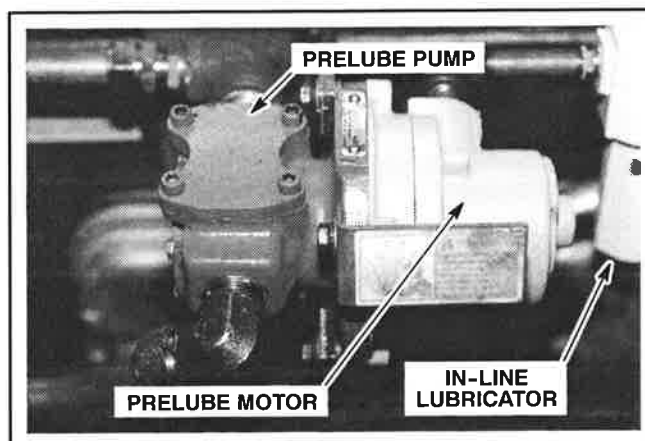


Figure 2.45-2. Prelube Pump and Motor

PRELUBE AND STARTING SYSTEM DESCRIPTION

IN-LINE LUBRICATOR

The in-line lubricator (see Figure 2.45-3) provides the prelube motor with lubrication during the starting sequence.

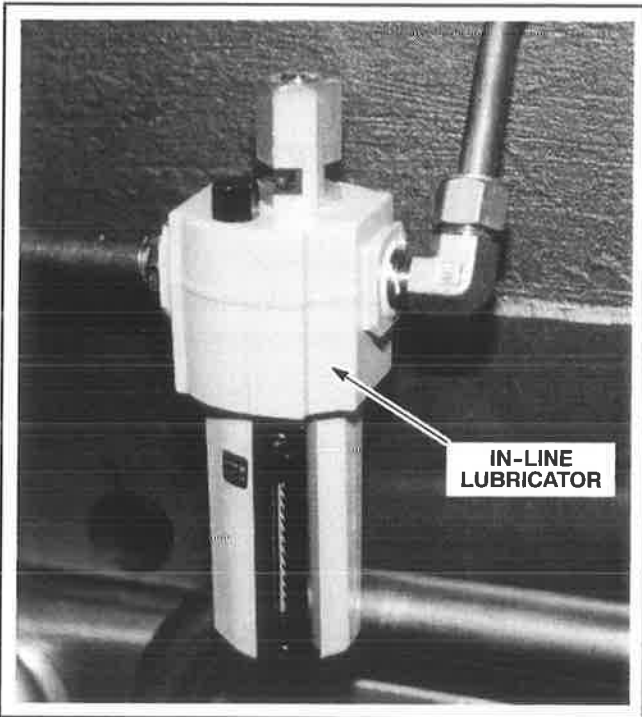


Figure 2.45-3. In-line Lubricator

START PUSHBUTTON VALVE

The START pushbutton valve activates the starter motor system (see Figure 2.45-1). On air/gas starter systems the START pushbutton valve activates a series of valves that allow air/gas pressure to activate the air/gas starter motor. On electric start systems, an additional solenoid is added to the system to replace the signal normally provided by air/gas pressure.

STARTER MOTOR - AIR/GAS

The air/gas pressure causes the starter pinion to shift into engagement with the flywheel ring gear and activates the starter motor (see Figure 2.45-4) to crank the engine. A lubrication reservoir provides lubrication to the air/gas starter during the starting sequence.

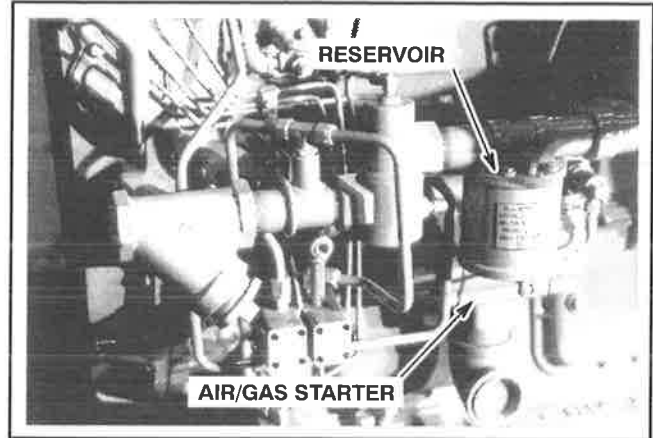


Figure 2.45-4. Air /Gas Starter

STARTER MOTOR - ELECTRIC START

This system functions in much the same way as the air/gas starting system with the obvious difference being the use of electric starting motors (Figure 2.45-5). An additional solenoid is added to the system to replace the signal normally provided by air/gas pressure.

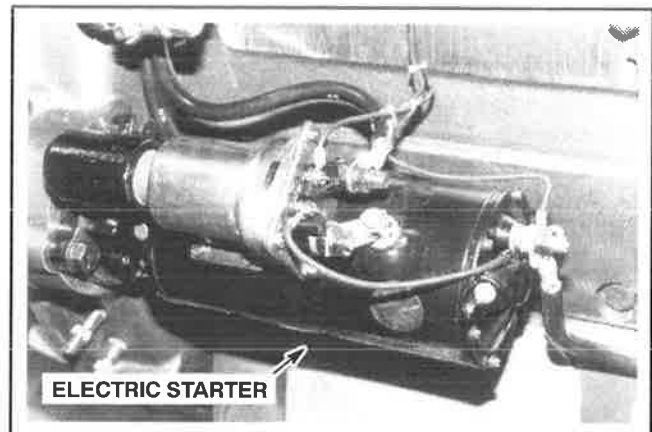


Figure 2.45-5. Electric Starter

SECTION 2.50

ENGINE PROTECTION SHUTDOWN SYSTEM DESCRIPTION

ENGINE PROTECTION SHUTDOWN SYSTEM DESCRIPTION OPTIONS

The control switches that make up the engine protection shutdown system must be supplied by the customer. Waukesha provides the following:

- Sensors and Thermocouples
- Thermocouple Junction Box
- Manual Shutdown Switches

⚠ WARNING

Switches for alarms and automatic engine shutdown must be supplied by the customer. The sensors provided are for measuring and monitoring temperatures and **WILL NOT** shut the engine down if potentially harmful temperatures are reached. Waukesha will not be responsible for any property damage, personal injury or death, due to the failure to follow these instructions.

NOTE: The customer supplied control switches must be incorporated into the remote engine control panel logic.

K-TYPE THERMOCOUPLES

Thermocouples are used to measure lube oil (see Figure 2.50-1), jacket water (see Figure 2.50-2), and intake manifold (left and right bank on Vee engines) air temperature (see Figure 2.50-4). These thermocouples are wired through the thermocouple junction box to a remote mounted instrument panel (customer supplied or as a Waukesha option). Additional thermocouples (see Figure 2.50-3 and Figure 2.50-5) are used to measure exhaust temperature and turbine inlet temperature.

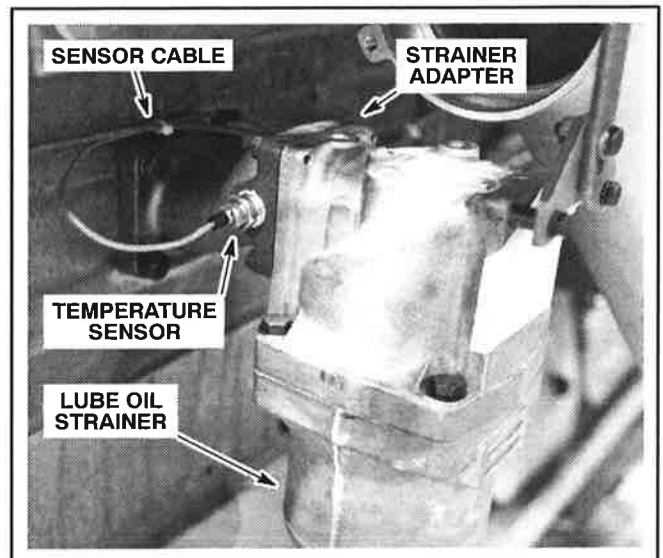


Figure 2.50-1. Lube Oil Inlet Temperature Sensor - 5115GL Engine Shown

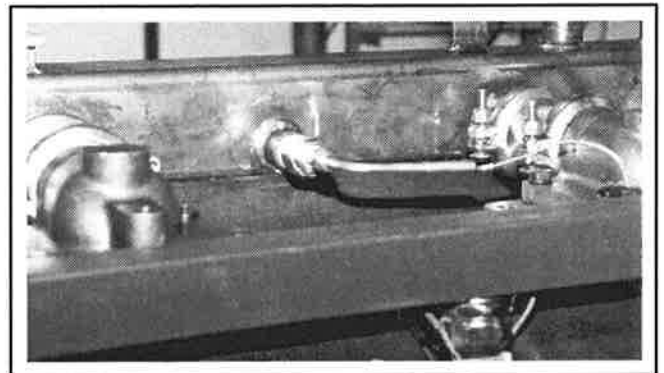


Figure 2.50-2. Jacket Water Temperature Sensor - 5115GL Engine Shown

ENGINE PROTECTION SHUTDOWN SYSTEM DESCRIPTION

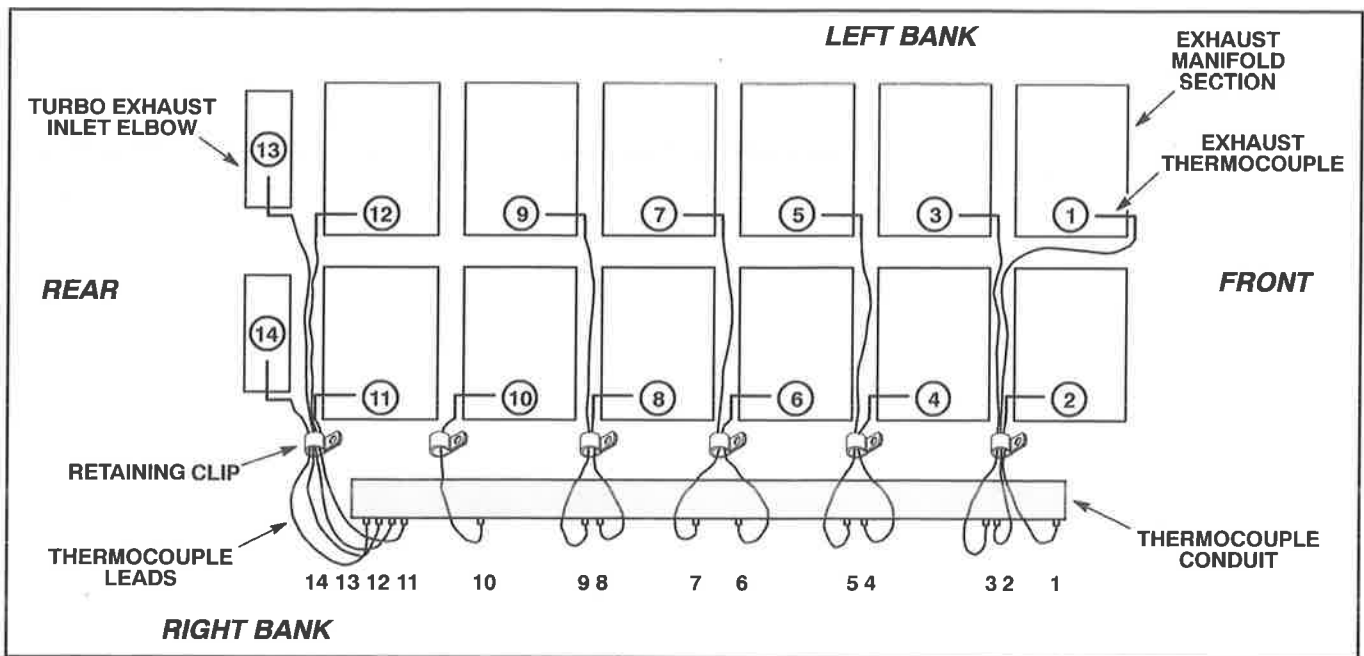


Figure 2.50-3. Exhaust Thermocouples Arrangement - 12 Cylinder Engine

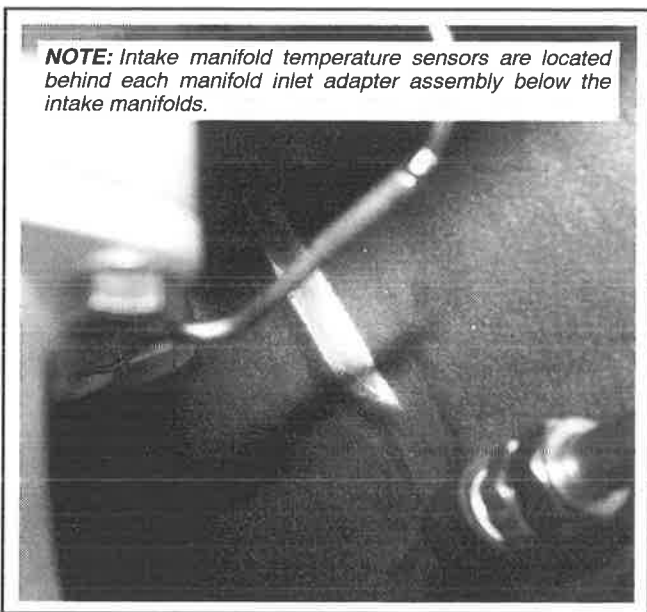


Figure 2.50-4. Intake Manifold Temperature Sensor - 5115GL Engine Shown

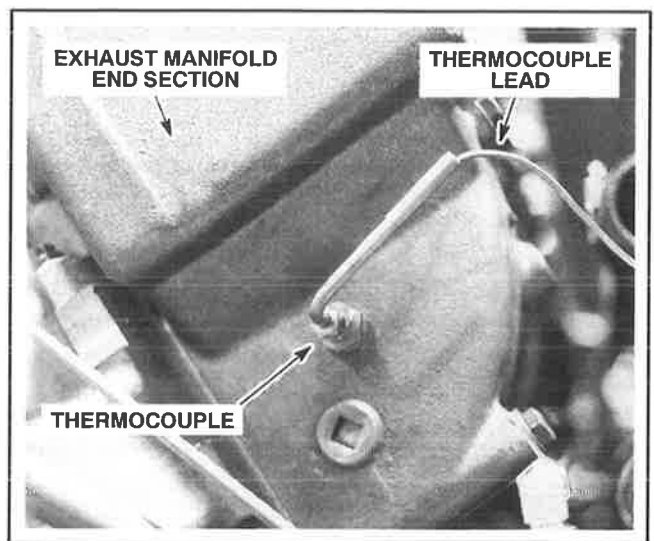


Figure 2.50-5. Exhaust Thermocouple - 12 Cylinder Engine Rear Left

ENGINE PROTECTION SHUTDOWN SYSTEM DESCRIPTION

Additional K-Type thermocouples that may be found on the engine, are:

- Thermocouples used to monitor the main bearing temperatures (see Figure 2.50-6). All thermocouples end at the thermocouple junction box when shipped. It is the customer's responsibility to connect the wiring to the remote-mounted instrument panel. Main bearing sensor logic must be supplied by the customer.
- Thermocouple used to monitor oil sump temperature.
- Oxygen sensors mounted in the exhaust system.
- Detonation sensors (one for each cylinder) are used to detect detonation in the combustion chambers. Refer to Section 2.10, *Ignition Systems*, for information concerning the detonation sensors.
- Thermocouples for the compressor system.

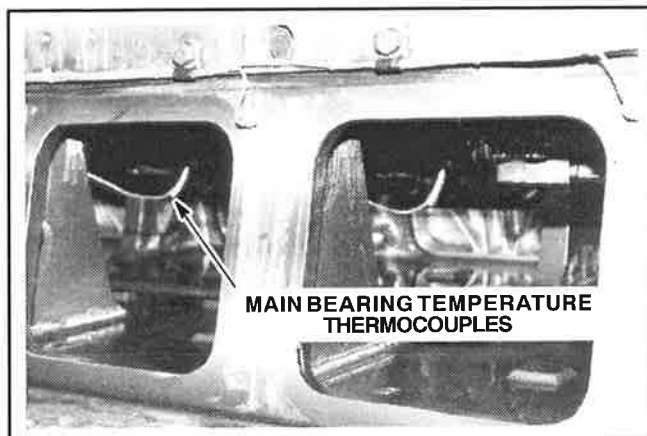


Figure 2.50-6. Main Bearing Temperature Thermocouples - 12 Cylinder Engine

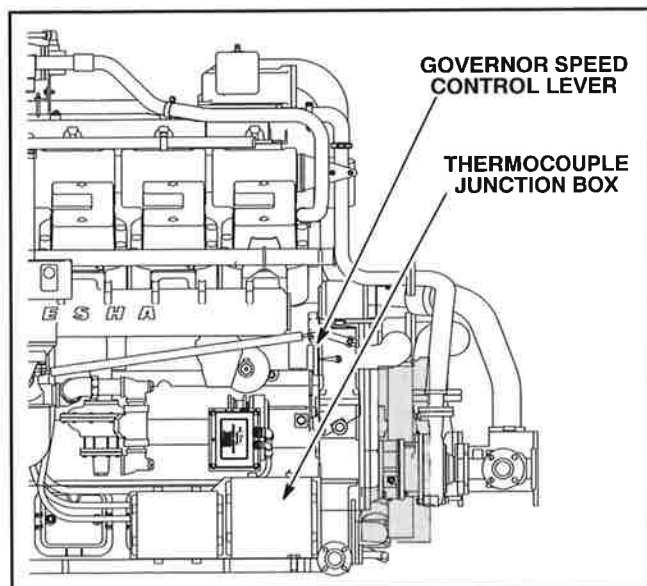


Figure 2.50-7. Thermocouple Junction Box And Governor Speed Control Lever - 5115GL Engine

THERMOCOUPLE JUNCTION BOX

The function of the thermocouple junction box (see Figure 2.50-7) is to serve as the main junction point for the wiring of engine protection shutdowns.

MANUAL SHUTDOWN LEVER AND GOVERNOR SPEED CONTROL LEVER

⚠ WARNING

Always insure that the fuel gas valve(s) are closed after engine shutdown. Failure to close fuel gas valve(s) could cause severe personal injury or death.

All engines have manual shutdown levers located on the right side carburetor (Figure 2.50-8) and may also have a governor speed control lever on the governor. These levers will return the engine to idle speed. Under some conditions, the engine may shutdown completely when using these levers. After the engine reaches idle speed, close the fuel gas valves to completely shutdown the engine. Always shutdown the fuel gas supply after the engine is shutdown.

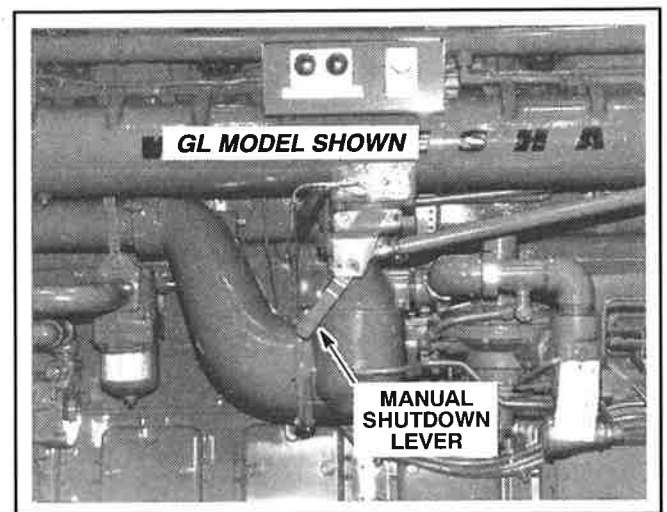


Figure 2.50-8. Manual Shutdown Lever - 12 Cylinder

ENGINE PROTECTION SHUTDOWN SYSTEM DESCRIPTION

IGNITION SWITCH/SWITCHES

WARNING

Always insure that the fuel gas valve(s) are closed after engine shutdown. Failure to close fuel gas valve(s) could cause severe personal injury or death.

On 6 and 12 cylinder engines, IGNITION (Emergency Stop) button(s), are located on the left and right sides of the engine on 12 cylinder engines, and the right side only on 6 cylinder engines (see Figure 2.50-9). Depressing either IGNITION (Emergency Stop) button(s) will stop the engine by de-energizing the ignition and electrical fuel supply solenoid valves. Always shut down the fuel gas supply after engine shutdown. To restart the engine after depressing either IGNITION (Emergency Stop) button(s), simply pull the depressed shutdown switch back out to its original position. The manual shutdown switches are wired to the main junction box.



Figure 2.50-9. Control Panel - Left Side

On 16 engines, the engine may be shut down by turning the IGNITION switch, located on the control panel to the OFF position (see Figure 2.50-10). Always shut down the fuel gas supply after engine shutdown.



Figure 2.50-10. 16 Cylinder Control Panel

CUSTOMER SUPPLIED CONTROL SWITCHES

Control switches must be supplied by the customer. Control switches must include, but are not limited to; low oil pressure, high coolant temperature, high lube oil temperature, high intake manifold air temperature, and an overspeed switch. Switches should be wired to an alarm to warn of high temperatures and low pressure, as well as provide for automatic engine shutdown if potentially harmful temperatures, pressure, or overspeed conditions exist.

PRESSURE AND TEMPERATURE SWITCH CALIBRATION

Calibrating and testing pressure and temperature switches, should be performed by qualified service technicians every 90 days.

OPTIONAL INSTRUMENT PANEL

Waukesha Engine offers an optional instrument panel (see Figure 2.50-11). The instrument panel is shipped loose and requires 24VDC power.

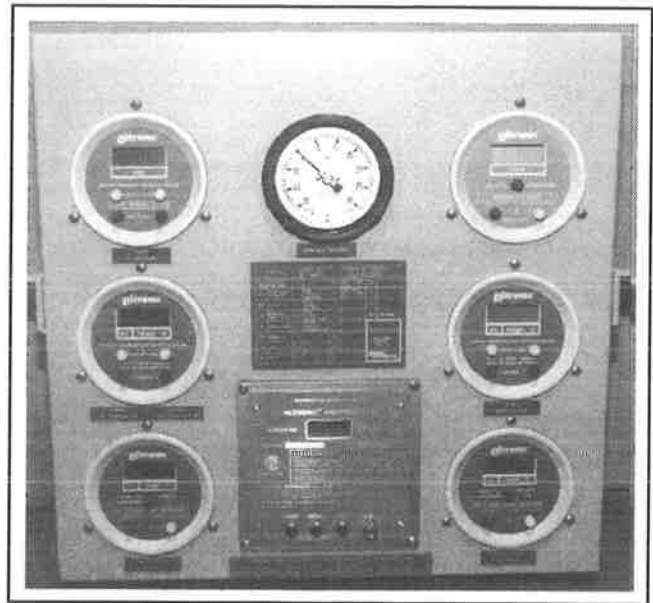


Figure 2.50-11. Optional Remote Instrument Panel

The instrument panel includes switch gauges for jacket water temperature, lube oil pressure, intake manifold temperature and overspeed. Gauges are included for individual exhaust thermocouples, pre and post turbine temperature, intake manifold pressure, tachometer and hourmeter. An annunciator will display the cause of the shutdown.

ENGINE PROTECTION SHUTDOWN SYSTEM DESCRIPTION

DETONATION SENSING MODULE AND SENSORS

⚠ WARNING

For maximum engine protection, the DSM system must be connected to a safety shutdown. The DSM system is considered a safety system and, as such, must be connected to shutdown the engine if the engine cannot be brought out of detonation. Disregarding this information could result in severe personal injury or death.

The DSM module is equipped with several features to inform site personnel of system status. These features include:

- “Power”, “Alarm”, and “Shutdown” lights (LED display) on the front panel of the DSM module (see Figure 2.50-12)
- A liquid crystal display (LCD) located inside the DSM module which continually shows the current status of the system through diagnostic codes (see Figure 2.50-13)
- The capability to drive remote alarms or lights

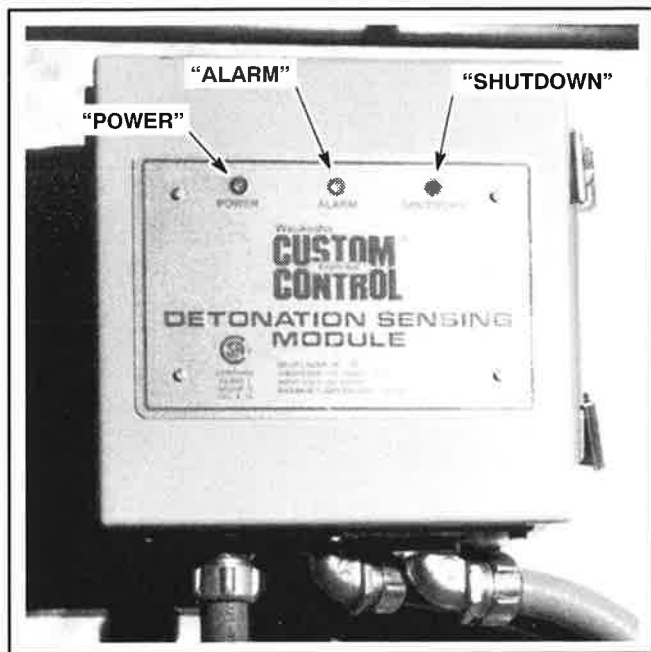


Figure 2.50-12. Detonation Sensing Module Front Panel

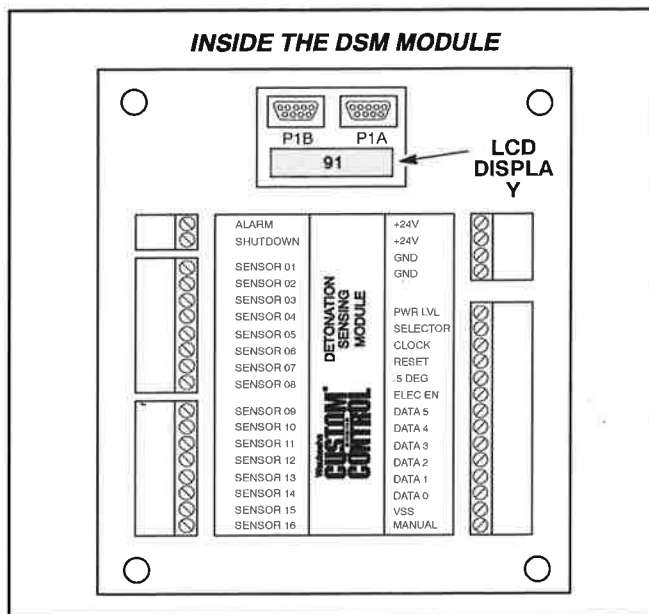


Figure 2.50-13. Detonation Sensing Module LCD Display

One DSM sensor per cylinder is installed just below the intake manifold (see Figure 2.50-14). These sensors send their signals back to the DSM module.



Figure 2.50-14. Detonation Sensor (VHP Series)

Refer to Form 6268, *DSM Custom Engine Control® Detonation Sensing Module Installation, Operation, And Maintenance Manual*, for further information.

ENGINE PROTECTION SHUTDOWN SYSTEM DESCRIPTION

CONTENTS

SECTION 3.00 - ENGINE STARTUP AND SHUTDOWN

SECTION 3.00

ENGINE STARTUP AND SHUTDOWN

PRESTART INSPECTION

⚠ WARNING

To avoid severe personal injury or death, be sure that the clutch, circuit breaker or other main power transmission device is disconnected.

1. Inspect the entire cooling system to verify that all control valves are properly opened and that all drain cocks are completely closed.

⚠ WARNING

Always wear protective clothing when checking or venting the cooling system on a heated engine. Slowly loosen the air bleed petcock to relieve any excess pressure. Use the vent on the pressure cap to allow pressure to escape. Escaping steam and/or hot water can result in severe burns or death.

2. Check the coolant level; add coolant when necessary. If coolant is needed, open the cooling system air vents to allow trapped air to escape.

3. Check for lube oil and/or coolant leaks.

4. Verify that all protective guards and shields on both the engine (see Figure 3.00-1) and the driven equipment are secure. Remove tools, rags, fittings or any other objects that may get caught by rotating parts.

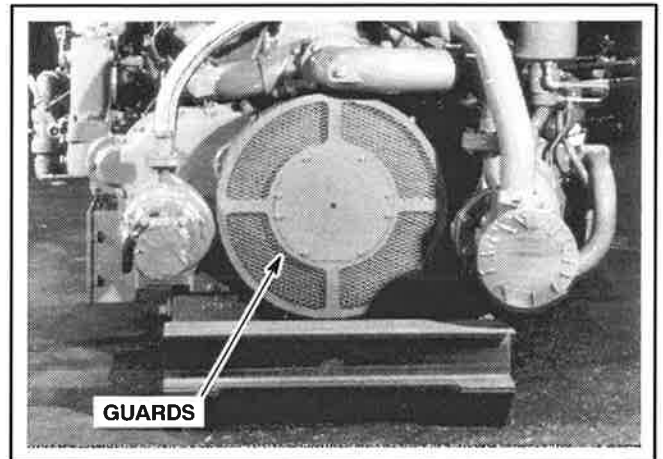


Figure 3.00-1. Engine Guards - 5115GL Engine Shown

ENGINE STARTUP AND SHUTDOWN

5. On 6 and 12 cylinder engines, check air cleaner restriction indicator. If indicator shows red, clean pre-cleaner and/or air cleaner elements (see Figure 3.00-2). 16 cylinder engines have indicator gauges that are checked while the engine is running.

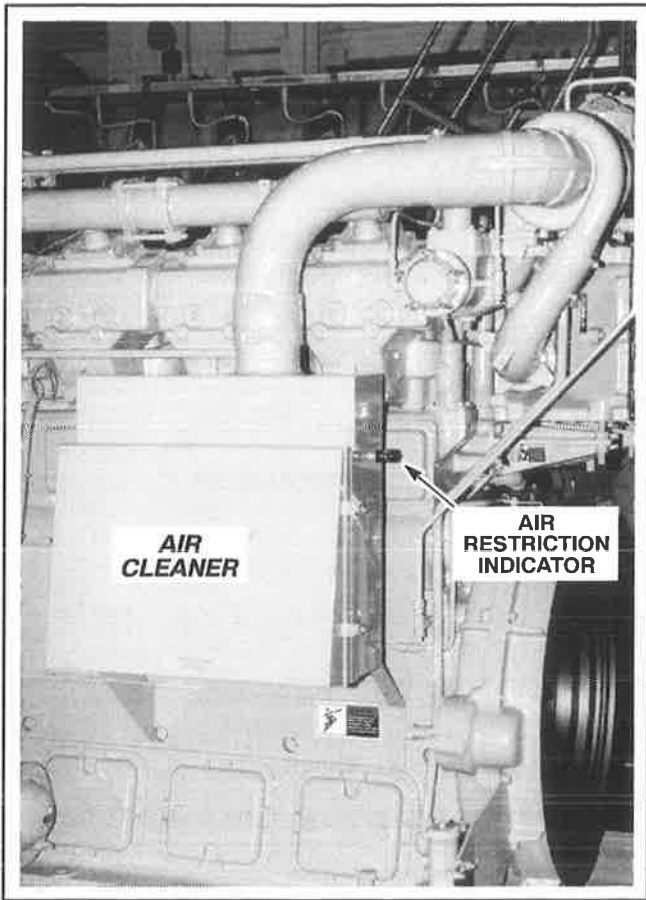


Figure 3.00-2. Air Restriction Indicator/Filter - 6 Cylinder Engine Shown

WARNING

Make certain barring device is disengaged from flywheel prior to starting engine. Remove all wrenches from the barring device before engaging starter. Failure to follow proper procedures could cause severe personal injury or death.

6. Bar the engine over two revolutions in a counter-clockwise direction, to verify that nothing interferes with its rotation (see Figure 3.00-3).

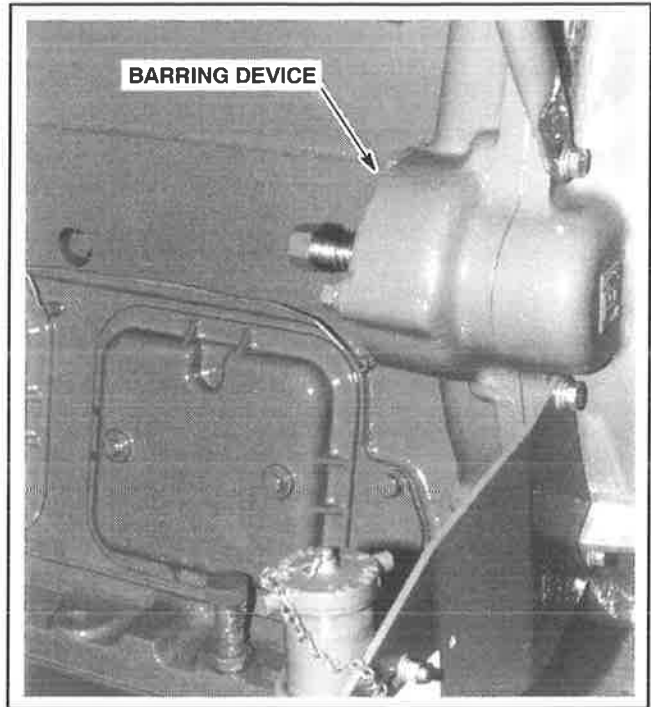


Figure 3.00-3. Engine Barring Device - 12 Cylinder Engine

7. Check the crankcase oil level daily before the engine is started. The blade of the dipstick is marked "low" and "full" (see Figure 3.00-4). Always maintain the oil level at the "full" mark. Both marks on the dipstick are "static lines." The dipstick does not indicate where the level of the oil should be when the engine is running.

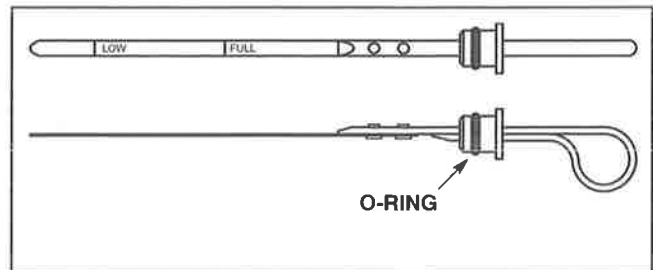


Figure 3.00-4. Dipstick

8. Check UG-8 governor oil level in sight glass (see Figure 3.00-5).

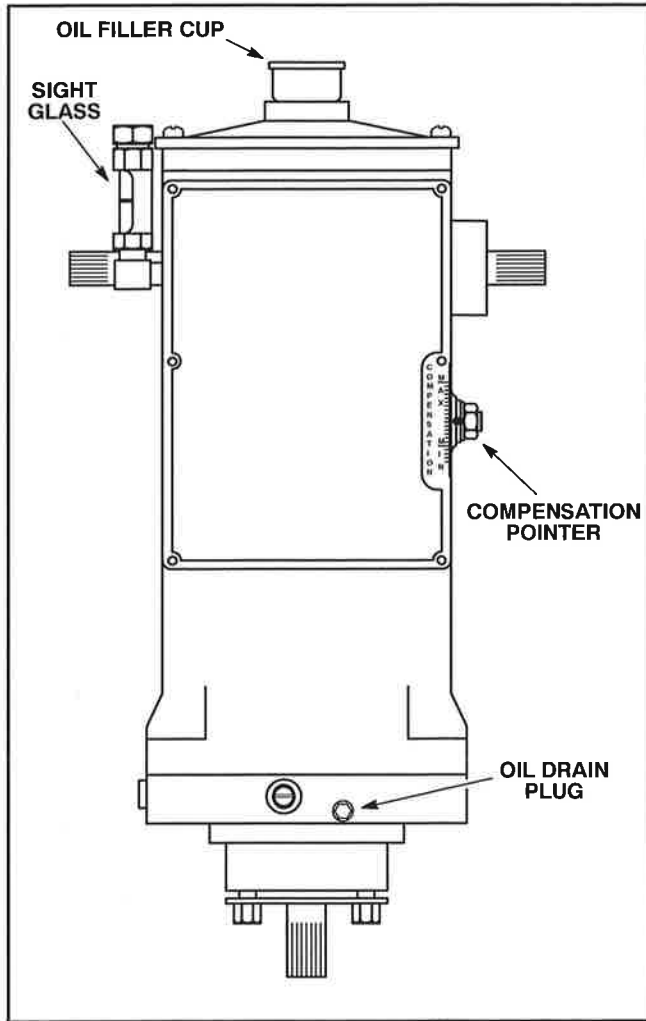


Figure 3.00-5. Woodward UG-8L Governor

9. Examine the engine foundation for condition of grout, tightness of hold down bolts and general alignment of driven equipment.

ENGINE STARTUP PROCEDURES

1. Reset all engine protection switches and devices.
2. Press and hold down the PRELUBE button for 5 minutes to operate the prelube motor (see Figure 3.00-6 and Figure 3.00-7). Check the lube oil pressure gauge for a minimum of 5 psi (35 kPa).

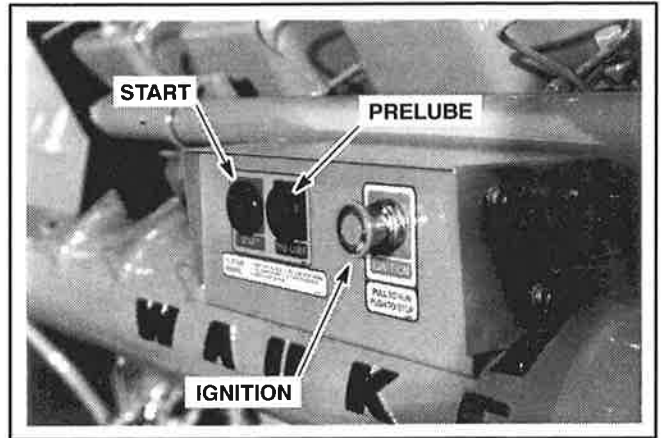


Figure 3.00-6. Control Panel - 12 Cylinder Engine

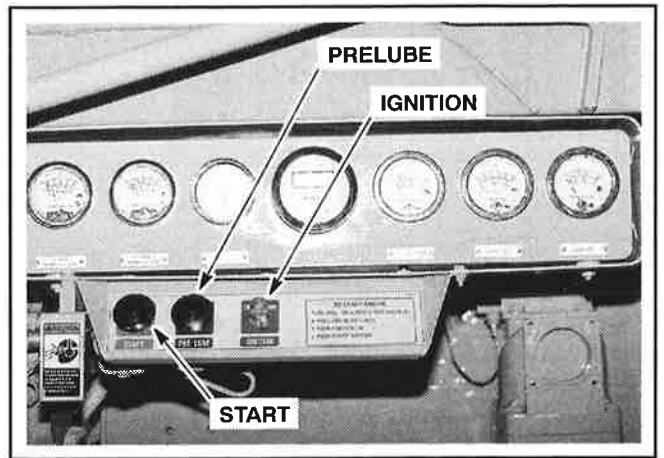
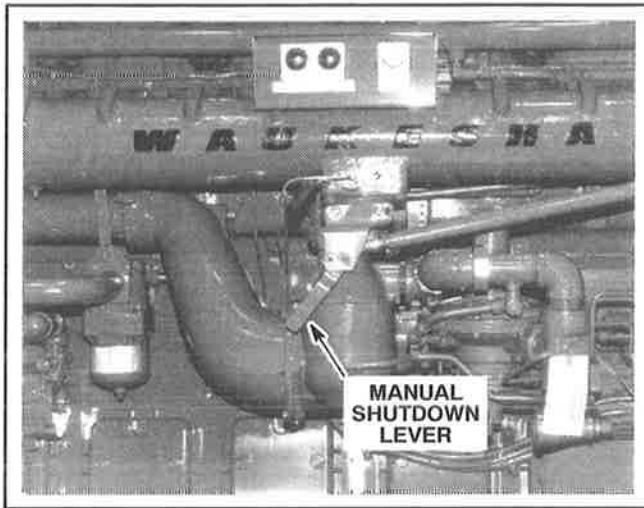


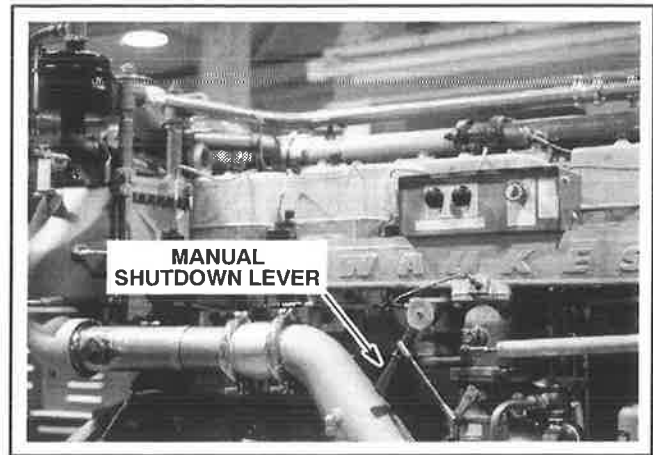
Figure 3.00-7. Control Panel - 16 Cylinder Engine

ENGINE STARTUP AND SHUTDOWN

3. Place the manual shutdown lever in the open position (see Figure 3.00-8, Figure 3.00-9 and Figure 3.00-10).

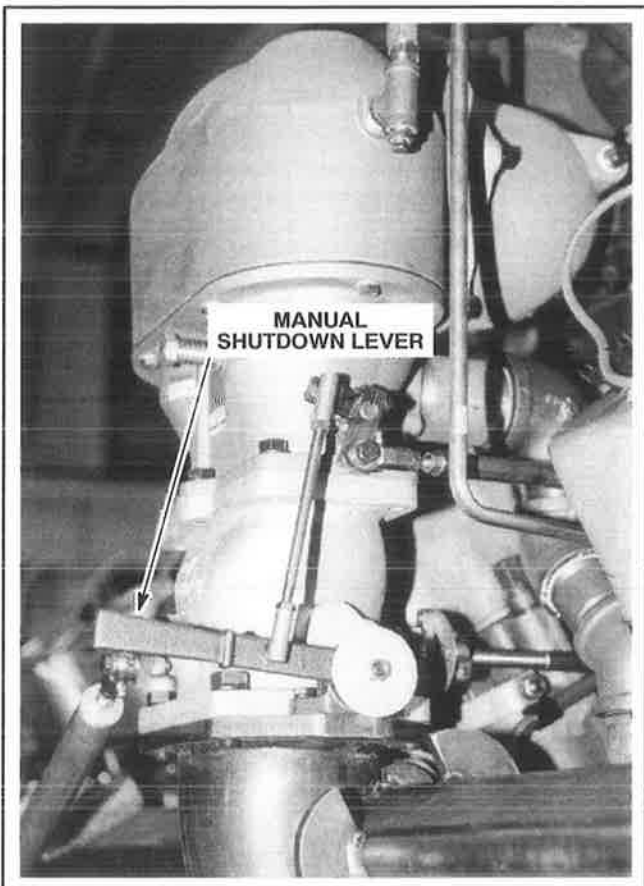


**Figure 3.00-8. Manual Shutdown Lever -
12 Cylinder GL Engine**

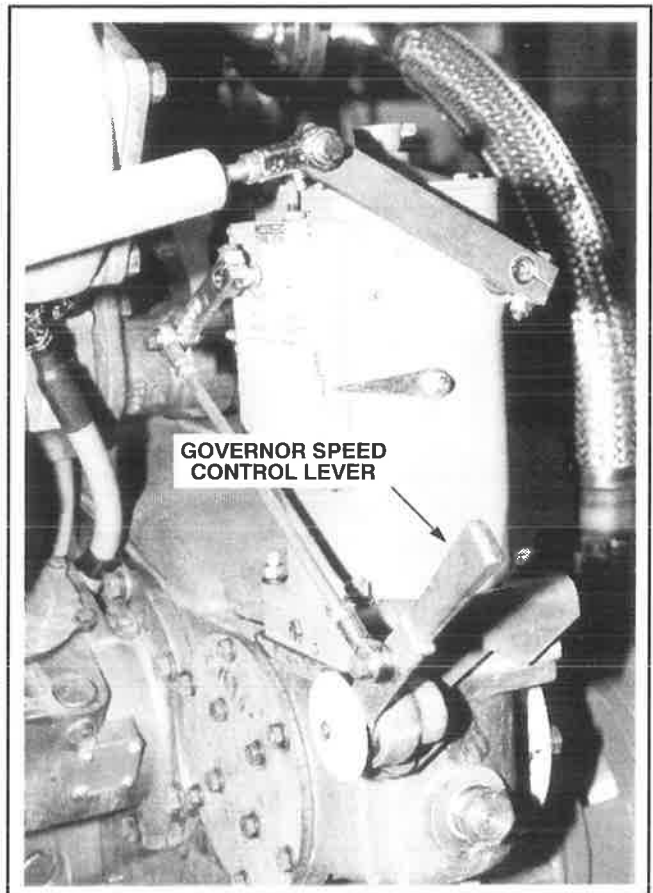


**Figure 3.00-10. Manual Shutdown Lever -
6 Cylinder GSI Engine**

4. Place the governor speed control lever or dial to 1/3 open position (see Figure 3.00-11 and Figure 3.00-12).



**Figure 3.00-9. Manual Shutdown Lever -
16 Cylinder GSI Engine**



**Figure 3.00-11. Governor Speed Control Lever -
12 Cylinder Engine**

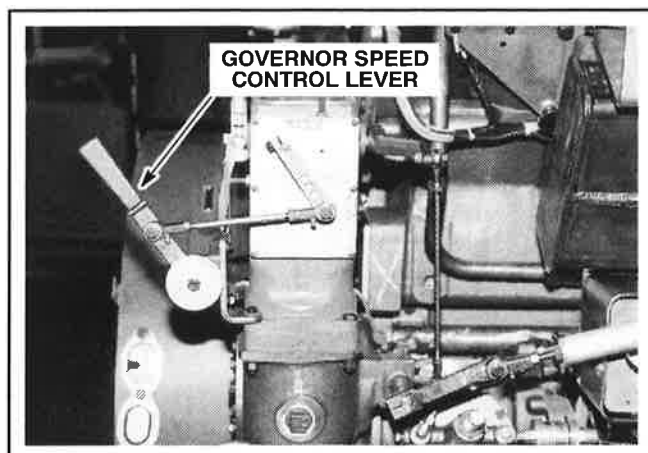


Figure 3.00-12. Governor Speed Control Lever - 16 Cylinder Engine

5. Open the fuel shutoff valve(s) (Figure 3.00-13).

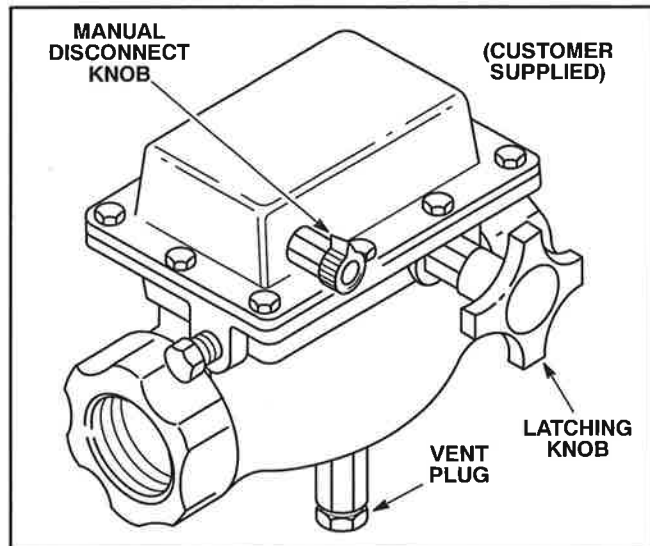


Figure 3.00-13. Fuel Shutoff Valve - Customer Supplied

6. On 6 and 12 cylinder engines, make sure that the IGNITION (Emergency Stop) buttons are pulled out (see Figure 3.00-6). On 16 cylinder engines turn the ignition switch to the ON position (see Figure 3.00-7).
7. Press the START button until engine starts (see Figure 3.00-6 and Figure 3.00-7).
8. Check for oil pressure as soon as the engine starts. Refer to Table 1.15-2, *VHP Specification* in Section 1.15 - *General Information*, for operating pressures.

CAUTION If the lube oil pressure gauge does not indicate sufficient oil pressure within 15 seconds, shut the engine down immediately. Never operate the engine without the proper oil pressure indication. Disregarding this information could result in product damage.

CAUTION Turbocharged engines should not be idled for extended periods. Accumulated carbon may damage turbocharger. Shut down and restart when needed.

9. Warm the engine by running with little or no load until the oil pressure is normal and the coolant temperature reaches 100° F (38° C). Refer to Table 1.15-2, *VHP Specifications* in Section 1.15 - *General Information*, for operating pressures and temperatures.

10. Gradually apply load, to avoid overloading the engine.

NOTE: Engines that are required to start at temperatures below 50° F (10° C) should be equipped with both an oil and coolant heater. These devices allow the engine to be started with the proper oil flow. If the heaters are manually controlled, allow the engine to become warm enough for normal starting.

ENGINE STARTUP AND SHUTDOWN

ENGINE DURING OPERATION CHECKS

CAUTION Stop the engine immediately if the oil pressure is low or fluctuating. Disregarding this information could result in product damage.

1. Observe and record the normal operating readings for oil pressure, oil temperature, and water temperature on the engine instrument panel (see Figure 3.00-7 and Figure 3.00-14) or optional remote instrument panel (see Figure 3.00-15). Refer to Table 1.15-2, *VHP Specifications* in Section 1.15 - *General Information*, for operating pressures and temperatures.

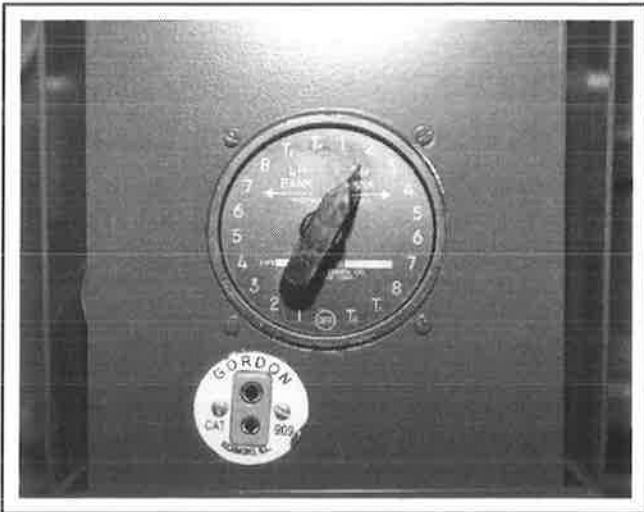


Figure 3.00-14. Thermocouple Selection Switch - 16 Cylinder

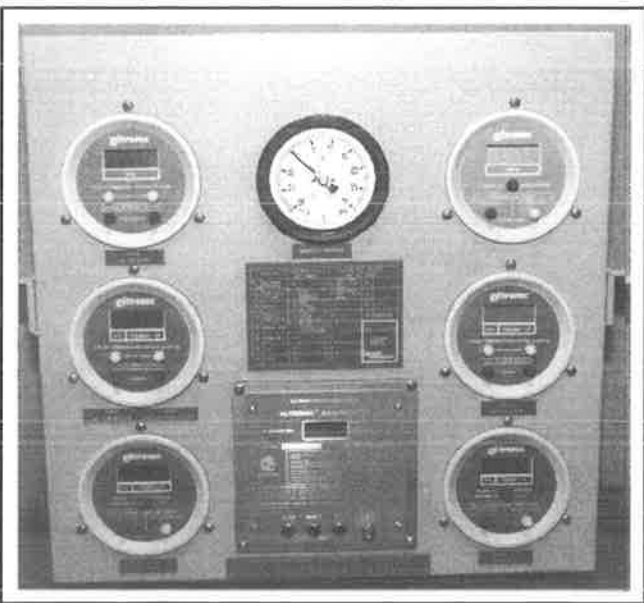


Figure 3.00-15. Optional Remote Instrument Panel

2. Check the air restriction indicator on the air cleaner while the engine is running. Refer to *Air Induction System*, and clean/replace precleaner and/or air cleaner elements if indicator shows red on 6 and 12 cylinder engines (see Figure 3.00-16). On 16 cylinder engines, check that the air restriction gauge is showing in the green for both the prefilter and final filter (see Figure 3.00-17). A toggle switch allows the operator to select the filter reading desired. The toggle switch should be left in the FINAL FILTER position during engine operation.

3. Listen to the engine. Certain problems, such as occasional misfiring, turbocharger bearing failure, or water pump problems, may first be noticeable in the engine sound.

4. Visually examine fuel, water, and lubrication lines for signs of leaks, damage, or corrosion.

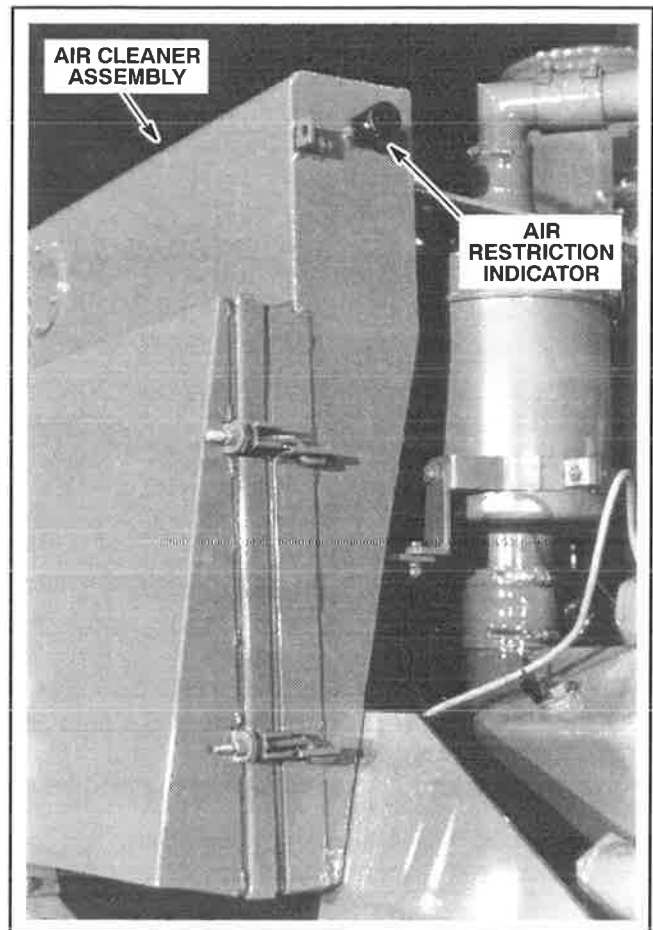


Figure 3.00-16. Air Restriction Indicator - 5115GL Engine

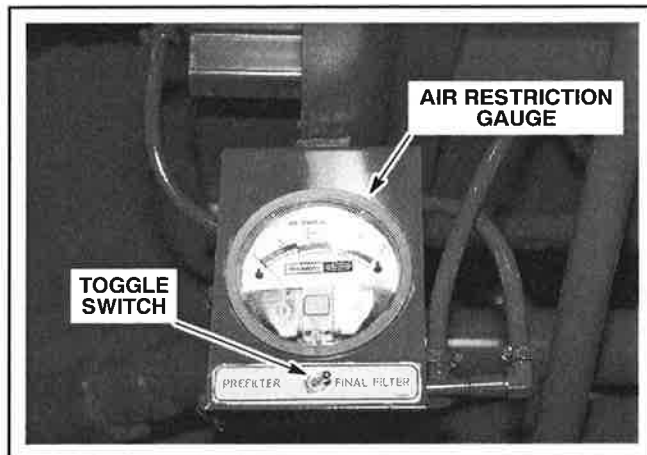


Figure 3.00-17. Air Restriction Indicator - 16 Cylinder Engine

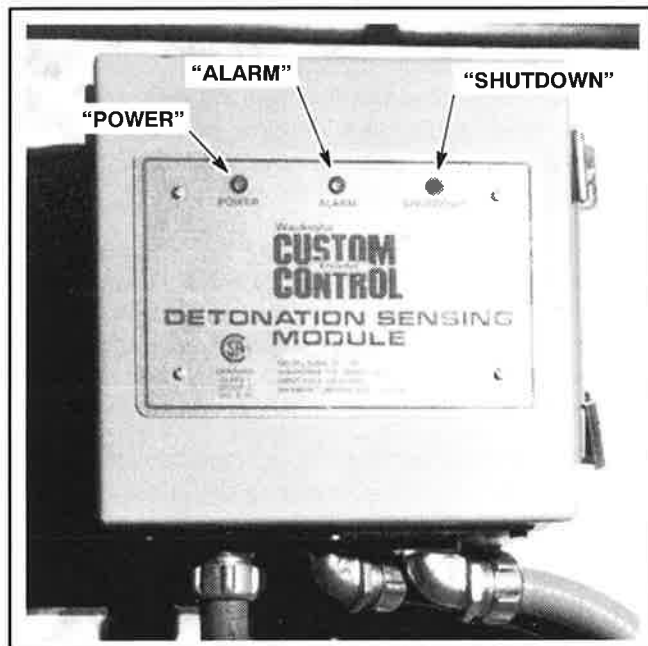


Figure 3.00-18. Detonation Sensing Module - Front Panel

5. Monitor the DSM module (see Figure 3.00-18) for system status. The DSM is equipped with several features to inform site personnel of system status. These features include:

- “Power”, “Alarm”, and “Shutdown” lights (LED display) on the front panel of the DSM module.
- A liquid crystal display (LCD) located inside the DSM module which continually shows the current status of the system through diagnostic codes.
- The capability to drive remote alarms or lights.

6. If red “Shutdown” light is illuminated, shut down the engine if automatic devices have not already done so. Call a Waukesha certified technician for assistance.

7. The yellow “Alarm” light illuminates to indicate that sensor output has been lost or disconnected. Call a Waukesha certified technician for assistance.

NOTE: Refer to Form 6268, *DSM Custom Engine Control® Detonation Sensing Module Installation, Operation, And Maintenance Manual*, for information concerning the DSM.

NOTE: Refer to Form 6253, (Previous Model) or Form 6272 (Current Model) *IM Custom Engine Control® Ignition Module Installation, Operation, And Maintenance Manual*, for further information concerning the IM.

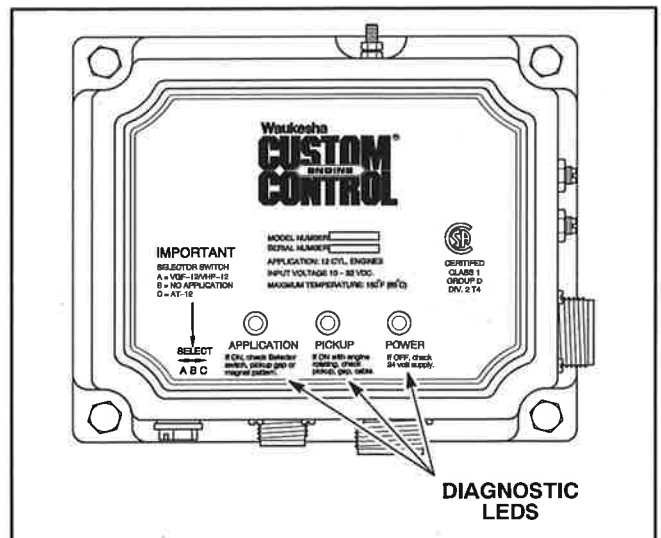


Figure 3.00-19. IM Diagnostic LEDs

8. Monitor the three diagnostic LEDs on front of the IM housing: “Power,” “Pickup,” and “Application” (see Figure 3.00-19). These LEDs give operators visual confirmation on (1) incoming power, (2) Hall-effect pickup signal, and (3) proper application settings (see Figure 3.00-19).

- The green “Power” LED is lit any time power is applied to the IM. The power LED confirms to the operator that connection has been made to the IM from the VDC power supply.
- The red “Pickup” LED is lit when there is no Hall-effect pickup signal being detected by the IM due to a failed pickup, an incorrect air gap setting, and/or incorrect (bad) wiring. The pickup LED will also be lit when the engine is at rest.

ENGINE STARTUP AND SHUTDOWN

- The red "Application" LED is lit whenever the IM detects a magnet pattern that does not match the application for which the IM Selector Switch is set (6 versus 8 cylinder) or when the incorrect IM model is installed (inline IM model versus vee engine IM model). Additionally, this LED will light when the Hall-effect pickup is lost (disconnected or failed), or if a magnet is lost or is very weak. The application LED will also light when the Selector Switch is in the "B" position (no application).

9. If green "Power" LED is not illuminated, shutdown the engine. Call a Waukesha certified technician for assistance.

10. If red "Pickup" LED is illuminated, shutdown engine. Call a Waukesha certified technician for assistance.

11. If red "Application" LED is illuminated, shutdown engine. Call a Waukesha certified technician for assistance.

ENGINE SHUTDOWN PROCEDURES

ROUTINE SHUTDOWN

WARNING

To avoid severe personal injury or death, allow the engine to cool for at least ten minutes after the engine is stopped. Do not restart an overheated engine or an engine that has been shutdown by the engine protection system until the reason for the shutdown has been determined and corrected.

1. Gradually reduce engine load.
2. Place the governor speed control lever or dial in idle speed position, and allow the engine to idle for 5 minutes to cool down engine temperatures.

WARNING

Always insure that the fuel gas valve(s) are closed after engine shutdown. Failure to close valve(s) could cause severe personal injury or death.

3. Under normal operation, close the fuel valves to shut the engine down.
4. Press and hold the Prelube button for five minutes to post-lube the engine.

CAUTION

If the engine is being shut down for an extended period of time, cap the exhaust pipe to prevent moisture or contaminants from entering the engine. Failure to follow these instructions could cause severe engine damage and/or personal injury.

EMERGENCY SHUTDOWN

WARNING

To avoid severe personal injury or death, allow the engine to cool for at least ten minutes after the engine is stopped. Do not restart an overheated engine or an engine that has been shutdown by the engine protection system until the reason for the shutdown has been determined and corrected.

WARNING

Always insure that the fuel gas valve(s) are closed after engine shutdown. Failure to close fuel gas valve(s) could cause severe personal injury or death.

In the event of an emergency, the engine may be shutdown by using the IGNITION switch or buttons. The manual shutdown lever or governor speed lever/dial may be used to return the engine to idle speed. In all cases after engine shutdown, the fuel shutdown valve(s) must be closed.

NOTE: Some governors may not have a speed control lever. The UG-8 dial governor is equipped with a dial speed control.

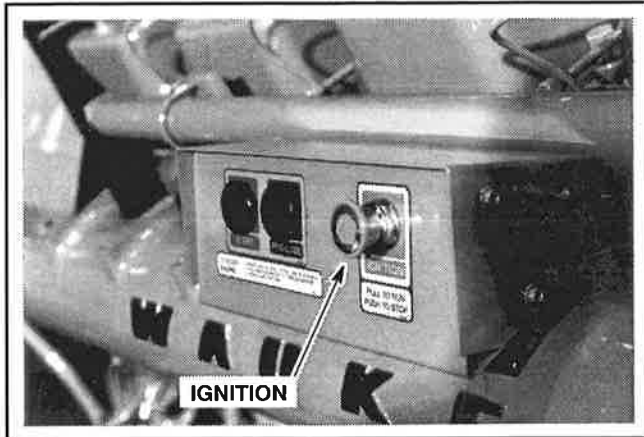
**Engine Shutdown Using Ignition
(Emergency Stop Button/Switch)
6 & 12 Cylinder Engines**

NOTE: CSA equipped engines have a similar **IGNITION (Emergency Stop button/switch)** located on a separate sealed box (see Figure 3.00-21).

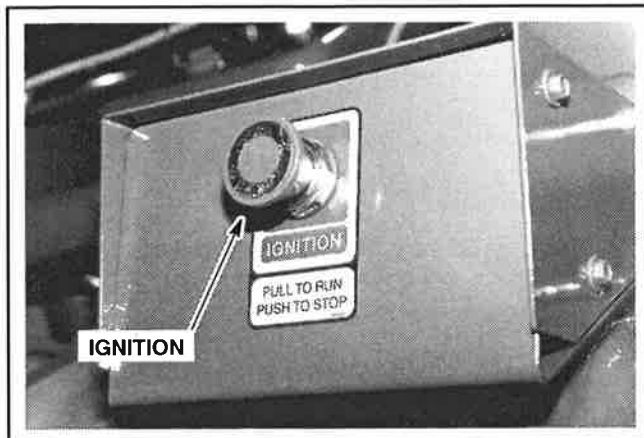
1. On 6 and 12 cylinder engines, shut down the engine by pushing in the **IGNITION (Emergency Stop)** button(s), located on the control panel(s) and simultaneously close the fuel shutdown valve(s). 12 cylinder engines have an ignition switch located on each side of the engine (see Figure 3.00-20 and Figure 3.00-21) while 6 cylinder engines have only one panel located on the right side of the engine (see Figure 3.00-22).

⚠ WARNING

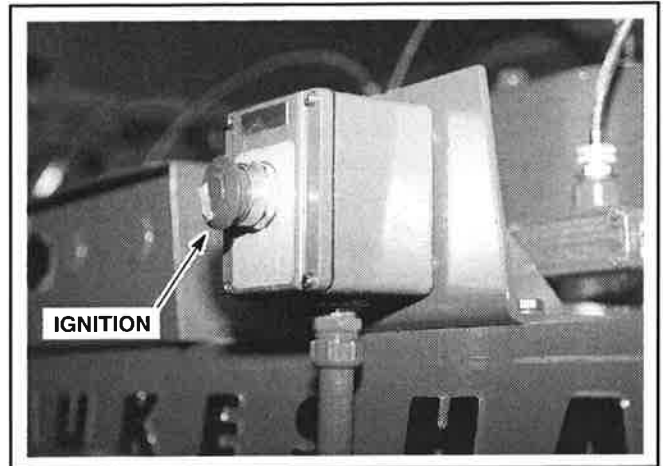
Always insure that the fuel gas valve(s) are closed after engine shutdown. Failure to close fuel gas valve(s) could cause severe personal injury or death.



**Figure 3.00-20. Control Panel -
12 Cylinder Engine Right Side**



**Figure 3.00-21. Control Panel -
12 Cylinder Engine Left Side**



**Figure 3.00-22. CSA Control Panel -
6 Cylinder Engine Right Side**

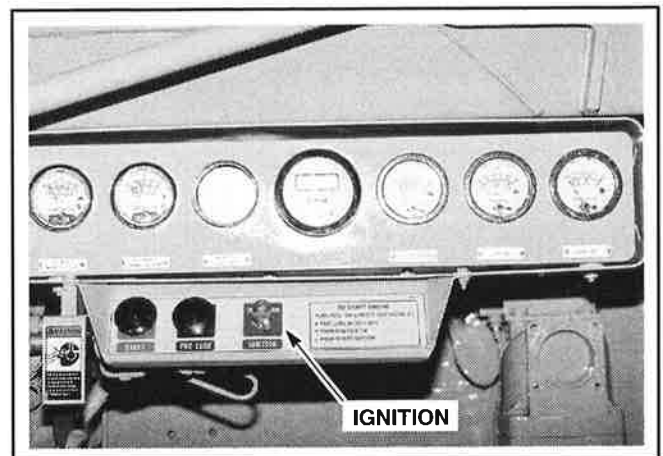
**Engine Shutdown Using Ignition Switch -
16 Cylinder Engines**

To shut down the engine using the **IGNITION** switch, perform the following Steps.

1. On 16 cylinder engines, shut down the engine by turning the **IGNITION** switch, located on the control panel, to the **OFF** position, and simultaneously close the fuel shutdown valve(s) (see Figure 3.00-23).

⚠ WARNING

Always insure that the fuel gas valve(s) are closed after engine shutdown. Failure to close fuel gas valve(s) could cause severe personal injury or death.



**Figure 3.00-23. Control Panel -
16 Cylinder Engine Right Side**

ENGINE STARTUP AND SHUTDOWN

Using Manual Shutdown Lever Or Governor Speed Control Lever To Return Engine To Idle Speed

NOTE: Some governors may not have a speed control lever. The UG-8 dial governor is equipped with a dial speed control.

1. The manual shutdown lever (located on the right side carburetor) (see Figure 3.00-24, Figure 3.00-25 and Figure 3.00-26) or the governor speed control lever/dial (mounted on the governor) (see Figure 3.00-27) may be used to return the engine to idle speed. Under some conditions, the engine may stop. In this case, close the fuel shutdown valve(s). If the engine does not stop, push in the IGNITION (Emergency Stop) button(s) on 6 and 12 cylinder engines, or turn the IGNITION switch to the OFF position, on 16 cylinder engines, and simultaneously close the fuel shutdown valve(s) to shutdown the engine.

WARNING

Always insure that the fuel gas valve(s) are closed after engine shutdown. Failure to close fuel gas valve(s) could cause severe personal injury or death.



Figure 3.00-24. Manual Shutdown Lever - 6 Cylinder GSI Engine

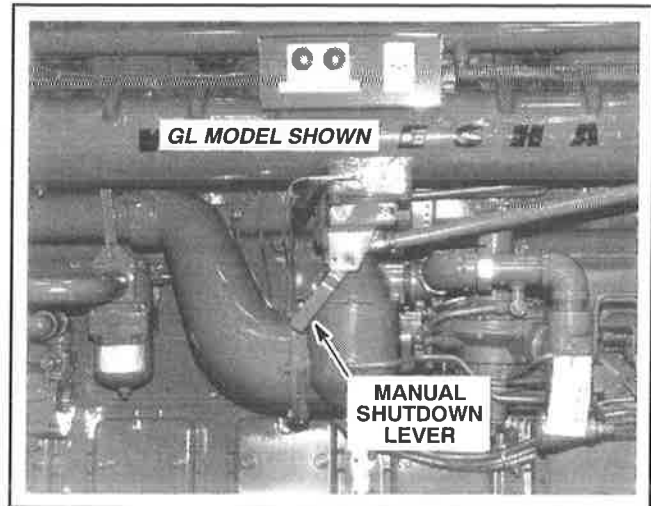


Figure 3.00-25. Manual Shutdown Lever - 12 Cylinder

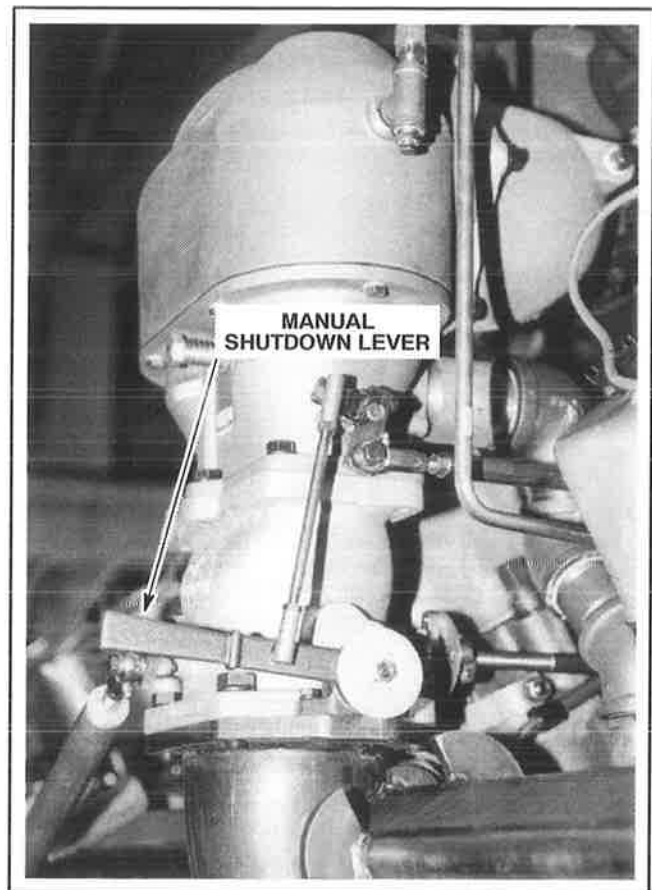


Figure 3.00-26. Manual Shutdown Lever - 16 Cylinder GSI Engine

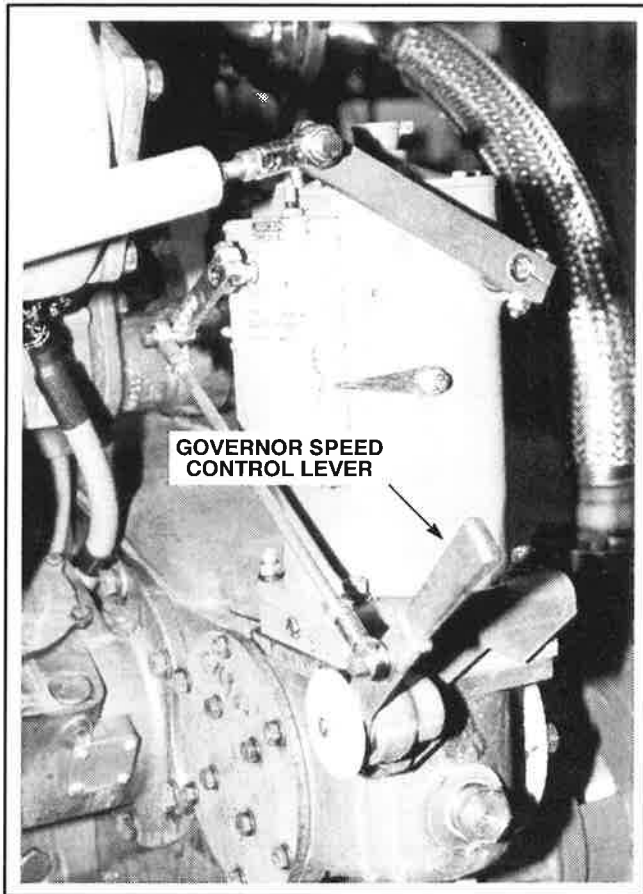


Figure 3.00-27. Governor Speed Control Lever -
12 Cylinder Engine

or check starting circuitry and safety equipment with the starter disabled. Special attention must be taken to prevent internal corrosion, sticking and gumming of fuel controls, and deteriorated starting batteries. Arrangements should be made to run the engine and driven equipment under load at least every 90 days.

ENGINE PERFORMANCE RECORD

Engine operating information, recorded during regular inspections, is necessary to apply proper Routine Maintenance schedules. Accurate records help control costs by avoiding unnecessary servicing, insuring needed servicing, and providing "trend" information on general engine condition. It is recommended to keep a record of the following information listed in Table 3.00-1.

MAINTENANCE OF STANDBY UNITS

A generator set, or other standby unit, should be exercised once each week. A record should be maintained of performance and servicing, of both the engine and driven equipment.

CAUTION Turbocharged engines should not be idled for extended periods. Accumulated carbon may damage turbocharger. Shut down and restart when needed.

Always run the engine long enough to stabilize the oil and water temperatures at the normal operating level expected under load. Do not operate the engine under no-load conditions for other than very brief periods. Loads of at least one-third the normal rated capacity, are recommended. Ordinarily, an exercise run of one to two hours will be needed.

Some types of driven equipment cannot be operated without fairly extensive procedures "to put them on the line".

Weekly exercise may have to consist of periods long enough to check the engine's ability to crank and start,

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SECTION 4.05 - FUEL SYSTEM MAINTENANCE

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SECTION 4.15 - AIR INTAKE SYSTEM MAINTENANCE

SECTION 4.20 - TURBOCHARGER SYSTEM MAINTENANCE

SECTION 4.25 - COOLING SYSTEM MAINTENANCE

SECTION 4.30 - LUBRICATION SYSTEM MAINTENANCE

SECTION 4.35 - EXHAUST SYSTEM MAINTENANCE

**SECTION 4.40 - CRANKCASE BREATHER SYSTEM
MAINTENANCE**

**SECTION 4.45 - PRELUBE AND STARTING SYSTEM
MAINTENANCE**

**SECTION 4.50 - ENGINE PROTECTION SHUTDOWN SYSTEM
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SECTION 4.55 - VALVE ADJUSTMENT

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SECTION 4.00

SPEED GOVERNING SYSTEM MAINTENANCE

SPEED GOVERNING SYSTEM MAINTENANCE

GOVERNOR MAINTENANCE

Check oil level in sight glass daily (see Figure 4.00-1).
Change oil every 8000 hours. Use the same lubricating oil used in the engine crankcase.

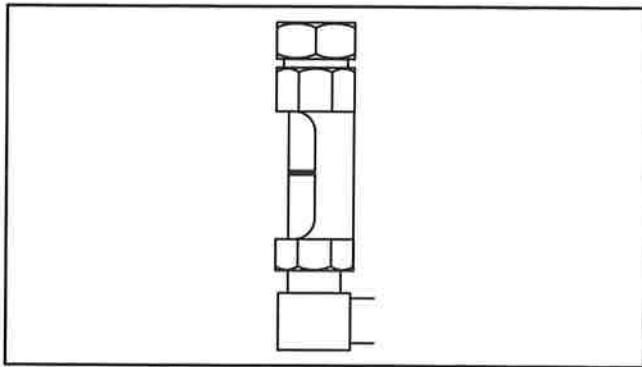


Figure 4.00-1. Governor Oil Level Sight Glass

Governor Oil Change And Fill (UG-8L Governor)

1. Place a small oil pan beneath the governor.
2. Remove oil drain plug from governor and allow oil to drain (see Figure 4.00-2).
3. Replace oil drain plug.
4. Lift up oil filler cap and slowly add oil until the oil appears at the line marked on the sight glass.

NOTE: Use the same oil as used in the engine crankcase.

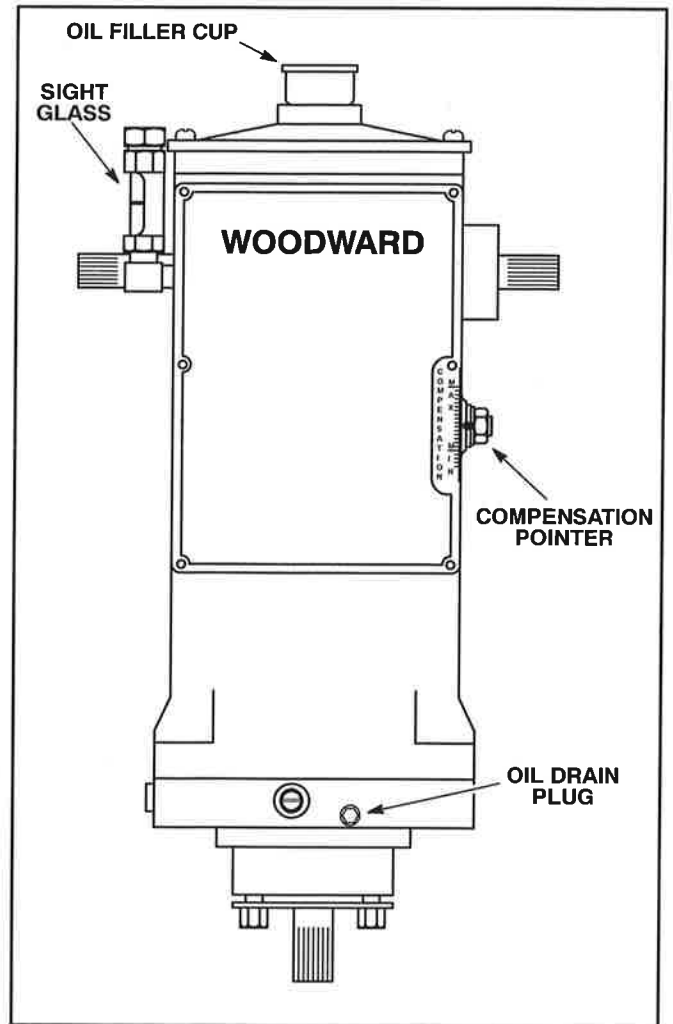


Figure 4.00-2. Woodward UG-8L Governor

SPEED GOVERNING SYSTEM MAINTENANCE

GOVERNOR ROD MAINTENANCE

Governor Rod Inspection And Lubrication

1. Inspect that the jam nuts on both ends of the governor rod are secure (see Figure 4.00-3).
2. Inspect the governor rod for straightness and damage.
3. Lubricate the grease fittings on both ends of the governor rod at each oil change. Clean off any excess grease.

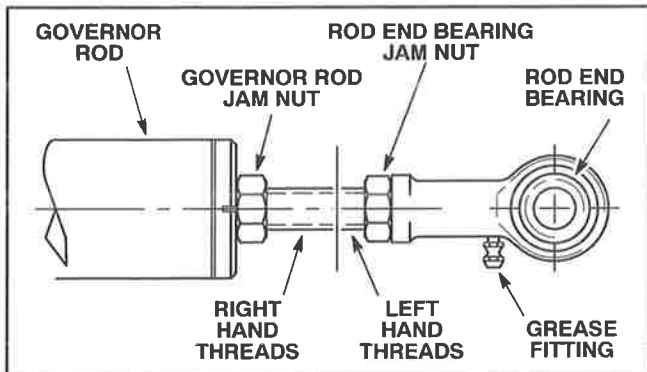


Figure 4.00-3. Governor Rod Assembly

SECTION 4.05

FUEL SYSTEM MAINTENANCE

FUEL SYSTEM MAINTENANCE

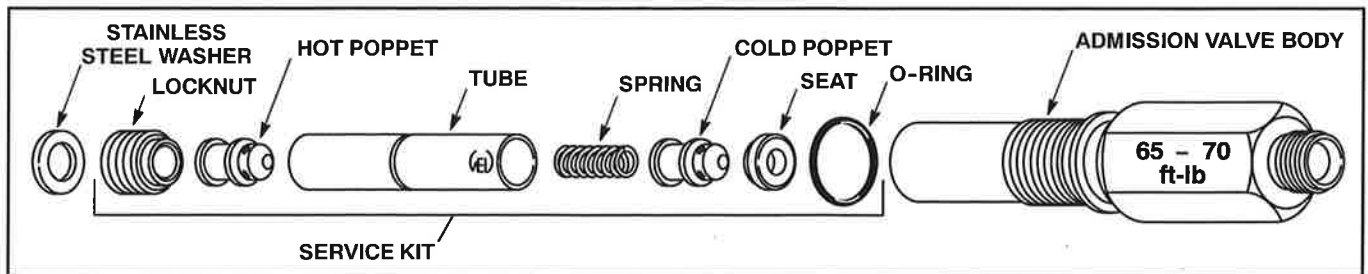


Figure 4.05-1. Admission Valve Assembly

ADMISSION VALVE MAINTENANCE

Admission Valve Removal - GL

WARNING

Ensure that the fuel source is completely shut off prior to working on fuel system components. Clear the engine supply lines and piping of accumulated gas before performing any maintenance work on the fuel system or severe injury or death could result.

NOTE: This procedure applies only to the P/N 211587A admission valve. Refer to Service Bulletin 9-2574A or latest edition, for information on previous admission valves.

1. Disconnect the fuel supply tube from the admission valve body.
2. Remove the admission valve from the engine by turning counter-clockwise. Remove and discard the O-ring from the valve body (see Figure 4.05-1 and Figure 4.05-2).
3. Remove the stainless steel washer at the bottom of the admission valve bore using the seal remover (Tool P/N 494385) or an O-ring pick. Discard this washer.

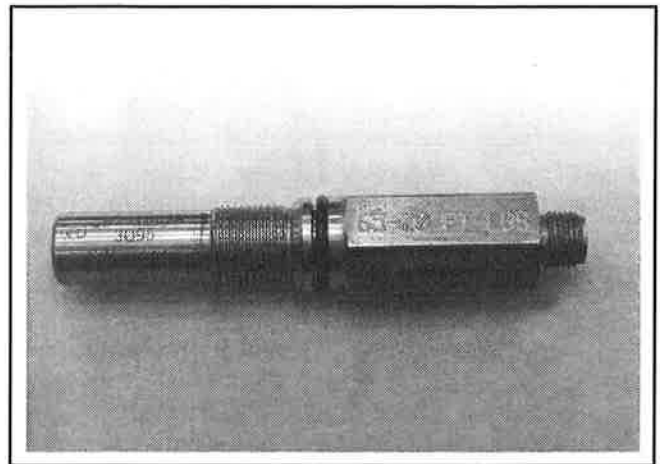


Figure 4.05-2. Admission Valve

Admission Valve Disassembly - GL

 CAUTION Intermixing components with those of other valves is not permitted. Admission valves (and rebuild kits) are inspected as assemblies during manufacture. Disregarding this information could result in product damage and/or personal injury.

1. Remove the lock nut from the end of the admission valve body using a 1/4 inch Allen wrench.

FUEL SYSTEM MAINTENANCE

CAUTION If a vise is needed to remove the lock nut, install a pair of brass jaw inserts to avoid damaging the assembly.

2. Remove the tube assembly. Remove the tube seat. Strike the admission valve body sharply against a piece of wood to free the tube and tube seat, if necessary.
3. Remove the contents of the tube. Remove the spring and cold poppet from one end. Remove the hot poppet from the other.
4. Remove and discard the O-ring from the admission valve body.

Admission Valve Clean And Inspect - GL

1. Remove any loose carbon using a rag or soft nonmetallic bristle brush.
2. Boil all parts in a solution of one cup laundry detergent to one gallon of water for 30 - 45 minutes.
3. After boiling, rinse the parts in cold water and wipe dry.

Admission Valve Assembly - GL

CAUTION The service kit parts may separate after the packaging is removed. There are internal differences between the hot and cold poppets, as well as the hot (flame trap) and cold (check valve) sides of the tube. The valve will not function properly if incorrectly assembled. Disregarding this information could result in product damage and/or personal injury.

CAUTION Do not mix parts from various admission valves, components are in matched sets. Disregarding this information could result in product damage and/or personal injury.

NOTE: Before assembling, all parts must be dry and oil free.

1. Look into both poppets. Note that the bore of the hot poppet is approximately 1/8 inch deeper than the cold poppet.

NOTE: The parts in the service kit are assembled in the proper order for installation in the valve body (see Figure 4.05-3). The service kit parts may separate after the packaging is removed. If the parts become separated, an easy way to identify the hot and cold poppets is to visually inspect the inside of the poppets (see Figure 4.05-3). Another way to identify the poppets is to install the spring. The spring will extend farther out of the cold poppet (see Figure 4.05-3). The cold poppet and spring are installed in the end of the tube that is marked with the WED label. Proper assembly is required.

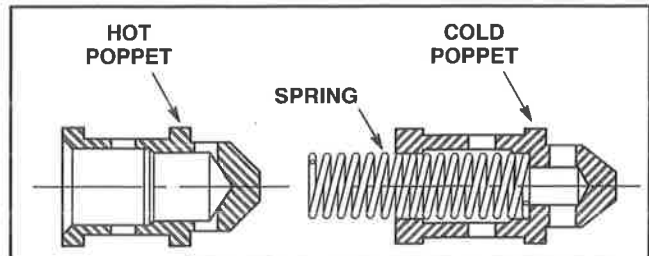


Figure 4.05-3. Spring Seats In Cold Poppets

2. Install the spring in the open end of the cold poppet. (see Figure 4.05-3).
 3. Look into each end of the tube. Note that one end has a larger diameter counterbore (to fit the tip of the hot poppet), while the other end of the tube has a small opening encircled with a lip (spring seat).
 4. Insert the cold poppet (spring end first) into the tube until the end of the spring contacts the spring seat. Verify that the tip of the poppet sticks out slightly.
- NOTE:** If the entire poppet fits within the tube, then the wrong (hot) end of the tube has been selected. Fit the cold poppet into the other end of the tube.
5. Install the hot poppet into the opposite end of the tube. The flat side of the poppet must face toward the open end of the tube, so that the tip of the poppet seats inside the counterbore.
 6. Hold the tube assembly upright in one hand with the tip of the cold poppet pointing upward. Use a finger to keep the hot poppet in the other end of the tube.
 7. Place the tube seat over the tip of the cold poppet, so that the lip on the seat fits within the tube ID.
 8. With the long hex on top, slide the admission valve body over the cold poppet end of the tube until the entire assembly fits easily within the valve body.
 9. Finger tighten the lock nut into the end of the admission valve body.

CAUTION Do not over-torque the lock nut or the tube may be permanently damaged. Disregarding this information could result in product damage.

CAUTION Do not over tighten the admission valve or the valve may become damaged.

10. Use an inch pound torque wrench and Allen socket to tighten the lock nut to 70 - 90 in-lb (8 - 10 N·m).

4. Tighten the valve to a torque of 65 - 70 ft-lb (88 - 95 N·m) dry.

11. Install a new O-ring on the admission valve body. To prevent tears when the assembly is inserted into the cylinder head admission valve bore, lubricate the O-ring with Parker Super O-Lube®.

5. Reattach both ends of the prechamber fuel inlet tube on the prechamber manifold and the admission valve assembly. Finger tighten the ferrule nuts. Use a wrench to tighten the ferrule nuts. Inspect for fuel leaks.

Admission Valve Installation - GL

1. Clean the washer seat at the bottom of the cylinder head admission valve bore.

NOTE: Previous production admission valves use a copper washer.

2. Install a new stainless steel washer at the bottom of the cylinder head admission valve bore (see Figure 4.05-4).

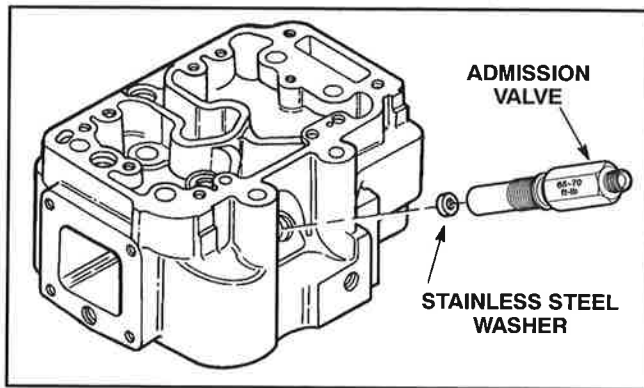


Figure 4.05-4. Install Stainless Steel Washer In Cylinder Head

CAUTION When installing the admission valve, make sure only a stainless steel washer is used and is seated flat against the seating surface in the cylinder head. If the stainless steel washer is damaged, fuel leaks will occur.

CAUTION Do not use copper washer P/N 16409 with P/N 211587A admission valve or with a P/N 211587 valve that has been upgraded by machining the lock nut. If the copper washer is used, the new assembly torque will drive the admission valve through the washer, causing damage.

3. Install the admission valve in the cylinder head bore.

FUEL SYSTEM MAINTENANCE

SECTION 4.10

IGNITION SYSTEM MAINTENANCE

IGNITION MAINTENANCE

SPARK PLUG MAINTENANCE - NON-CSA

Spark Plug Removal - NON-CSA

1. Detach the spark plug cable from the cable clip mounted on the rocker arm cover. Remove the rubber boot from the coil terminal connection (see Figure 4.10-1 and Figure 4.10-2). Remove the spark plug cable from the ignition coil.
2. Pull back the rubber recess cover from the spark plug well on G and GSI engines or the spark plug carrier bore on GL models.

CAUTION Do not pull on the spark plug cables to remove the spark plug connectors. Pulling on the cable may loosen or detach the terminal connection within the Teflon tube. Disregarding this information could result in product damage and/or personal injury.

3. Holding onto the Teflon tube, remove the spark plug connector from the spark plug terminal nut.
4. Refer to Table 4.10-2 and select the proper spark plug tools. Remove the spark plug from the cylinder head or spark plug carrier bore.

Table 4.10-1. Spark Plug Troubleshooting

FIRING TIP APPEARANCE	CONDITION	REMEDY
Light casting of whitish ash, uniformly deposited	Normal with medium to high ash lube oils	No change; reflects a healthy operating cylinder
Excessive ash buildup	High oil consumption	Change engine lube oil type
	Wrong lube oil; ash content too high	Change engine lube oil type
Excessive ash buildup	Poor oil control around valve guides and piston rings	Inspect and replace worn parts as necessary
Black oil fouling deposits	Poor oil control around valve guides and piston rings	Replace worn parts as necessary
	Engine too lightly loaded	Adjust engine load
Gap bridging	Contaminated or "dirty" fuel gas	Add fuel filter
		Use more "open" electrode type plug
Carbon fouling	Spark plug firing tip temperature too low	Change plug heat range
	Engine too lightly loaded	Adjust engine load
	High oil consumption	Inspect and replace worn parts as necessary
Electrode burning	Spark plug firing tip temperature too high	Change plug heat range
Wear on side electrodes	Reverse polarity	Reverse ignition coil wiring
Aluminum contamination	Engine operated with severe detonation resulting in piston damage	Inspect piston crowns with borescope; replace worn parts as necessary
		Check ignition timing, fuel gas octane
		Reduce engine load
Bright blue or green deposits	Oxide of cobalt fouling from burning of Stellite® on valves and seats	Replace valves and seats

NOTE: 1. If any of the above conditions exist, be sure to correct the cause before installing new spark plugs.
 2. "Stellite®" is a registered trademark of Stoddy Deloro Stellite, Inc."

IGNITION SYSTEM MAINTENANCE

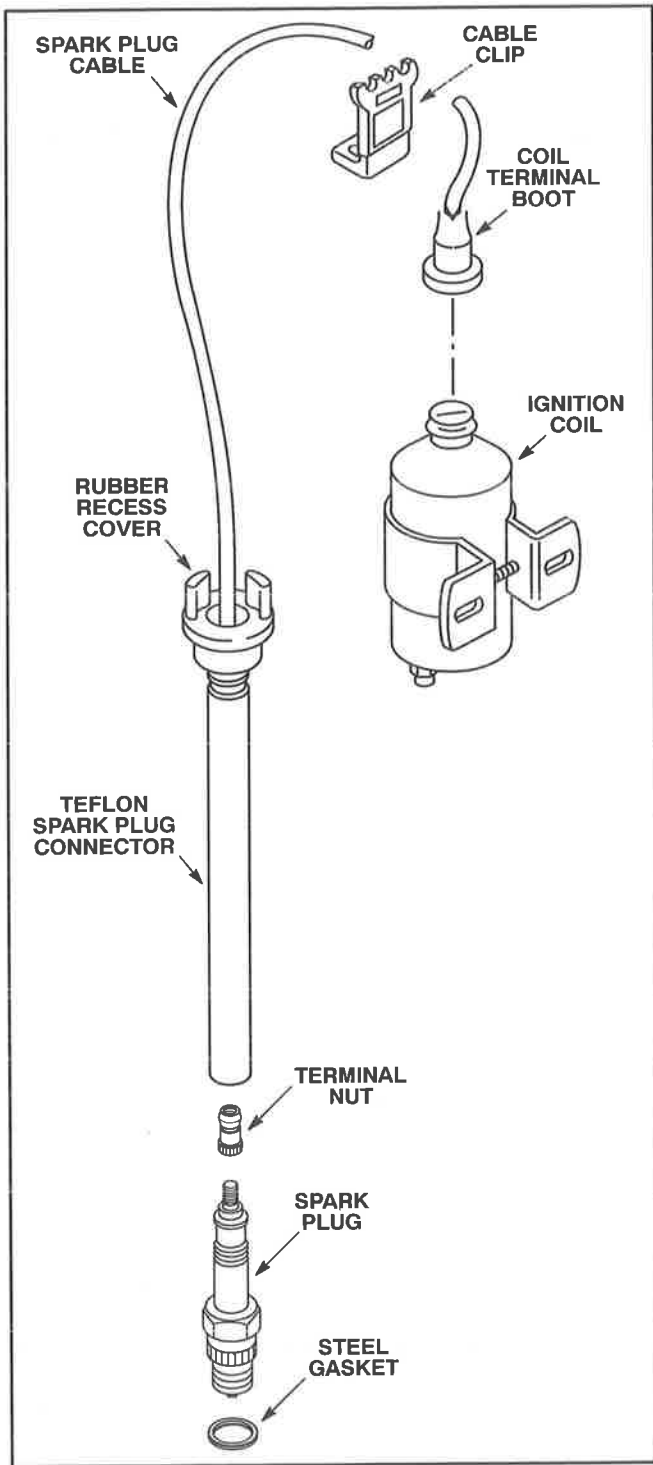


Figure 4.10-1. Install Spark Plug/Connections

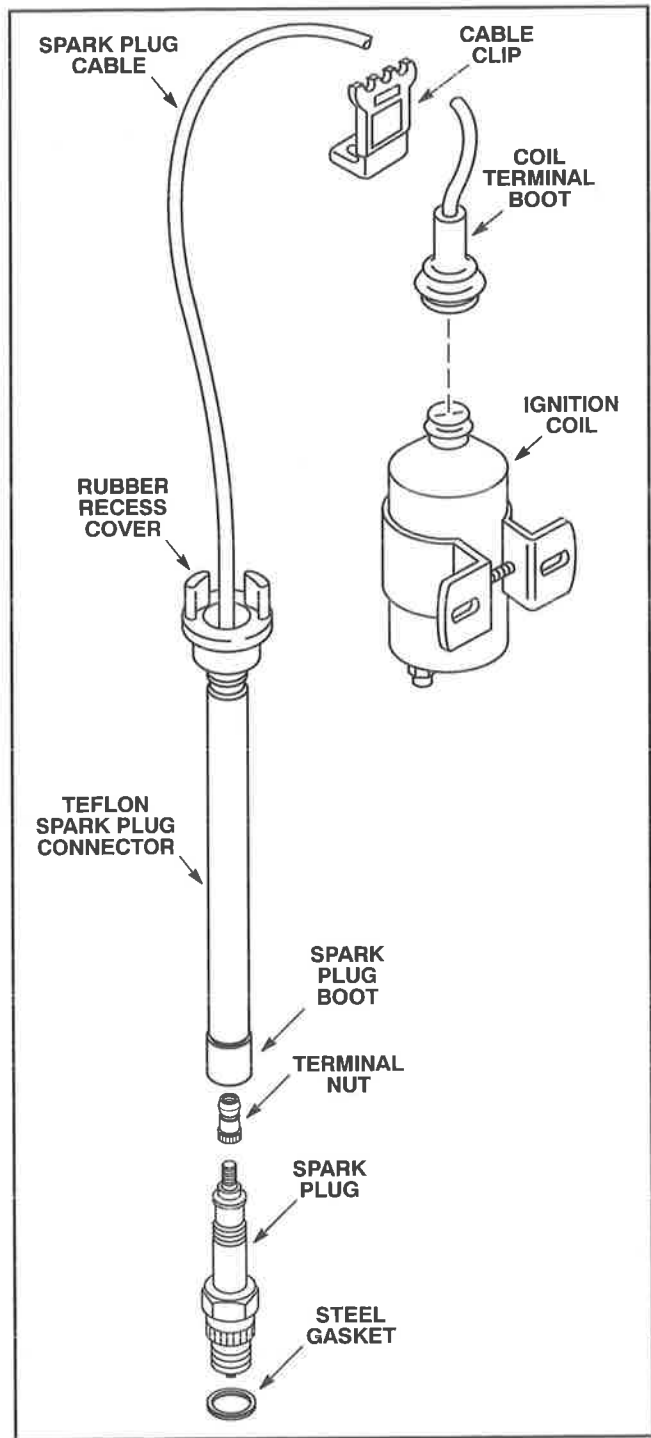


Figure 4.10-2. Install Spark Plug/Connections P/N 211357H Extension

Spark Plug Inspection

Inspect the condition of the spark plugs, paying particular attention to the firing tip. Spark plugs often yield visual clues to abnormal conditions existing in the engine's power cylinders. Your observations also can be used as a guide in establishing the proper service interval. See Table 4.10-1.

Table 4.10-2. Spark Plug Tools

TOOL P/N	TOOL DESCRIPTION
167164D	Spark Plug Socket/Ext. (1 inch socket with 10 inch extension, for Shielded, CSA w/ F.M. coils)
475037	Spark Plug Socket (NEW) (7/8 inch Socket 15-1/2 inch long w/rubber O-ring insert)

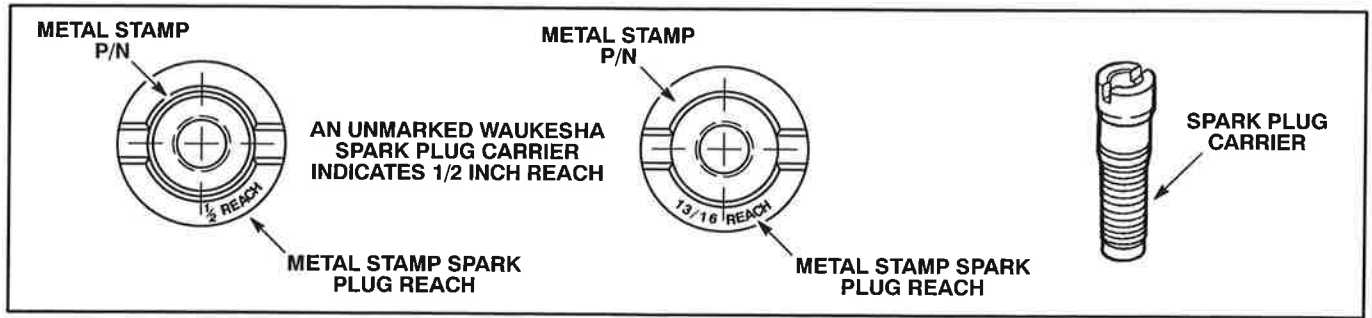


Figure 4.10-3. Spark Plug Carriers

Spark Plug Installation - Non CSA

CAUTION 13/16 inch reach spark plugs must be used with 13/16 inch reach carriers, and 1/2 inch reach spark plugs must be used with 1/2 inch reach carriers. Mixing carrier and spark plug components will cause damage to equipment and/or personal injury.

1. Obtain a set of new spark plugs (see Table 1.15-4 and Table 1.15-5). On GL models verify which size carrier is present and use the correct size spark plug, see **CAUTION** above and Figure 4.10-3. On G and GSI models select the 1/2 inch reach spark plug desired.

CAUTION The spark plug gasket must be properly seated to seal the combustion chamber and transfer heat from the plug. Disregarding this information could result in product damage and/or personal injury.

2. Install the steel gasket on the spark plug (see Figure 4.10-1). Use only new steel gaskets. Verify that the gasket is flat against the gasket seat.

3. Install the terminal nut.

4. Refer to Table 1.15-4 and Table 1.15-5 and set the spark plug gap.

CAUTION The presence of oil or grease on the ceramic insulator of the spark plug can cause flashover. Flashover, a condition where the spark fails to jump the gap because of an easier path to ground, results in misfire. Disregarding this information could result in product damage and/or personal injury.

CAUTION When using Actrel® 3338L for cleaning, always wear rubber gloves to prevent the cleaner from touching the hands as burning may occur.

WARNING

Always read and comply with safety labels on all containers. Do not remove or deface the container labels. Improper handling or misuse could result in severe personal injury or death.

5. Verify that the spark plug is clean. If necessary, use a dielectric solvent to remove any grease or oily fingerprints. Waukesha Engine Service Operations recommends the use of Actrel® 3338L dielectric solvent manufactured by Exxon Corp. and distributed by Safety-Kleen Corp., (800-669-5750), to clean the connectors.

6. Apply a light coat of KRYTOX® GPL-206 (P/N 489341) grease (or equivalent) on OD of the spark plug ceramic insulator on the portion of the ceramic insulator that will contact the spark plug extension assembly (see Figure 4.10-4).

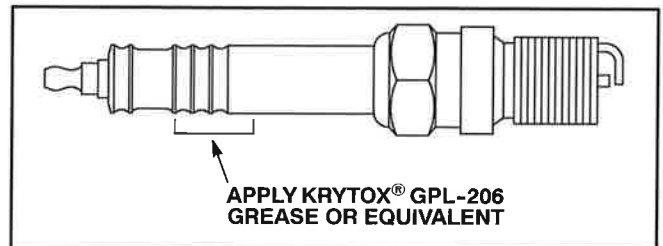


Figure 4.10-4. Apply KRYTOX® GPL-206 Grease

CAUTION Do not use oil or anti-seize compound on the spark plug threads. The spark plug may be overtorqued if oiled. distorts the spark plug and may crack the ceramic construction. Anti-seize compound may foul the firing tip, resulting in a plug shorted to ground. Disregarding this information could result in product damage and/or personal injury.

IGNITION SYSTEM MAINTENANCE



CAUTION

By missing the threaded hole in the spark plug carrier bore, the spark plug gap may be inadvertently closed or altered. Exercise caution to avoid bumping the electrodes into the spark plug carrier counterbore. Disregarding this information could result in product damage and/or personal injury

7. Torque the spark plug to 40 – 45 ft-lb (54 – 61 N·m) dry.

NOTE: The rubber recess cover keeps dirt and debris out of the spark plug well and functions as a rain shield for those engines that are outside. Any accumulation of rain water in the spark plug well can short out the spark plug, resulting in a misfire or a stalled engine. Before installing VHP spark plug recess covers, (see Figure 4.10-5), check to be sure that the rubber vent caps are opened. If the rubber vent caps are not opened, the spark plug recess covers and spark plug extensions, may pop off the spark plugs, due to pressure build up.

8. The rubber vent cap is pre-cut at the factory, but needs to be pulled back initially, to insure proper operation. About half of the rubber vent cap circumference is cut, the remaining half acts as a rubber hinge.

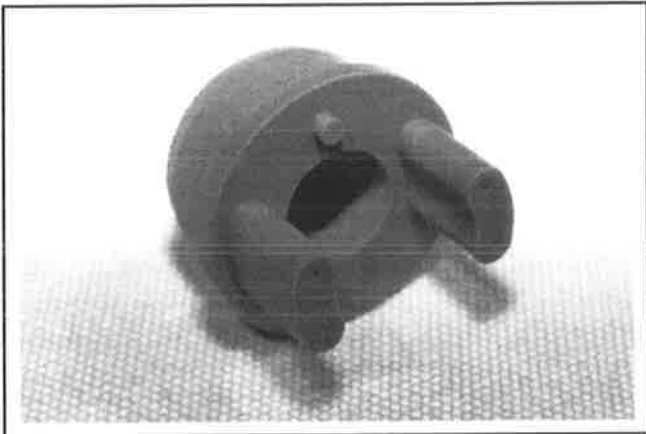


Figure 4.10-5. VHP Spark Plug Recess Cover

9. Using your thumb, gently pull the rubber vent cap towards the center hole of the spark plug recess cover until the vent hole is exposed (see Figure 4.10-6). Release the vent cap. The cap should close.

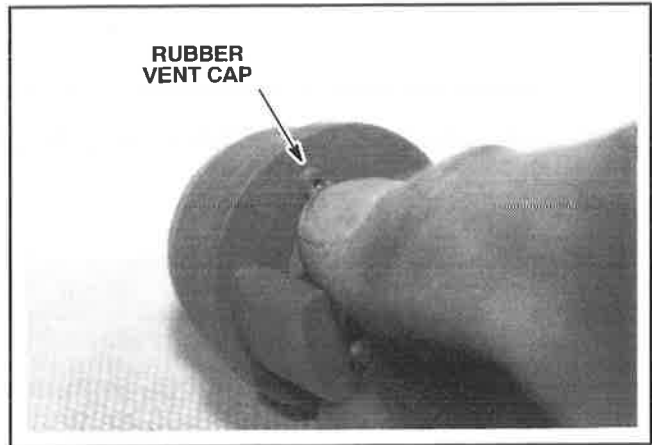


Figure 4.10-6. VHP Spark Plug Recess Cover Vent Cap

10. During normal operation, pressures generated in the spark plug recess will vent through the vent hole in the spark plug recess cover. During venting of pressure, the upper half of the rubber vent cap will pop up, and then return to the closed position

NOTE: If the rubber vent cap is torn off, the spark plug recess cover should be replaced, when it is to be used in outdoor environments.

11. Install the spark plug recess cover on the spark plug connector assembly.

NOTE: The rubber spark plug boots must be installed on the P/N 211357H spark plug extensions. These boots prevent flashover from the spark plug insulators.

NOTE: KRYTOX[®] GPL-206 (P/N 489341) is a higher temperature fluorinated grease.

12. On P/N 211357H connector assemblies, lightly coat the inside surface of the spark plug boot on the connector with a high performance fluorinated grease such as KRYTOX[®] GPL-206 (P/N 489341) or equivalent. Install the spark plug connector assembly to spark plug (see Figure 4.10-2).

13. Attach the spark plug cable to the ignition coil. Make sure that the cable terminal connection bottoms out in the coil contact well. Fit the rubber boot over the coil terminal connection. On P/N 211357H extensions, insure the rubber boot is fitted over the upper end of the spark plug extension. Secure the cable by snapping it into the cable clip mounted on the rocker arm cover.

SPARK PLUG MAINTENANCE - CSA

Spark Plug Removal - CSA (G, GSI)

1. Disconnect the spark plug cable from the coil (see Figure 4.10-7).

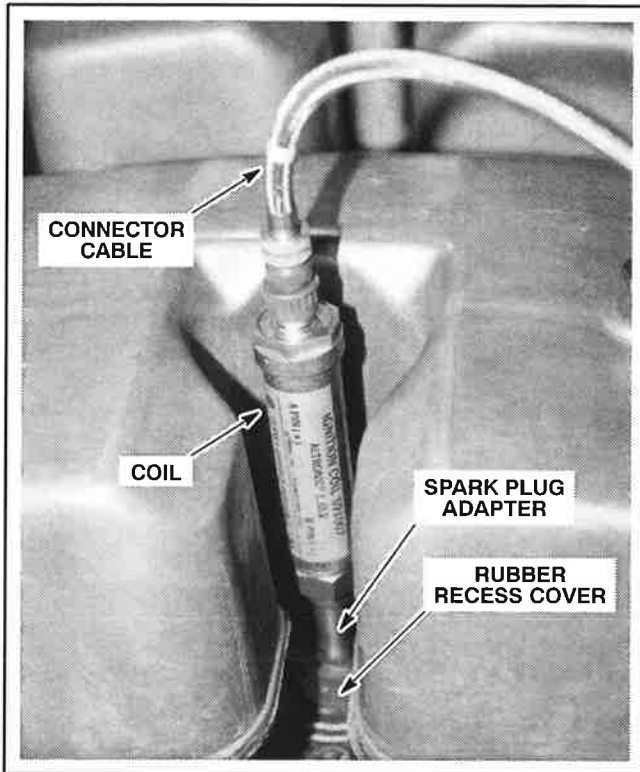


Figure 4.10-7. CSA Spark Adapter And Coil - G, GSI

2. Remove the rubber recess cover from the bottom of the spark plug recess. The recess cover is cut on one side to allow the recess cover to be removed from the spark plug adapter.
3. Remove the coil, spark plug adapter, and spark plug from the cylinder head (see Figure 4.10-8).

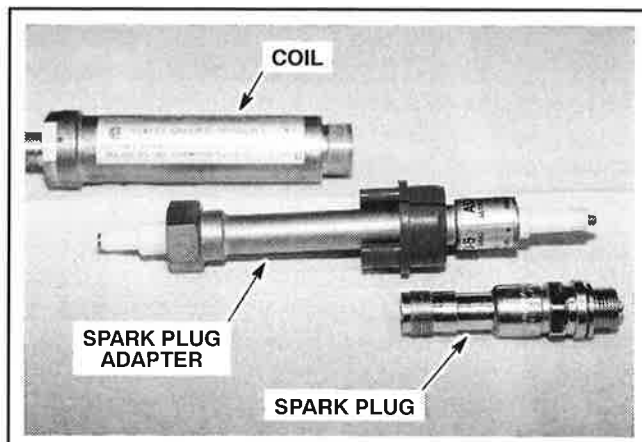


Figure 4.10-8. CSA Spark Adapter And Coil - G, GSI

Spark Plug Installation - CSA (G, GSI)

CAUTION The spark plug gasket must be properly seated to seal the combustion chamber and transfer heat from the plug. Disregarding this information could result in product damage and/or personal injury.

1. Install the steel gasket on the spark plug (see Figure 4.10-1). Use only new steel gaskets. Verify that the gasket is flat against the gasket seat (see Figure 4.10-9).

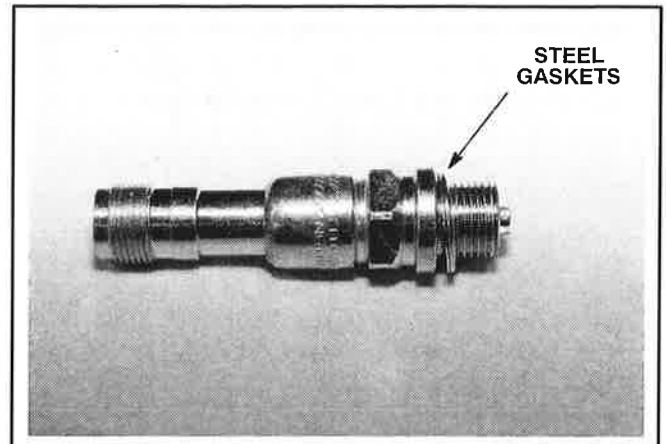


Figure 4.10-9. CSA Spark Plug - G, GSI

2. Refer to Table 1.15-4, *1/2 Inch Reach Spark Plugs* in Section 1.15, *General Information*, and set the spark plug gap.

CAUTION The presence of oil or grease on the ceramic insulator of the spark plug can cause flashover. Flashover, a condition where the spark fails to jump the gap because of an easier path to ground, results in misfire. Disregarding this information could result in product damage and/or personal injury

CAUTION When using Actrel[®] 3338L for cleaning, always wear rubber gloves to prevent the cleaner from touching the hands as burning may occur.

WARNING

Always read and comply with safety labels on all containers. Do not remove or deface the container labels. Improper handling or misuse could result in severe personal injury or death.

IGNITION SYSTEM MAINTENANCE

3. Verify that the spark plug is clean. If necessary, use a dielectric solvent to remove any grease or oily fingerprints. Waukesha Engine Service Operations recommends the use of Actrel[®] 3338L dielectric solvent manufactured by Exxon Corp. and distributed by Safety-Kleen Corp., (800-669-5750), to clean the connectors.

CAUTION Do not use oil or anti-seize compound on the spark plug threads. The spark plug may be overtorqued if oiled, distorts the spark plug and may crack the ceramic construction. Anti-seize compound may foul the firing tip, resulting in a plug shorted to ground. Disregarding this information could result in product damage and/or personal injury

4. Install the spark plug in the spark plug bore. Torque the spark plug to 40 - 45 ft-lb (54 - 61 N-m) dry.

CAUTION By missing the threaded hole in the spark plug carrier bore, the spark plug gap may be inadvertently closed or altered. Exercise caution to avoid bumping the electrodes into the spark plug carrier counterbore. Disregarding this information could result in product damage and/or personal injury

5. Install the spark plug adapter, and coil on the spark plug and hand tighten components (see Figure 4.10-7).

6. Refer to *Spark Plug Installation - Non CSA* in this section (see Figure 4.10-5), and install the rubber recess cover around the spark plug adaptor and press it firmly into place in the cylinder head spark plug recess.

7. Connect the spark plug cable to the coil (see Figure 4.10-7).

Spark Plug Removal - CSA (GL) (13/16 Inch Current Production)

NOTE: Previous production CSA GL models used a "long" coil P/N 69694D, mounted directly to a shielded 1/2 in. spark plug. This configuration is used with the previous 1/2 in. shorter spark plug carriers. See Table 1.15-4, 1/2 Inch Reach Spark Plugs in Section 1.15, General Information, for previous components. See Spark Plug Removal/Installation - CSA (G, GSI) in this section for similar procedures. Conversion Kits are available update to the new configuration shown in Figure 4.10-10.

CAUTION Do not pull on the spark plug cables to remove the spark plug connectors. Pulling on the cable may loosen or detach the terminal connection within the Teflon tube.

1. Disconnect the spark plug connector from the coil.
2. Remove three capscrews, lock washers and coil from the coil adapter.
3. Remove four capscrews, washers and coil adapter from the spark plug carrier.
4. Remove spark plug extension and the spark plug from the spark plug carrier (see Figure 4.10-10).

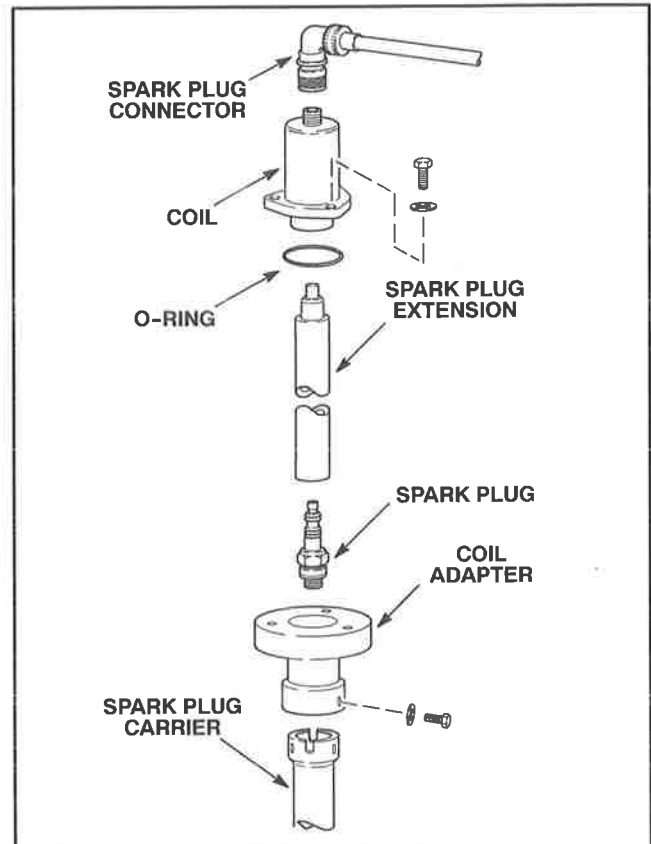


Figure 4.10-10. CSA GL Spark Plug Extension And Coil Assembly - Current Production

Spark Plug Installation - CSA (GL) (13/16 Inch Current Production)

CAUTION 13/16 inch reach spark plugs must be used with 13/16 inch reach carriers, and 1/2 inch reach spark plugs must be used with 1/2 inch reach carriers. Mixing carrier and spark plug components will cause damage to equipment and/or personal injury.

1. Obtain a set of new spark plugs (see Table 1.15-5, 1/2 Inch Reach Spark Plugs in Section 1.15, General Information). Always use the correct size spark plug, see CAUTION above and Figure 4.10-3.

CAUTION The spark plug gasket must be properly seated to seal the combustion chamber and transfer heat from the plug. Disregarding this information could result in product damage and/or personal injury.

2. Install the steel gasket on the spark plug. Use only new steel gaskets. Verify that the gasket is flat against the gasket seat.
3. Install the terminal nut.
4. Refer to Table 1.15-5, *1/2 Inch Reach Spark Plugs* in Section 1.15, *General Information*, and set the spark plug gap.

CAUTION The presence of oil or grease on the ceramic insulator of the spark plug can cause flashover. Flashover, a condition where the spark fails to jump the gap because of an easier path to ground, results in misfire. Disregarding this information could result in product damage and/or personal injury

CAUTION When using Actrel® 3338L for cleaning, always wear rubber gloves to prevent the cleaner from touching the hands as burning may occur.

WARNING

Always read and comply with safety labels on all containers. Do not remove or deface the container labels. Improper handling or misuse could result in severe personal injury or death.

5. Verify that the spark plug is clean. If necessary, use a dielectric solvent to remove any grease or oily fingerprints. Waukesha Engine Service Operations recommends the use of Actrel® 3338L dielectric solvent manufactured by Exxon Corp. and distributed by Safety-Kleen Corp., (800-669-5750), to clean the connectors.

NOTE: KRYTOX® GPL-206 (P/N 489341) is a higher temperature fluorinated grease.

6. Apply a light coat of KRYTOX® GPL-206 (P/N 489341) grease (or equivalent) on O.D. of the spark plug ceramic insulator on the portion of the

ceramic insulator that will contact the spark plug extension assembly (see Figure 4.10-11).

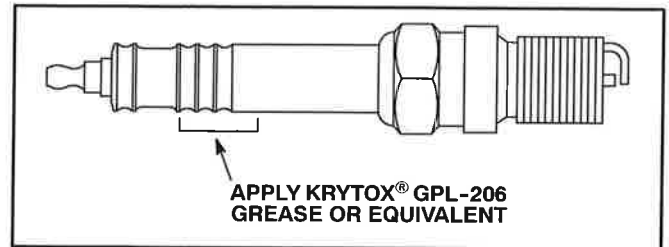


Figure 4.10-11. Apply KRYTOX® GPL-206 Grease

7. Install spark plug in the spark plug carrier with spark plug tool P/N 475037.

CAUTION By missing the threaded hole in the spark plug carrier bore, the spark plug gap may be inadvertently closed or altered. Exercise caution to avoid bumping the electrodes into the spark plug carrier counterbore.

8. Torque spark plug to 40 - 45 ft-lb (54 - 61 N·m) dry.
9. Lightly coat the inside surface of the spark plug boot on the connector with KRYTOX® GPL-206 (P/N 489341) (or equivalent) Install spark plug extension assembly to spark plug (see Figure 4.10-12).
10. Install the coil adapter on the spark plug carrier with four capscrews and washers. Torque capscrews to 6 - 7 ft-lb (8.1 - 9.5 N·m) oiled.
11. Apply a small amount of KRYTOX® GPL-206 (P/N 489341) (or equivalent) to the small silicone O-ring on the coil end of spark plug extension (see Figure 4.10-12).
12. Install the new O-ring P/N 292843, on the nose of the coil (see Figure 4.10-10).
13. Install the coil on the coil adapter with O-ring, three capscrews and lock washers. Torque capscrews to 11 - 13 ft-lb (14.9 - 17.6 N·m) oiled.
14. Connect the shielded primary cable to the coil (see Figure 4.10-10).

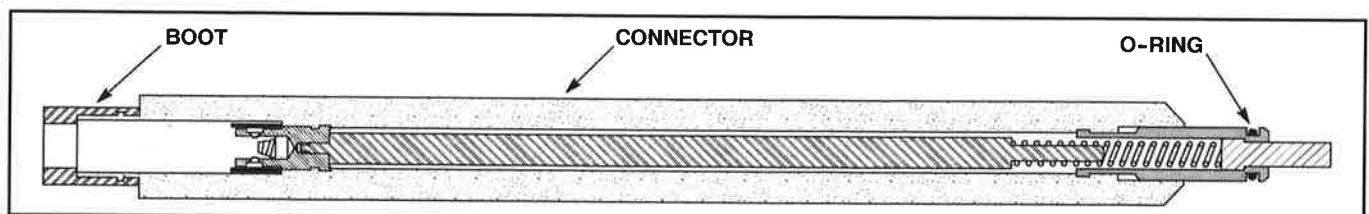


Figure 4.10-12. Spark Plug Extension

IGNITION SYSTEM MAINTENANCE

TIMING ADJUSTMENT - DYNAMIC (MAGNETO SYSTEM)

CAUTION Overly advanced ignition timing can result in detonation which may severely damage pistons and rings. Retarded timing will result in loss of power and poor fuel economy. Disregarding this information could result in product damage.

CAUTION Be sure all engine connections are completed properly before engine startup. Follow all startup procedures. Check that all engine openings are properly closed and that all tools are removed from the engine. Disregarding this information could result in product damage.

CAUTION Detonation is not allowed at any time, during engine operation, regardless of the specified timing. If detonation occurs at the specified timing, a timing adjustment must be made to retard the ignition timing until NO audible detonation exists. Engine damage may result if detonation occurs.

NOTE: This task applies to magnetos that have already been installed and static timed by a Waukesha Certified Technician. Call a Waukesha Certified Technician for the installation and static timing of magnetos.

1. Refer to the engine nameplate for the engine timing value (see Figure 1.15-2 and Figure 1.15-3).
2. Start the engine and run at rated speed (with or without load).
3. Connect a stroboscopic type timing light to the ignition cable of the #1R cylinder.
4. Turn up the timing pointer cover on the upper right side of the rear flywheel housing (see Figure 4.10-13).
5. Align the beam of the timing light with the timing pointer. The timing light will flash at the instant the spark occurs, making the tape on the rim of the flywheel visible (see Figure 4.10-15).

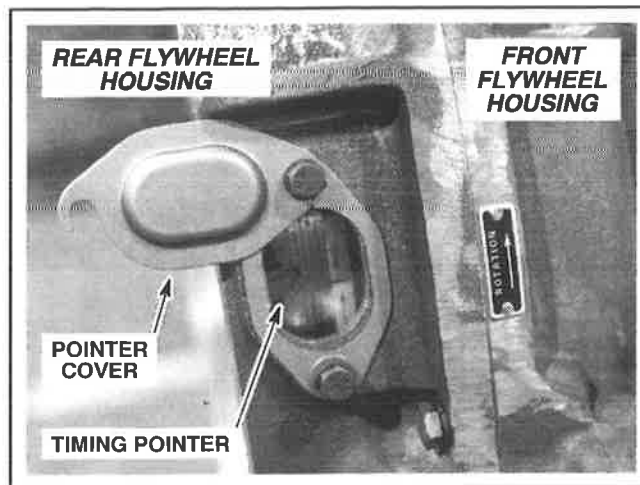


Figure 4.10-13. Timing Pointer - Rear Right

NOTE: The magneto flange has slots to allow the magneto to be rotated slightly once the capscrew hex nuts are loosened.

6. If required, readjust the timing by loosening the magneto's flange bolts just enough to allow the magneto to rotate (see Figure 4.10-14). Rotate the magneto slightly until the correct timing mark is aligned with the timing pointer.

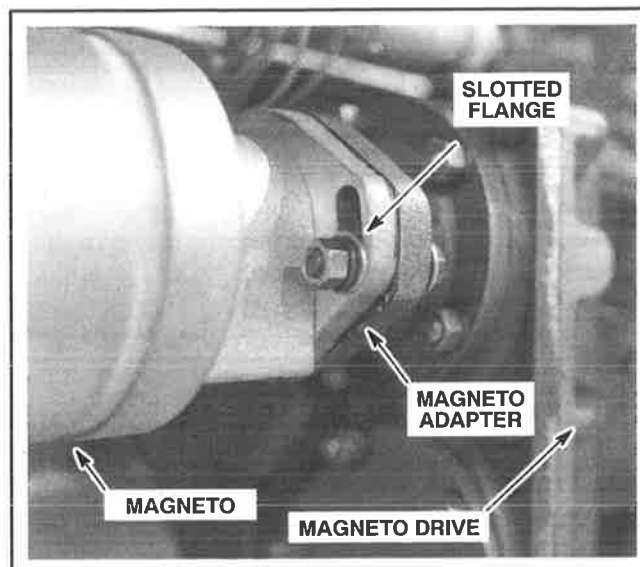


Figure 4.10-14. Magneto/Magneto Adapter Flange

7. Snug the flange capscrew hex nuts (see Figure 4.10-14).
8. Check the timing again with the timing light.
9. If the timing is not correct, repeat Steps 6 through 8.
10. Alternately wrench tighten the hex nuts on the two magneto/magneto adapter flange capscrews.

NOTE: 6 Cylinder engines "TDC" of the timing tape is aligned with the "TDC" stamped on the flywheel. For 12 and 16 Cylinder engines, "TDC" of the timing tapes is aligned with the "#1 RB TDC" stamped on the flywheel. In all cases the White side of the tape is BTDC and the red side of the tape is ATDC.

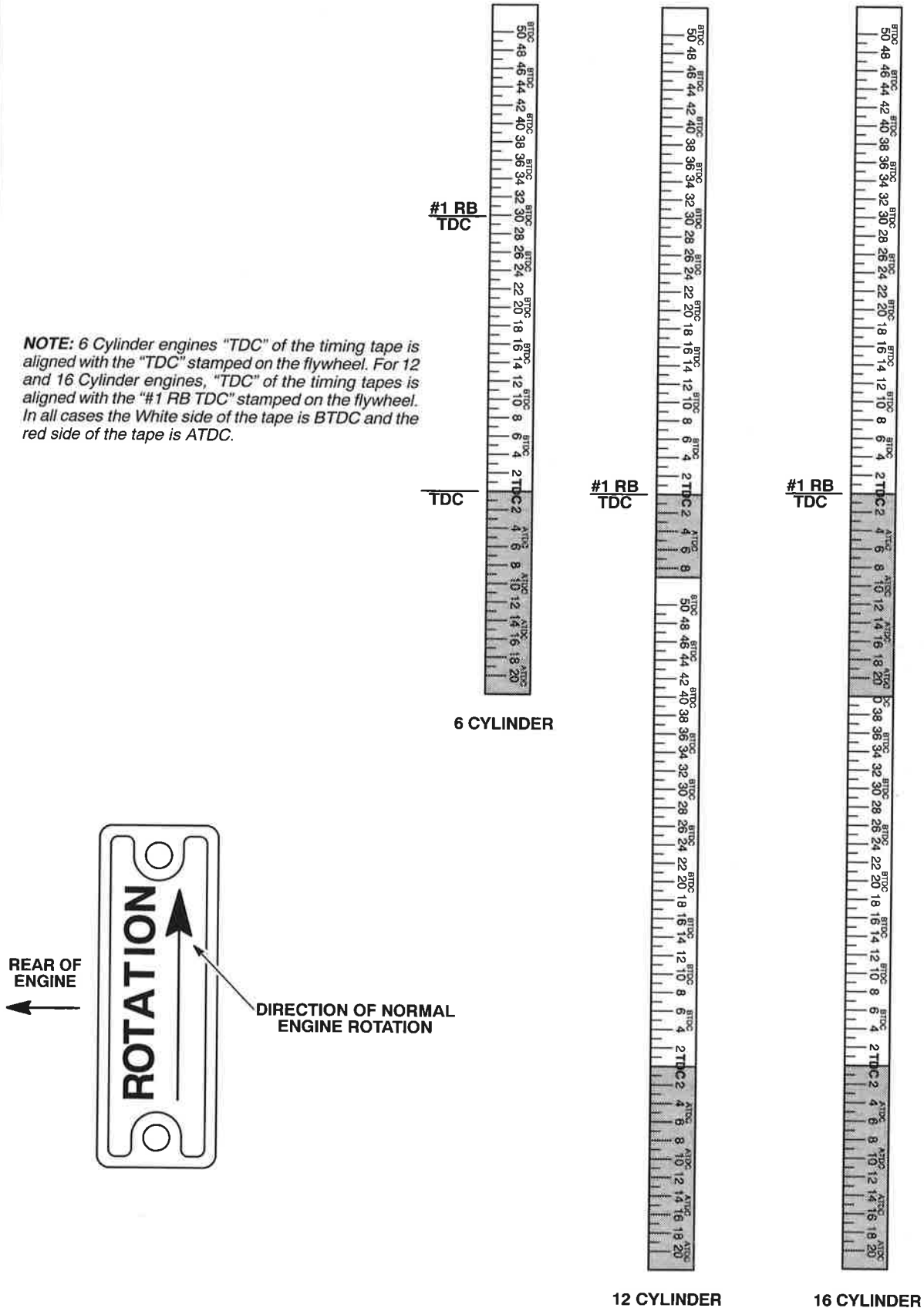


Figure 4.10-15. Timing Tapes

IGNITION SYSTEM MAINTENANCE

CEC IGNITION MODULE TIMING ADJUSTMENT - DYNAMIC

NOTE: This task applies to ignition modules that have already been installed and static timed by a Waukesha Certified Technician. For the initial installation and timing of a CEC ignition module, call a Waukesha Certified Technician. Refer to Form 6253 (Previous Model) or Form 6272 (Current Model) IM Custom Engine Control® Ignition Module Installation, Operation, And Maintenance Manual for further information concerning the IM.

The ignition module has two 16-position timing switches located under white plastic caps at one end of the box, one marked "A" and another marked "B" (see Figure 4.10-16). Grounding lead "D" in the 7-pin connector to the engine crankcase gives the timing selected by switch A. Open-circuiting lead "D" gives the timing selected by switch "B". This feature gives the engine operator the ability to switch between two different timing settings to accommodate automatic changeover between two fuels.

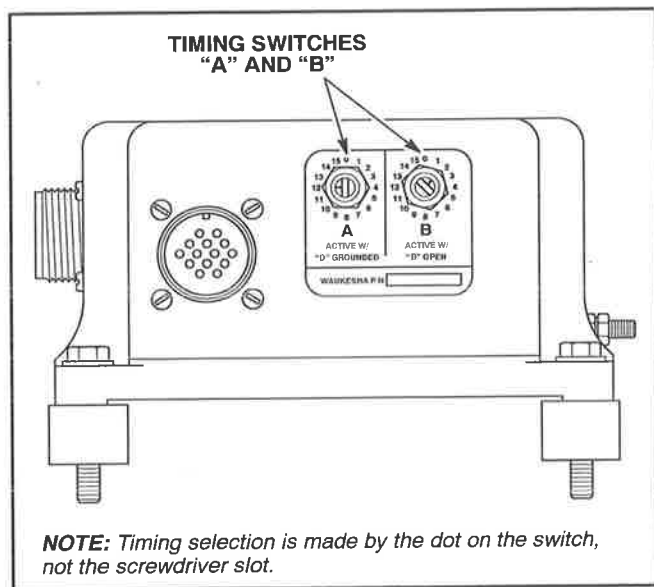


Figure 4.10-16. Timing Switches "A" And "B"

Each timing adjust switch has 16 switch positions (0 - 15) with a 1° timing variation per position. Switch position 15 gives the most advanced timing, while switch position 0 is full retard.

CAUTION Do not switch from position 15 to position 0, or from position 0 to 15 while the engine is running. The timing change is so large that it may damage the engine and/or cause it to shut down. Disregarding this information could result in product damage and/or personal injury.

NOTE: The outside temperature of ignition module casing should not exceed 150° F (65° C) in operation.

1. Check the engine's nameplate (see Figure 1.15-2 and Figure 1.15-3) to determine the exact timing (or most advanced) of the primary and secondary (if equipped) fuels.

2. Run the engine on primary fuel with the "D" lead (found in the 7-pin connector from box) **grounded** to the engine block and the detonation sensing module deactivated.

NOTE: VHP gas engines are to be run with no load on fuels other than natural gas fuel. With natural gas fuel, the engines may be run at any load.

3. Check engine timing at the flywheel using a timing light (see Figure 4.10-17).

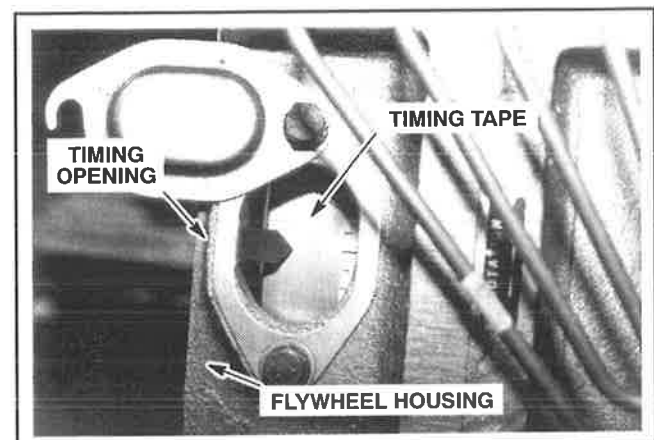


Figure 4.10-17. Flywheel Timing Opening

4. Adjust the "A" switch as required to achieve correct timing. Single fuel ignition adjustments are now complete.

NOTE: Increasing the timing switch position by one will advance the timing one degree. Decreasing the timing switch position by one will retard the timing one degree.

5. Run the engine on secondary fuel with the "D" lead (found in the 7-pin connector from box) **open** and the detonation sensing module deactivated.

NOTE: VHP gas engines are to be run with no load on fuels other than natural gas fuel. With natural gas fuel, the engines may be run at any load.

6. Check engine timing at the flywheel using a timing light (see Figure 4.10-17).

7. Adjust the "B" switch as required to achieve correct timing. Dual fuel ignition adjustments are now complete.

NOTE: Increasing the timing switch position by one will advance the timing one degree. Decreasing the timing switch position by one will retard the timing one degree.

CAUTION To prevent the timing from being altered, always replace the white caps over the timing switches once the desired setting has been selected. Disregarding this information could result in product damage.

WARNING

If a gas engine has been cranked excessively without starting, shut off the gas fuel supply and ignition, and then crank the engine to purge the cylinders and exhaust system of accumulated unburned gas. If this is not done a spark could ignite the gas and cause an exhaust explosion. Failure to comply could cause severe personal injury or death.

WARNING

If the ignition switch is left in the ON position when a CEC ignition module is disconnected, then the spark plugs may fire when the ignition system harness is reconnected, and could cause severe personal injury or death.

Before connecting the ignition harness (to the coils) to the CEC ignition module, discharge the storage capacitor to ground. Attach one end of a wire lead to the crankcase and then touch the other end to the harness connector pins on the CEC, one at a time. A snap is heard when a capacitor discharges.

WARNING

As a safety measure, ground all the pins. Some breakerless ignition systems have more than one storage capacitor. Severe personal injury or death could result.

NOTE: If the ignition switch is in the OFF position, the capacitor is immediately grounded when the ignition harness is reconnected to the CEC ignition module.

IGNITION SYSTEM GENERAL MAINTENANCE AND INSPECTION

WARNING

Disconnect all electrical power supplies before making any connections or servicing any part of the electrical system. Electrical shock can cause severe personal injury or death.

1. Inspect cables and wires for broken or cracked insulation. Replace or repair as necessary.
2. Inspect ignition coils, ground wires, and brackets for loose hardware. Tighten as necessary.
3. Inspect spark plug and cable connectors for loose connections. Tighten as necessary.

IGNITION SYSTEM MAINTENANCE

SECTION 4.15

AIR INTAKE SYSTEM MAINTENANCE

AIR INTAKE SYSTEM MAINTENANCE

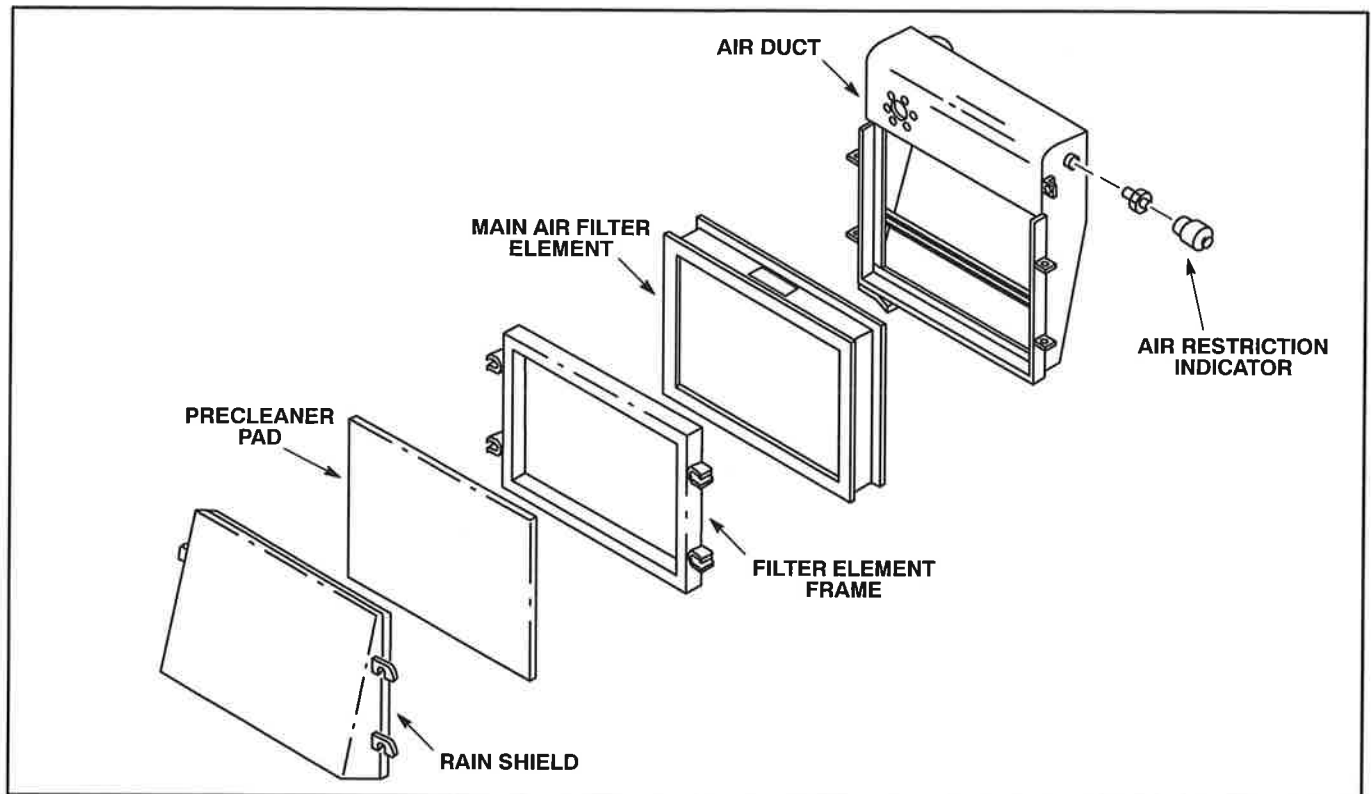


Figure 4.15-1. Air Cleaner Assembly - 6 And 12 Cylinder Engines

AIR FILTER MAINTENANCE

On 6 and 12 cylinder engines, the air restriction indicator (see Figure 4.15-1) will "pop red" if the air intake restriction is 15 in. (381 mm) of water. This indicates a clogged or dirty main air filter element and/or clogged or dirty precleaner element.

On 16 cylinder engines a gauge for each air filter indicates the condition of the precleaner filter and main air filter. Each gauge should register in the "green range". A switch allows the operator to monitor the pressure of the precleaner and main filter pressure independently.

Precleaner Pad Removal - 6 And 12 Cylinder

The precleaner is a foam rubber pad that increases the life of the main air filter element. Inspect and clean the precleaner pad daily or as required. This can be done while the engine is running. Replace the precleaner pad every 4000 running hours, or more often if necessary.

1. Locate the four threaded mounting studs on the air cleaner assembly and loosen the front lock nut (5/16 inch) on each (see Figure 4.15-2). (The rear locknut is loosened only for removal of the main air filter frame and element.)
2. Raise up and remove the rain shield.

AIR INTAKE SYSTEM MAINTENANCE

3. Peel the precleaner pad off the main air filter element.

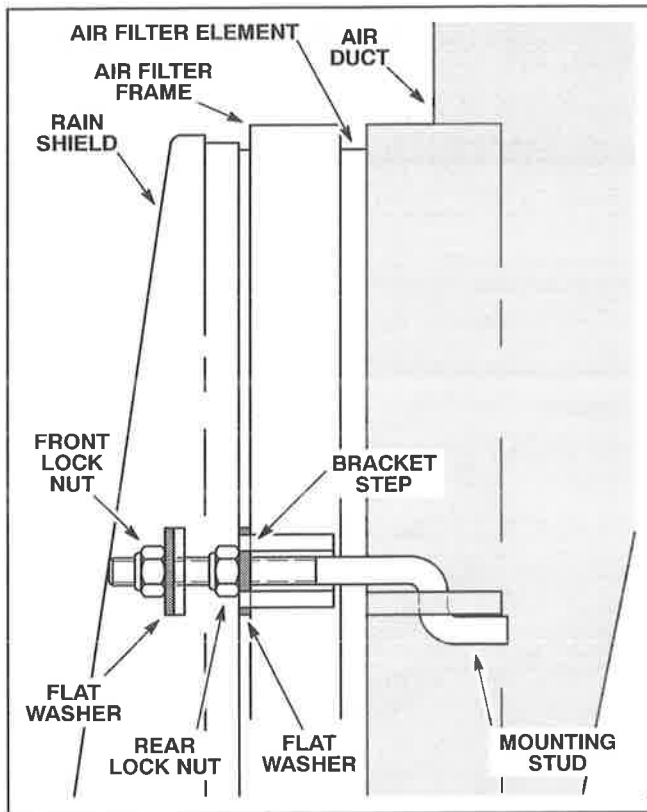


Figure 4.15-2. Air Cleaner Assembly -
6 And 12 Cylinder Engines

Precleaner Pad - Cleaning And Inspection - 6 and 12 Cylinder

1. Wash the precleaner pad with soap and water.

CAUTION Compressed air can easily damage the foam rubber pad.

2. Air dry the pad. Do not use compressed air.

Precleaner Pad Installation - 6 And 12 Cylinder

CAUTION On new engines, a cardboard insert between the rainshield and precleaner pad must be removed before the engine is started. Disregarding this information could result in product damage.

1. Reinstall the precleaner pad between the rain shield and the main air filter element. If necessary, use a drop of adhesive on the corners to keep it from falling.
2. Do not clean and reuse the precleaner pad more than three times. Replace with a new precleaner pad.

NOTE: Use only Waukesha supplied precleaner pads.

3. Lower the rain shield on the four mounting studs of the air cleaner assembly. Alternately re-tighten the front lock nuts (5/16 inch).

4. Clean or replace the main air filter element if the air intake restriction indicator "pops" red after installation of a new or cleaned precleaner pad.

Main Air Filter Element Removal - 6 And 12 Cylinder

Inspect and clean the main air filter element daily or as required. Replace main air filter element if the air restriction indicator "pops red" after the air cleaner is cleaned and the precleaner pad has been replaced or cleaned.

1. Locate the four threaded mounting studs on the air cleaner assembly and loosen the front lock nut (5/16 inch) on each (see Figure 4.15-2 and Figure 4.15-3).
2. Raise up and remove the rain shield.
3. Peel the precleaner pad off the main air filter element.
4. Loosen the rear lock nut (5/16 inch) on each mounting stud until the flat washer behind it can be brought forward far enough to clear the step in the welded bracket of the main air filter frame (see Figure 4.15-2).
5. Swing the four mounting studs to the outside in a horizontal motion. Remove the main air filter frame and element.

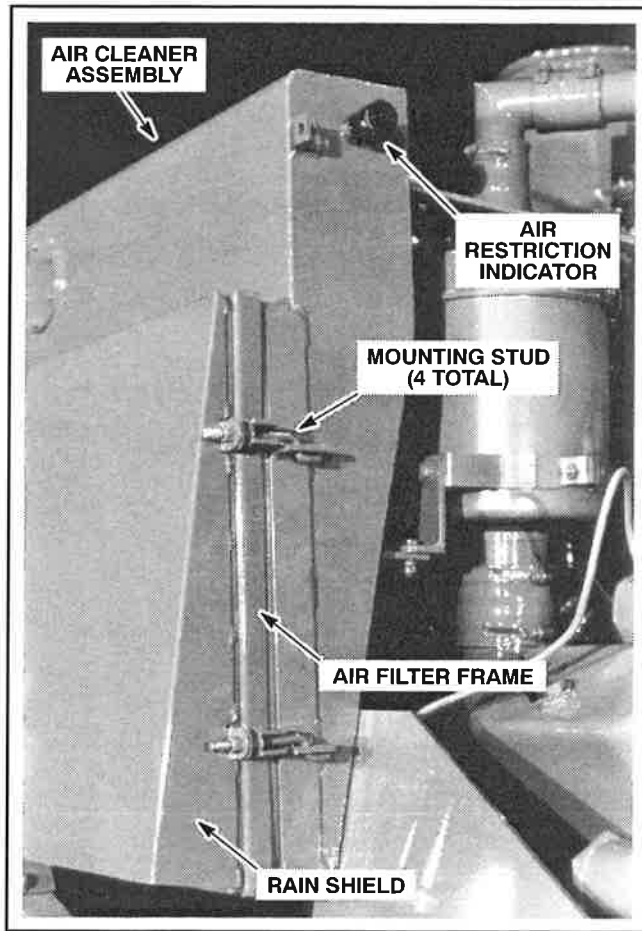


Figure 4.15-3. Air Cleaner Assembly - 6 Cylinder

Main Air Filter Element - Cleaning And Inspection - 6 And 12 Cylinder

1. Clean the main air filter element using the following method.
 - A. Gently tap the element on a flat surface with the dirty side of the element down.

WARNING

Compressed air can pierce the skin and cause severe injury or death. Never use your hand to check for leaks or to determine air flow rates. Wear safety glasses to shield your eyes from flying dirt and debris.

- B. Using an OSHA approved safety nozzle, direct compressed air through the element opposite the direction of the air flow, as indicated by the orange arrow on the instruction label. The air pressure should be a maximum of 30 psi (207 kPa).

CAUTION

Compressed air can easily damage the pleated paper of the main air filter element.

- C. Air dry the element. Do not use compressed air.
2. Carefully examine the element after cleaning. If damaged, replace.

NOTE: Use only Waukesha supplied air filter elements.

3. Do not clean and reuse the main air filter element more than three times. Replace with a new element.
4. Inspect the air duct for cracks. All of the combustion air must pass through the main air filter element, not through cracks or defects in the air cleaner assembly. If inspection of the duct work and intake manifold yields an accumulation of dust and grit, it is an indication that the main air filter element is not properly maintained or that air is getting into the system around or behind the element.

5. Inspect all air duct hoses. Replace any hose that is cracked or aged.

Main Air Filter Element Installation - 6 And 12 Cylinder

NOTE: The orange flow arrow on the instruction label points toward the air outlet side. Always store the elements with the air outlet side down. Dirt and dust on the outlet side will pass into the engine when the element is installed.

1. Install the main air filter element with the instruction label facing up. Fit the deflection brace on the outlet side of the filter element over the horizontal bar running across the front of the air duct chamber.
2. Place the frame over the main air filter element.
3. Swing the four threaded mounting studs to the inside in a horizontal motion so that they fit within the welded brackets on the air filter frame. Move the flat washer behind the rear lock nut back into the step in the welded bracket.
4. Install the precleaner pad between the rain shield and the main air filter element. If necessary, use a drop of adhesive on the corners to keep it from falling.
5. Lower the rain shield on the four mounting studs.
6. Alternately tighten the rear lock nuts (5/16 inch).
7. Alternately tighten the front lock nuts (5/16 inch) on the four mounting studs.

AIR INTAKE SYSTEM MAINTENANCE

8. Check the frame of the main air filter element to verify that its perimeter is sealed tightly. Damage to the frame may result in improper element sealing.

NOTE: After the restriction problem is corrected, reset the indicator by depressing the black button on the plastic housing.

⚠ WARNING

The location of the air restriction indicator relative to the intake manifold causes it to be subjected to high pressure if the engine backfires. A restriction filter must be installed in the indicator air passage to dampen high pressure surges which would otherwise damage the indicator. Through the projection of broken material, damage to the indicator might pose a potential danger to persons standing nearby. The restriction filter also protects against the entrance of dust and dirt in the event that the restriction indicator is broken off or removed. Disregarding this information could result in severe personal injury or death.

Verify that the restriction filter is in place between the clean air tap and indicator.

⚠ WARNING

Do not grasp the indicator housing; the plastic may crack or break resulting in a hand injury.

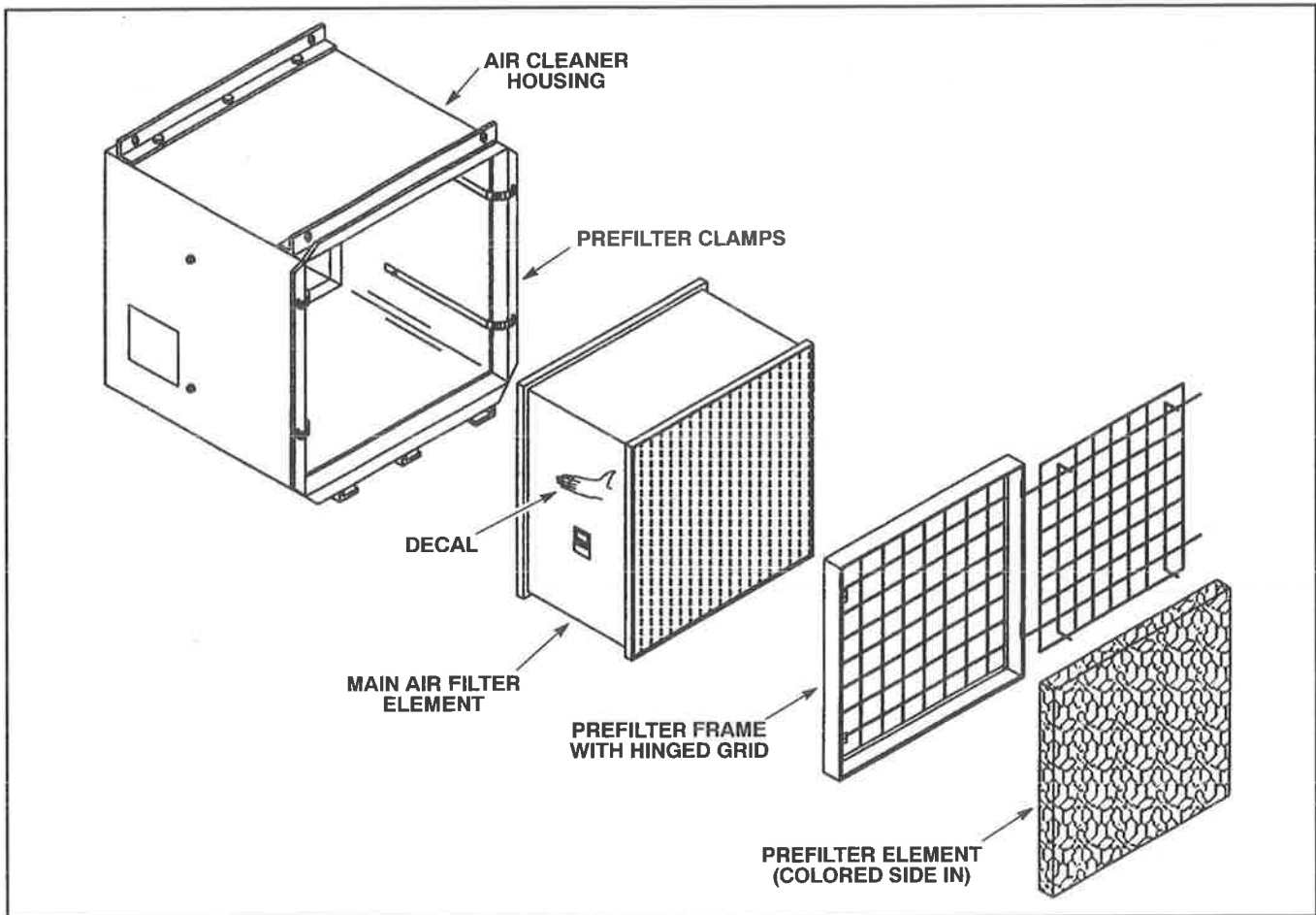


Figure 4.15-4. Air Cleaner Assembly - 16 Cylinder Engines

Prefilter Pad Removal - 16 Cylinder

The prefilter is a filament pad that increases the life of the main air filter element (see Figure 4.15-4 and Figure 4.15-5). Inspect and clean the prefilter pad daily or as required. This can be done while the engine is running. Replace the prefilter pad every 4000 running hours, or more often if necessary.

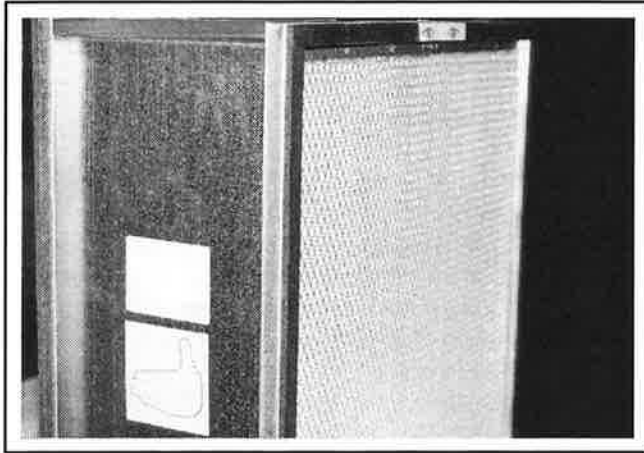


Figure 4.15-5. Air Cleaner Assembly - 16 Cylinder

1. Raise up and remove the rain shields.
2. Open the front grate to remove the prefilter pads from the prefilter frame (see Figure 4.15-6).

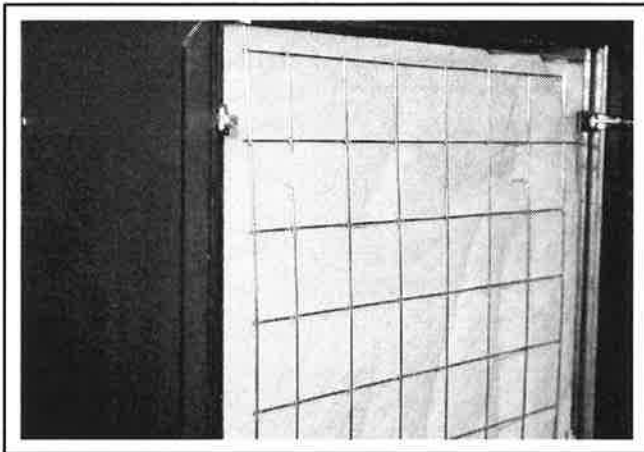


Figure 4.15-6. Prefilter Pad - 16 Cylinder

3. Discard the prefilter pads.

Prefilter Pad Installation - 16 Cylinder

CAUTION The dark blue sides of the prefilter pads must face the main air cleaner elements or damage to equipment could result.

1. Install the new prefilter pads in the grates so that the dark blue sides of the prefilter pads will face towards the main air filter elements when the prefilter pads are installed.
2. Close the front grate door and secure by inserting the ends of the grate in the slots in the prefilter frame (see Figure 4.15-6).
3. Install the rain shields.

Main Air Filter Element Removal - 16 Cylinder

Inspect and clean the main air filter element daily or as required. Replace main air filter element if the air restriction indicator "indicates red" after the air cleaner is cleaned and the prefilter pad has been replaced.

1. Raise up and remove the rain shield.
2. Locate the four mounting clamps on the front of the air cleaner assemblies and loosen the clamps to remove the prefilter frame and prefilter pads (see Figure 4.15-6).
3. Discard the prefilter pads.
4. Pull out the main air filter elements.

AIR INTAKE SYSTEM MAINTENANCE

Main Air Filter Element - Cleaning And Inspection - 16 Cylinder

1. Clean the main air filter element using the following method.

- A. Gently tap the element on a flat surface with the dirty side of the element down.

WARNING

Compressed air can pierce the skin and cause severe injury or death. Never use your hand to check for leaks or to determine air flow rates. Wear safety glasses to shield your eyes from flying dirt and debris.

- B. Using an OSHA approved safety nozzle, direct compressed air through the element opposite the direction of the air flow, as indicated by the hand on the side of the filter element. The air pressure should be a maximum of 30 psi (207 kPa).

 **CAUTION** Compressed air can easily damage the pleated paper of the main air filter element.

- C. Air dry the element. Do not use compressed air.
2. Carefully examine the element after cleaning. If damaged, replace.

NOTE: Use only Waukesha supplied air filter elements.

3. Do not clean and reuse the main air filter element more than three times. Replace with a new element.
4. Inspect the air duct for cracks. All of the combustion air must pass through the main air filter element, not through cracks or defects in the air cleaner assembly. If inspection of the duct work and intake manifold yields an accumulation of dust and grit, it is an indication that the main air filter element is not properly maintained or that air is getting into the system around or behind the element.
5. Inspect all air duct hoses. Replace any hose that is cracked or aged.

Main Air Filter Element Installation - 16 Cylinder

 **CAUTION** On new engines, a cardboard insert between the rainshield and prefilter pad must be removed before the engine is started. Disregarding this information could result in product damage.

 **CAUTION** The pleats of the main air filter must be positioned vertically in the air filter housing or damage to equipment could result.

NOTE: The hand on the side of the filter element points toward the air outlet side of the air filter housing. Also a label with a pair of eyes printed on it is positioned on the air inlet side of the filter element. These eyes should be visible from the air filter housing inlet opening and at the top of the air cleaner, if the filter is properly installed. If both labels are missing, one side of the air filter element has a metal brace horizontally across the back. This side should be positioned, towards the air outlet side. Always store the elements with the air outlet side down. Dirt and dust on the outlet side will pass into the engine when the element is installed.

1. Install the main air filter elements with the hand on the side of the filter elements pointing toward the air outlet side of the filter housings. Insure that the pleats of the elements are positioned vertically.

 **CAUTION** The dark blue sides of the prefilter pads must face the main air cleaner elements or damage to equipment could result.

2. Install the new prefilter pads in the grates so that the dark blue sides of the prefilter pads will face towards the main air filter elements when the prefilter pads are installed.
3. Position the front grate and prefilter pad assemblies on the air filter housings and secure using the four clamps (see Figure 4.15-6).
4. Install the rain shields.

SECTION 4.20

TURBOCHARGER SYSTEM MAINTENANCE

TURBOCHARGER SYSTEM MAINTENANCE

TURBOCHARGER INSPECTION

⚠ WARNING

Turbocharger components are extremely hot. Always allow the turbocharger to cool prior to conducting an inspection. Failure to comply with these instructions could result in severe burns.

⚠ CAUTION

Inspection and repair of turbochargers must be performed by a factory qualified service agent. Failure to follow these instructions could cause engine damage and/or personal injury.

1. Inspect the engine air cleaner, service if required.
2. Inspect the turbocharger mounting and connections for lube oil and air leaks (see Figure 4.20-1 and Figure 4.20-2).

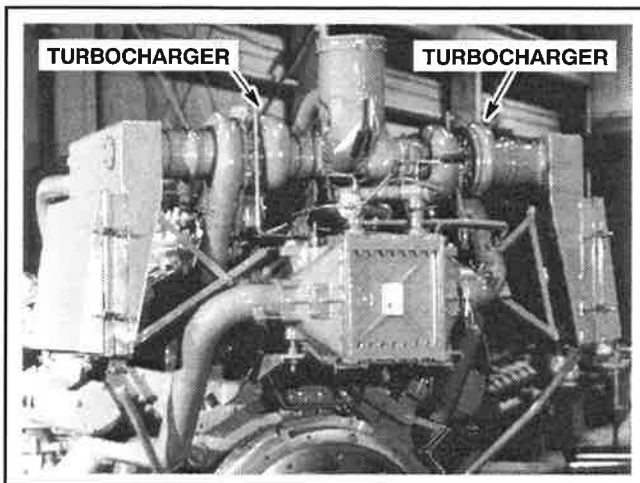


Figure 4.20-1. 5115GL - Rear View

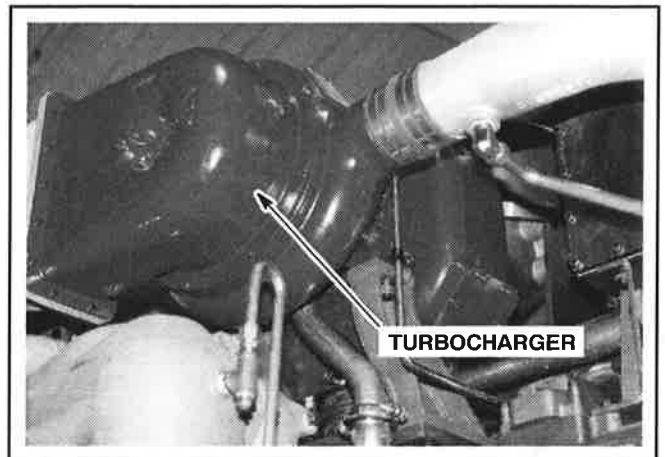


Figure 4.20-2. Turbochargers - 16 Cylinder GSI Side View

⚠ CAUTION

Do not run the engine if the air cleaner is not operating efficiently or if leaks exist in the ducting. Dust leaking into the air ducting can damage the engine and the turbochargers and/or cause personal injury.

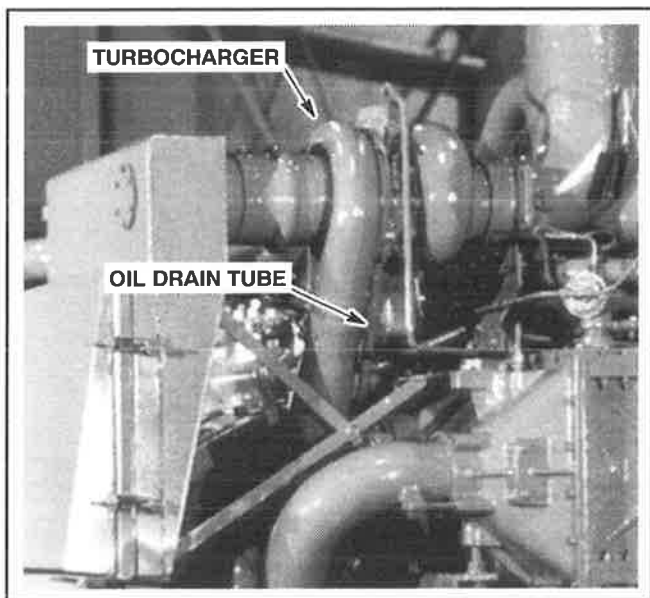
3. With the engine shutdown, inspect all air ducting for loose clamps or connections. Check the manifold connections to the turbine inlet and at the engine exhaust manifold gaskets.
4. Visually repeat the inspection while the engine is running.
5. Monitor the turbochargers for unusual vibrations or noise. If excessive vibration is evident, shutdown the the engine and call your Waukesha authorized service agent.
6. Establish a schedule with your Waukesha authorized service agent to inspect the interior of the compressor for accumulations of dirt. Dirt can cause the compressor wheel to become unbalanced, which reduces efficiency and causes bearing failure.

TURBOCHARGER SYSTEM MAINTENANCE

TURBOCHARGER LUBRICATION CHECK

CAUTION Before operating a new or rebuilt turbocharger (or starting a new engine for the first time), check to ensure that the turbocharger is receiving proper lubrication. Failure to follow these instructions could cause engine damage and/or personal injury.

1. Remove the oil drain tube (see Figure 4.20-3) from the turbocharger(s).



**Figure 4.20-3. Turbocharger Oil Drain Tubes -
12 Cylinder**

2. Activate the prelube system and visually check for oil flow at the turbocharger oil drain area.
3. Reconnect the oil drain tube only after oil is observed at the oil drain area.
4. Start the engine at reduced speeds until the coolant temperature gauge indicates a temperature of 100° F (38° C).
5. Run the engine at rated output and listen for unusual sounds at the turbocharger, especially those of metal contacting metal. If any noise of this type is apparent, contact your Waukesha authorized service agent.

SECTION 4.25

COOLING SYSTEM MAINTENANCE

COOLING SYSTEM MAINTENANCE

COOLING SYSTEM ADDITIVES

Standard closed heat exchanger or radiator cooled cooling systems operating up to 250° F (121° C) must be treated with industrial grade inhibited antifreeze or with some other effective commercial cooling water treatment product. These products usually provide corrosion protection by forming a film on the surfaces of the cooling system and also act as a scale suppressant by modifying or conditioning the dissolved scale forming minerals. To work effectively, all antifreeze and water treatment products require a clean system, free of dirt, oil, scale and rust.

Ethylene Glycol

The most common cooling water additive is ethylene glycol. The required proportion normally depends on the lowest ambient temperature levels from which the system must be protected. A fifty-fifty mix of water and ethylene glycol will produce the best results for freezing and boiling protection, but cooling water efficiency is reduced by as much as 15%. Since the radiator cooling system effectiveness drops by approximately 2 - 3% for each 10% of glycol concentration, the radiator sizing for the specified heat rejection value must be taken into account to accommodate this relationship.

A minimum of 30% ethylene glycol is generally recommended for adequate antifreeze and corrosion protection. The amount should not exceed 67% to avoid impairing the heat transfer processes. A concentration beyond this percentage does not tend to lower the freezing point any further and may result in engine damage.

Since it effectively raises the boiling point of the water, the use of ethylene glycol is also beneficial in hot temperatures. Therefore, ethylene glycol treated water is still recommended in those climates where antifreeze is not normally required (see Table 4.25-1).

Table 4.25-1. Water Versus Glycol Concentration

PERCENT WATER/GLYCOL	COMMENTS
70/30	Minimum Glycol for Adequate Anti-freeze/Corrosion Protection
50/50	Best for Corrosion, Freezing and Boiling Protection

With heat exchanger cooling systems, it should be remembered that the circulation of ethylene glycol solution only protects the closed system coolant. Therefore, the heat exchanger water supply, as well as the auxiliary cooling water circuit, must also be protected.

Propylene Glycol

Propylene glycol has similar cooling properties when compared to ethylene glycol. Ethylene glycol has the advantage of lower viscosity than propylene glycol at temperatures less than 0° F (-17° C). Propylene glycol has a low toxicity, and it may be less stringently regulated than ethylene glycol. Propylene glycol also has been proven to alleviate cavitation erosion that may be experienced when using ethylene glycol solutions.

COOLING SYSTEM MAINTENANCE

Other treatments the engine operator should consider are (see Table 4.25-2):

Table 4.25-2. Other Cooling System Treatments

TREATMENT	COMMENTS
Deionized, Distilled or Softened Water	Although a maximum hardness of 200 ppm is acceptable for initial fill and make-up, use only softened water, where the insolubles may be as low as 0.5 ppm.
Sodium Nitrate	Iron and steel corrosion inhibitor.
Molybdate	Slows the growth of bacteria.
Tolytriazole	Copper corrosion inhibitor.
Synthetic Polymer	Prevents hard scale build up.
Borax Buffer	Corrects the water pH to 8.5.
Silicates	General corrosion inhibitor; over 0.1% concentration is not recommended for industrial engines. A concentration that is too high can cause the cooling water in the radiator to gel, resulting in solid deposits. High silicate inhibitor concentration is used primarily for high speed aluminum engines.

NOTE: Refer to Service Bulletin 4-2429C or latest revision, for more detailed coolant treatment information.

COOLING SYSTEM SPECIFICATIONS AND RECOMMENDATIONS

Cooling System Specifications

Ensure that the temperature of the cooling water leaving the engine (as indicated by the temperature gauge) does not exceed 220° F (104° C).

Refer to Table 1.15-2 for the jacket water outlet temperature alarm and safety shutdown setpoints.

NOTE: Customer supplied fuel shutoff type safety equipment must be provided to prevent engine damage and possible personal injury.

Engine overheating, as evidenced by high jacket water temperatures, may be caused by one or more of the following conditions:

- restricted air flow through the radiator
- defective thermostats
- worn jacket water pump
- excessive jacket water pump suction
- blown head gasket
- faulty temperature gauge
- low coolant level
- overloaded engine
- air bound system

- insufficient air circulation
- exhaust recirculation

Cooling System Recommendations

1. Ensure that the rise in coolant temperature does not exceed 10° F (5.6° C).
2. Maintain the drop in system pressure at 8 - 15 psi (55 - 103 kPa). While pressure that is too low promotes cavitation erosion, pressure that is too high may cause the water pump seals to leak.
3. Analyze the raw water chemistry to verify that it does not contain contaminants and that it is not too hard. Use only soft water, where the insolubles are as low as 0.5 ppm. Hard water accelerates the formation of scale deposits.
4. Analyze the cooling water chemistry every month to verify that it contains the proper inhibitor and additive concentrations.
5. Measure antifreeze content according to the lowest anticipated temperature and refill as needed with the same brand.
6. Maintain cooling water pH between 8.5 and 10.5; an acidic coolant with a pH of less than 7 will speed the corrosion of cast iron, aluminum and steel, while a pH of 11 or higher will accelerate the corrosion of aluminum and solder.
7. Check the cooling system level each day or consider the installation of a coolant low level shutdown switch. Even if a high coolant temperature switch is provided, it will not shut the engine down if the system runs low on cooling water.
8. Check the cooling system for rust, sludge or other foreign matter. Clean and flush the entire cooling system once each year, unless evidence of corrosion or sediment build up demonstrates the need for more frequent changes. Use only clean, soft water.
9. To eliminate the recirculation of particles and contaminants in the cooling water circuit, install a cleanable filter (sized at approximately 10 microns) in the coolant flow. Inspect and clean the filter on a regular basis.
10. Frequently inspect hoses and all cooling system connections for cracks and leaks. Do this when the engine is operating at normal pressure.
11. On a radiator, check for damaged fan blades, a poorly fitting shroud, sticking shutters or dirt in the radiator core. Repair or clean as needed.
12. Check the radiator cap gasket for proper seal.

13. If a heat exchanger is used, inspect it for scale or corrosion, and when necessary, clean the inside of the tubes with a round, soft-wire brush. Flush with cleaning solvent.

14. Periodically remove the intercooler and rod-out the tubes with a soft-wire brush or circulate a suitable cleaning solution.

15. Consider the installation of the following cooling system safety accessories:

- A high water temperature shutdown device
- A low water level shutdown device
- A coolant level sight glass

To avoid scored pistons and other serious problems, a high water temperature shutdown device will stop the engine if the coolant gets too hot. A low water level device will shut down the engine if the coolant level drops excessively, preventing cracked or warped cylinder heads, exhaust manifolds and water manifolds. A sight glass is a quick and easy method of visually checking the coolant level.

JACKET COOLING WATER CIRCUIT - INITIAL FILL

NOTE: The following description is not applicable to permanent vent systems.

1. Remove the 3/4 inch NPT countersunk headless pipe plugs from the drain hole just below the level of the jacket water header (see Figure 4.25-1).

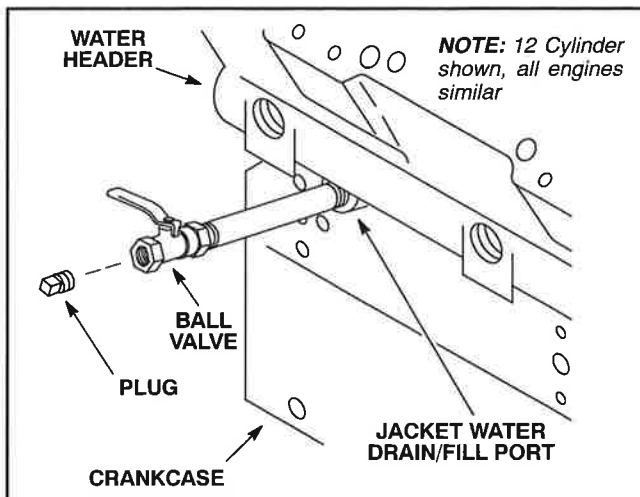


Figure 4.25-1. Customer Supplied Ball Valve - 12 Cylinder

NOTE: To facilitate draining and flushing of the engine jacket water, replace one of the 3/4 inch NPT countersunk headless pipe plugs with a customer-supplied ball valve (see Figure 4.25-1). The ball valve must be threaded to accept both a hose connection and pipe plug.

2. Open the air bleed petcock(s) on top of the cluster thermostat housing on 6 and 12 cylinder engines and on top of the water manifold on 16 cylinder engines.

3. Attach the makeup line to the ball valve and add treated cooling water to the crankcase (see *Water Treatment* in this section).

NOTE: Always fill the engine from the bottom up to minimize the formation of damaging air pockets. As the engine fills, air is pushed up and out.

⚠ WARNING

Antifreeze solution is toxic and poisonous. Always wear protective clothing when working with antifreeze solution. Follow the safety instructions provided on the container provided by the manufacturer. Failure to follow proper procedures could cause severe personal injury or death.

4. Add coolant to the engine until the level causes it to escape from the petcock(s) on top of the cluster thermostat housing on 6 and 12 cylinder engines. On 16 cylinder engines, petcock(s) are located on top of the water manifold. See Table 1.15-2 for jacket water capacities.

5. Close the cluster thermostat housing petcock(s) and continue filling the system until the level of the coolant reaches the top of the surge tank or radiator.

6. Close the ball valve and unthread the hose connection.

⚠ WARNING

Always install a pipe plug in the ball valve when the hose connection is removed. If the lever of the ball valve is inadvertently bumped open, the absence of a plug will cause the coolant to drain. During operation, loss of any coolant may result in catastrophic engine damage. Escaping steam and/or hot water can cause severe burns or severe personal injury or death.

7. Apply Perma Lok® Heavy Duty Pipe Sealant with Teflon® to the threads of the pipe plug. Install the plug in the ball valve.

COOLING SYSTEM MAINTENANCE

CAUTION Air in the cooling system speeds up the formation of rust, increases corrosion and produces hot spots within the engine.

8. Bleed trapped air (see *Cooling Water System Air Bleed*).

9. Top off the surge tank or radiator.

AUXILIARY COOLING WATER CIRCUIT - INITIAL FILL

NOTE: The following description is not applicable to permanent vent systems.

1. Open the air bleed petcocks in the intercooler cooling water inlet/outlet bonnets.

2. Open the air bleed petcocks on the intercooler water inlet and outlet tubes located behind the venturi extractor.

3. Open the air bleed petcocks in the inlet side of the wastegate water return tubes.

4. From the top of the surge tank or radiator, add treated cooling water (see *Water Treatment* in this section) to the auxiliary cooling water circuit.

5. Continue filling the circuit until the level causes it to escape from the air bleed petcock(s) in the intercooler cooling water inlet/outlet bonnet(s). Close the petcock(s) when water begins to flow out in a solid steady stream.

6. Continue filling the auxiliary cooling water circuit until the level causes it to escape from the petcocks in the intercooler cooling water supply and the inlet side of the wastegate water return tubes. Close the petcocks when water begins to flow out in a solid steady stream. See Table 1.15-2 for the capacities of the various auxiliary water system components.

NOTE: Customer supplied items and connections not included. Waukesha supplied items include the auxiliary water pump, intercooler, oil cooler and the engine mounted intercooler water supply and return piping.

7. Continue filling the auxiliary cooling water circuit until the level of the coolant reaches the top of the surge tank or radiator.

CAUTION Air in the cooling system speeds up the formation of rust, increases corrosion and produces hot spots within the engine.

8. Bleed trapped air (see *Cooling Water System Air Bleed*).

9. Top off the surge tank or radiator.

COOLING WATER SYSTEM - AIR BLEED

Air bleed the jacket water and auxiliary cooling water circuits at least once each day. Open and close the air bleed petcocks in the order that they are listed below, starting at the lowest petcock in the system and ending at the highest. Bleed one petcock at a time. The number of air bleed petcocks and their locations are listed in Table 4.25-3.

1. **Initial Bleed:** open each air bleed petcock prior to engine startup. A hissing sound often accompanies the escape of trapped air. Close the petcock when the hissing stops and water begins to flow out in a solid steady stream.

WARNING

Always wear protective clothing when bleeding the cooling system on a heated engine. Slowly loosen the air bleed petcock to relieve any excess pressure. Escaping steam and/or hot water can result in severe burns.

2. **Check Bleed:** start the engine and reopen each petcock. Close the petcock when the hissing stops and water begins to flow out in a solid steady stream.

3. **Final Bleed:** once the temperature of the jacket water circuit has stabilized (as indicated by the panel mounted temperature gauge), reopen each petcock. Close the petcock when the water begins to flow out in a solid steady stream.

CAUTION Air can be drawn into the engine through small leaks in the jacket water system. The problem is compounded when the void created by the loss of coolant is filled by more air. If aeration causes the coolant to foam, the probability of engine damage due to overheating is greatly increased.

4. Carefully inspect the jacket water system for coolant leaks while the engine is running.

Table 4.25-3. Air Bleed Petcocks

COOLING WATER CIRCUIT	NUMBER OF PETCOCKS	LOCATION
6 Cylinder Engine		
Jacket Water	1	Jacket water pump housing (front center); needle valve in lieu of petcock in outlet port to jacket water header
	1	Cluster thermostat housing (above bypass outlet port at front)
Auxiliary	1	Intercooler water inlet/outlet bonnet (upper rear)
	2	Intercooler cooling water inlet/outlet elbows (upper rear)
	1	Wastegate water tube (rear)
5115GL Engine		
Jacket Water	2	Cluster thermostat housing (above bypass outlet ports at front)
Auxiliary	2	Intercooler water inlet/outlet bonnets (upper rear)
	2	Intercooler water inlet/outlet tubes (behind venturi extractor)
	2	Wastegate water return tube (rear right and left bank)
12 Cylinder Engine		
Jacket Water	1	Jacket water pump housing (front center); outlet port to left bank jacket water header
	2	Cluster thermostat housing (above bypass outlet ports at front)
Auxiliary	2	Intercooler water inlet/outlet bonnets (upper rear)
	2	Wastegate water return tube (rear right and left bank)
16 Cylinder Engine		
Jacket Water	1	Top of jacket water pump
	1	Top of water manifold
Auxiliary	4	Intercooler cross pipes (2 per intercooler)
	4	Intercooler top center (2 per intercooler)

COOLING WATER CIRCUITS - DRAIN AND FLUSH

Unless evidence of corrosion or sediment buildup demonstrates the need for more frequent maintenance, clean and flush both the jacket water and auxiliary cooling water circuits at least once each year.

1. Start the engine. Let the engine run about 10 minutes to stir up any rust or sediment.



Always wear protective clothing when draining the cooling systems on a heated engine. Slowly loosen the air bleed petcocks to relieve any excess pressure. Escaping steam and/or hot water can result in severe burns or death.

2. Shut down the engine. Open the air bleed petcocks at the highest point in both the jacket water and auxiliary cooling water circuits, whether it be on top of the surge tank, radiator or other heat transfer device.

NOTE: To facilitate draining and flushing of the engine jacket water, replace one of the 3/4 inch NPT counter-sunk headless pipe plugs (just below the level of the jacket water header) with a customer-supplied ball valve. The ball valve must be threaded to accept both a hose connection and pipe plug.

3. Verify that the customer-supplied ball valve is in the closed position. Remove the pipe plug and attach the drainage line.
4. Drain the coolant from the jacket water and auxiliary cooling water circuits. Avoid delay, so that the water is drained before the rust and sediment has a chance to settle.

COOLING SYSTEM MAINTENANCE

5. Open all air bleed petcocks (see Table 4.25-4).

Table 4.25-4. Water Drain Petcocks

COOLING WATER CIRCUIT	NUMBER OF PETCOCKS	LOCATION
6 Cylinder Engines		
Jacket Water	2 (plugs)	Jacket water header (front and rear)
	2 (plugs)	Water manifold (front and rear)
	1	Jacket water pump housing (see exit hole in side panel of safety guard assembly)
	1	Oil cooler (bottom rear)
Auxiliary	2	Intercooler (rear, left and right)
	1	Auxiliary water pump (bottom)
	1	Wastegate water pipe (also used for air bleed)
5115GL Engine		
Jacket Water	4 (plugs)	Jacket water headers (front and rear)
	2	Water manifold (front and rear)
	1	Jacket water pump housing
Auxiliary	1	Auxiliary water pump
	4	Intercooler (lower)
12 Cylinder Engines		
Jacket Water	4 (plugs)	Jacket water headers (front and rear)
	2	Water manifold (front and rear)
	2	Water Elbows front left and right)
Auxiliary	8	Intercooler (rear, left and right)
	1	Auxiliary water pump (bottom)
	1	Water return pipe (pipe end at crankcase Vee, engine front)
16 Cylinder Engines		
Jacket Water	4 (plugs)	Jacket water headers (front and rear)
	2	Water manifold (front and rear)
	1	Jacket water pump housing (see exit hole in side panel of safety guard assembly)
Auxiliary	2	Intercooler (4 each intercooler)
	1	Auxiliary water pump (bottom)
	1	Wastegate (1 per wastegate)

6. Open all water drain petcocks. Remove all drain plugs. Place a small catch pan beneath each petcock before opening.

7. Close all water drain petcocks. Apply Perma Lok® Heavy Duty Pipe Sealant with Teflon® to the threads, and install all drain plugs.

8. Select and inspect an internal surface that is suitable for gauging the effectiveness of the cleaning and descaling solution. If necessary, insert a piece of drill

welding rod into the water passage opening to feel for an accumulation of lime and mineral scale deposits.

9. Attach the makeup line to the ball valve and add clean, soft water to the crankcase. Always fill the engine from the bottom up to minimize the formation of air pockets. As the engine fills, air is pushed up and out.

10. Successively close each air bleed petcock when water begins to flow out in a solid steady stream. Begin at the lowest petcock and finish at the highest.

11. Close the cluster thermostat housing petcock(s) and continue filling the jacket water system until the level reaches the top of the surge tank or radiator.

12. Bleed trapped air. Begin at the lowest petcock and finish at the highest. Bleed one petcock at a time. Close the petcock when the hissing stops and water begins to flow out in a solid steady stream.

13. Attach the makeup line and add clean, soft water to the surge tank or radiator of the auxiliary cooling water circuit.

14. Top off the surge tank or radiator of the jacket water circuit.

15. Successively close each air bleed petcock when water begins to flow out in a solid steady stream.

16. Continue filling the auxiliary cooling water circuit until the level reaches the top of the surge tank or radiator.

17. Bleed trapped air. Begin at the lowest petcock and finish at the highest. Bleed one petcock at a time. Close the petcock when the hissing stops and water begins to flow out in a solid steady stream.

18. Top off the surge tank or radiator of the auxiliary cooling water circuit.

WARNING

Always wear protective clothing when venting the cooling system on a heated engine. Slowly loosen the air bleed petcock to relieve any excess pressure. Escaping steam and/or hot water can result in severe burns or death.

19. Start the engine and slowly reopen each air bleed petcock. Close the petcock when the hissing stops and water begins to flow out in a solid steady stream.

20. Slowly reopen each air bleed petcock when the engine jacket water temperature has stabilized (as indicated by the panel mounted temperature gauge). Close the petcock when the water begins to flow out in a solid steady stream.

21. Let the engine run about 10 minutes to stir up any rust or sediment in the cooling water system.

WARNING

Always wear protective clothing when draining the cooling systems on a heated engine. Slowly loosen the drain petcocks to relieve any excess pressure. Escaping steam and/or hot water can result in severe burns or death.

NOTE: *Contaminants left in the cooling water systems will reduce or deplete the effectiveness of the cleaning solution.*

22. Stop the engine. Drain the crankcase and all cooling system accessories. Drain the auxiliary cooling water circuit. Avoid delay, so that the water is completely drained while the rust and sediment are still in suspension.

23. Attach the makeup line and fill the jacket water and auxiliary cooling water circuits with a suitable cleaning solution. Use a non-acidic, non-corrosive, biodegradable compound that prevents the loss of metal in the engine and avoids damage to internal gaskets and seals.

NOTE: *Follow the manufacturer's recommendations for the proper concentration of cleaning solution and length of cleaning time.*

24. Bleed trapped air.


25. Top off the surge tank or radiator of the jacket water and auxiliary cooling water circuits.

26. Start the engine. Let it run for at least 10 minutes or until the cleaning solution is depleted.

27. To ensure that the contaminants remain in suspension, drain the cooling systems as quickly as possible.

28. Inspect internal surfaces. If the results are not satisfactory, refill the engine with cleaning solution. Repeat Steps 23 thru 27 as necessary.

29. To flush the systems of cleaning solution and any residual contaminants, fill the jacket water and auxiliary cooling water circuits with clean, soft water. Drain immediately.


 **CAUTION** All antifreeze and water treatment products require a clean system in order to work effectively. If contaminants, such as dirt, rust, scale, lime, grease, oil and/or cleaning agents, are not completely flushed out, they can destroy the corrosion inhibitors and scale suppressants intended to keep freshly filled cooling systems clean.

30. Inspect the drain water for cleanliness. Fill and flush the systems again, if necessary. The best results are obtained when the drain water runs clear.

31. Fill the jacket water and auxiliary cooling water circuits with coolant. Be sure that the coolant has the proper inhibitor and additive concentrations (see *Water Treatment*). Bleed the system of trapped air.

WARNING

Always install a pipe plug in the ball valve when the hose connection is removed from the jacket water header. If the lever of the ball valve is inadvertently bumped open, the absence of a plug will cause the coolant to drain. During operation, loss of any coolant may result in catastrophic engine damage. Escaping steam and/or hot water can cause severe burns or death.

 **CAUTION** Air can be drawn into the system through small leaks in the cooling water circuit. The problem is compounded when the void created by any loss of coolant is filled by more air. Air in the cooling system speeds up the formation of rust, increases corrosion and produces hot spots within the engine. If aeration causes the coolant to foam, the probability of engine damage due to overheating is greatly increased.

32. Carefully inspect the jacket water and auxiliary cooling water circuits for leaks.

COOLING SYSTEM MAINTENANCE

IDLER PULLEY BEARING LUBRICATION

All engines with the exception of 5115GL engines require greasing the ball bearing in the jacket water pump idler pulley bracket every 720 running hours.

1. Locate the idler pulley bracket grease fitting mounted above the drain cock in the panel of the safety guard assembly (right bank side) (see Figure 4.25-2 and Figure 4.25-3).

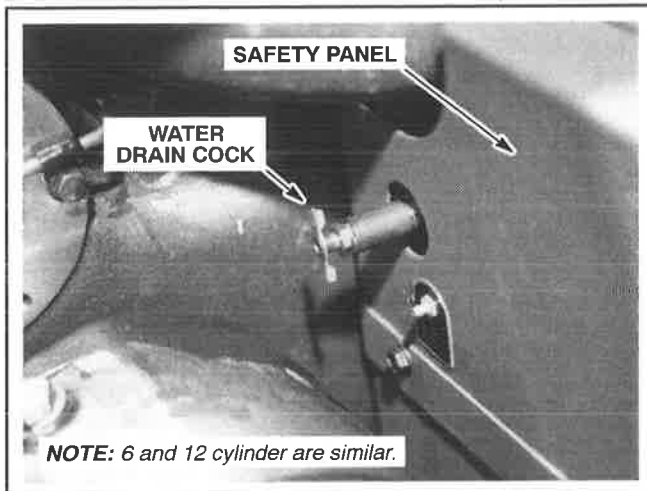


Figure 4.25-2. Idler Pulley Bearing Lube - 12 Cylinder Shown

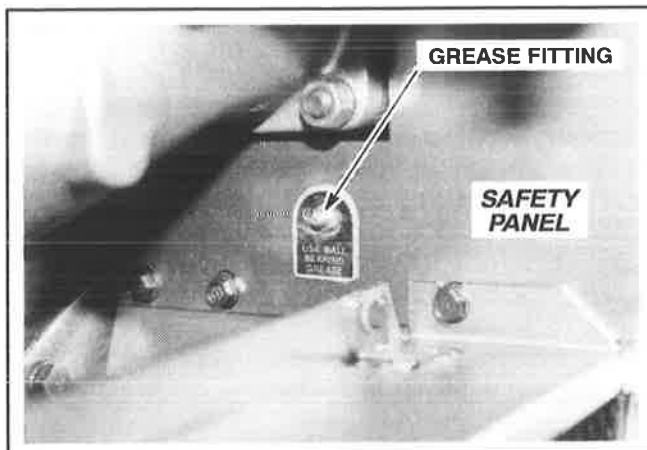


Figure 4.25-3. Idler Pulley Bearing Lube - 16 Cylinder

⚠ CAUTION

Do not over grease the idler pulley bearing. Over greasing causes high bearing temperatures that shorten bearing service life. Disregarding this information could result in product damage and/or personal injury.

2. Using a hand held grease gun, apply one stroke of Lithoplex[®] Grease No. 2 (Multipurpose Lithium Complex Formula Containing Molybdenum Disulfide) to the grease fitting.

AUXILIARY WATER PUMP BEARINGS LUBRICATION

All engines with the exception of 5115GL engines require greasing the ball bearing(s) in the auxiliary water pump every 720 running hours. The pump is mounted to a bracket at the front left or right corner of the oil pan. Depending on the model of the auxiliary water pump used, the pump may have one or two grease fittings. Safety guards on some engines may cover access to grease fittings. In this case an access hole is provided to allow the fitting to be greased.

1. Locate the grease fitting(s) on the auxiliary water pump (see Figure 4.25-4, Figure 4.25-5 and Figure 4.25-6).

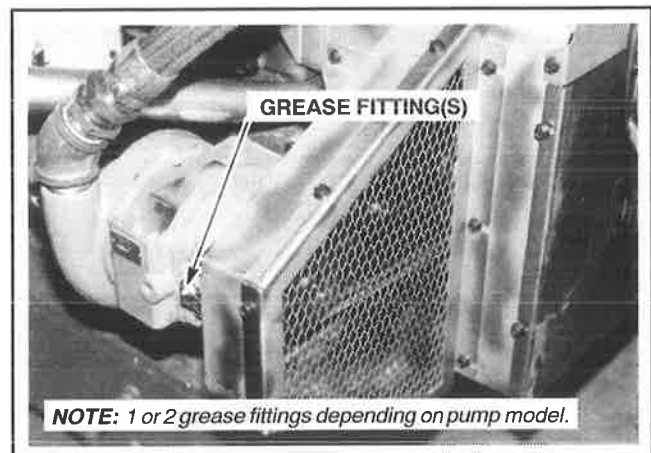


Figure 4.25-4. Auxiliary Water Pump Lube - 6 Cylinder

⚠ CAUTION

Do not over grease the water pump bearings. Over greasing causes high bearing temperatures that shorten bearing service life. Disregarding this information could result in product damage and/or personal injury.

2. Using a hand held grease gun, apply two or three strokes of Lithoplex® Grease No. 2 (Multipurpose Lithium Complex Formula Containing Molybdenum Disulfide) to the grease fitting(s).

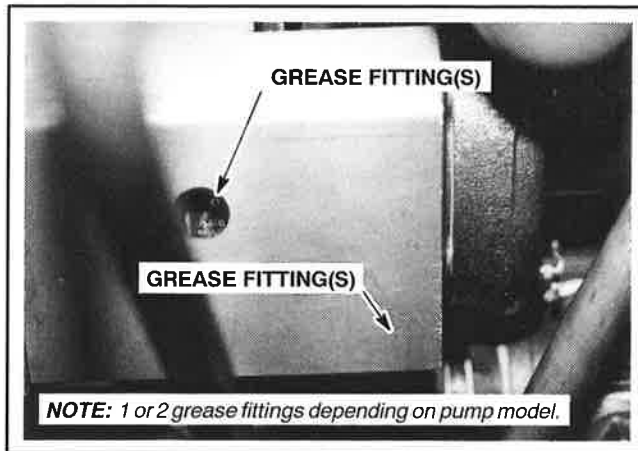


Figure 4.25-5. Auxiliary Water Pump Lube - 12 Cylinder

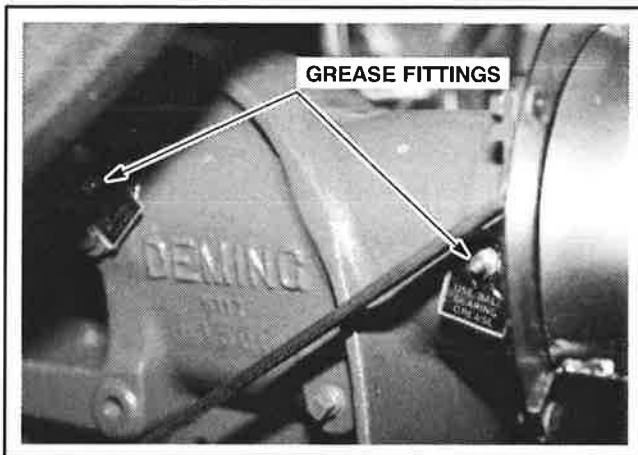


Figure 4.25-6. Auxiliary Water Pump Lube - 16 Cylinder

GREASE RECOMMENDATIONS

A Lithium complex type grease is now recommended over the Lithium soap base grease because of its ability to resist water. Lithium complex type grease also provides superior rust protection qualities (especially steel surfaces), as well as its thermal and mechanical stability at high operating temperatures. The Lithium complex grease has a continuous operating temperature of approximately 350° F (177° C), whereas the Lithium soap base grease has an upper operating temperature limit of approximately 225° F (107° C).

JACKET WATER PUMP DRIVE BELTS REPLACEMENT

⚠ WARNING

Always install the safety guards after completing any service operation. Never operate the engine with the safety guards removed. Disregarding this information could result in product damage, severe personal injury or death.

NOTE: 5115GL engines are not equipped with belts.

1. Remove front safety guard.

⚠ CAUTION An accumulation of dirt in the sheave grooves impairs traction and accelerates belt wear. Disregarding this information could result in product damage and/or personal injury.

2. Verify that the pulley sheaves are clean and completely free of grease, oil, dirt and grit.

3. Inspect the drive belts for fraying, cracks or wear. Belts must not be glazed, split, peeled or greasy. Replace as necessary.

⚠ CAUTION Belts are matched and tied in sets. Always replace the drive belts in sets. Never replace just one drive belt even if only one belt is worn. Since the older belts are stretched during hours of engine operation, the circumference of new belts is slightly smaller. A difference in belt size will cause the new belt to carry the full load, resulting in rapid belt failure and possible damage to driven equipment. Disregarding this information could result in product damage and/or personal injury.

COOLING SYSTEM MAINTENANCE

4. Remove the auxiliary water pump drive belts. Back the upper thin hex lock nut on the threaded rod away from the adjusting lever (see Figure 4.25-7 and Figure 4.25-8). The movement of the idler pulley releases the drive belt tension. Slip the drive belts off the auxiliary water pump and idler pulleys.

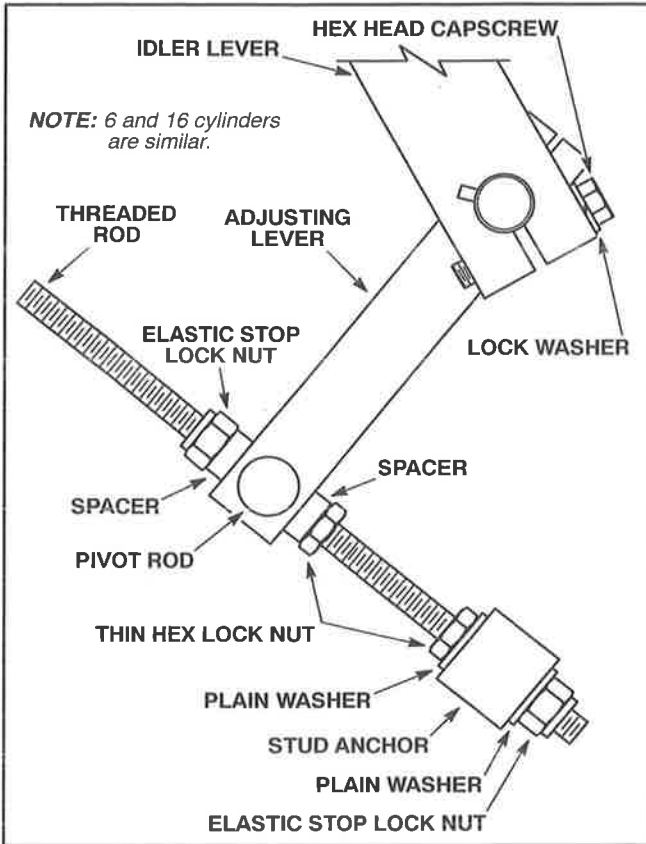


Figure 4.25-7. Adjusting/Idler Lever Assembly - 12 Cylinder Shown



Figure 4.25-8. Adjusting/Idler Lever Assembly - 6 Cylinder Shown

5. Loosen the pivot bolt on which the idler pulley bracket turns (see Figure 4.25-9). Loosen the slotted lock bolt to unlock the position of the bracket. The belt tension is released as the idler pulley bracket rotates.

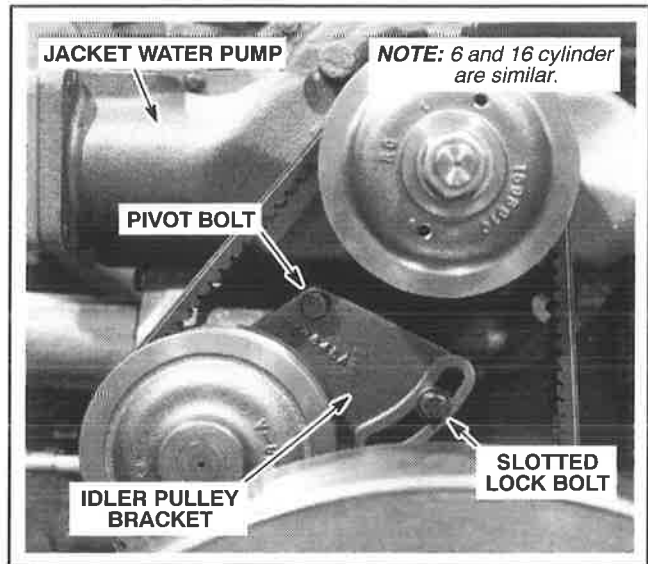


Figure 4.25-9. Tighten Idler Pulley Bracket Bolts - 12 Cylinder Shown

6. Slip the old drive belts off the jacket water pump and idler pulleys. Remove the belts from the rear crankshaft pulley and discard.
7. Place a new drive belt in the rear groove of the rear crankshaft pulley. The rear groove is the one closest to the gear cover. Slip the belt into the rear groove of the jacket water pump pulley.
8. Place a new drive belt into the second last groove of the rear crankshaft and jacket water pump pulleys.
9. Rotate the idler pulley bracket clockwise to seat the jacket water pump drive belts in the two pulley grooves.
10. Refer to *Jacket Water Pump Drive Belt Tension Adjustment* to adjust the belts.

⚠ WARNING

Always install the safety guards after completing any service operation. Never operate the engine with the safety guards removed. Disregarding this information could result in product damage, severe personal injury or death.

11. Install the safety guards.

JACKET WATER PUMP DRIVE BELT TENSION ADJUSTMENT

Check the tension and condition of the two jacket water pump drive belts weekly. Replace the drive belts every 8000 running hours or as necessary.

WARNING

Always install the safety guards after completing any service operation. Never operate the engine with the safety guards removed. Disregarding this information could result in product damage, severe personal injury or death.

NOTE: 5115GL engines and ebullient cooled engines, are not equipped with belts.

1. Remove the safety guard.

CAUTION

Be sure that the belts are cool when the tension is checked or adjusted. The thermal expansion of warm belts will result in a false tension reading. Disregarding this information could result in product damage and/or personal injury.

2. Using V-Belt Tension Tester (Tool P/N 474016), check the drive belt tension.

- A. Measure the distance between the center lines of the crankshaft and jacket water pump pulleys. Align the bottom of the large O-ring on the "Inches of Span" scale to the measured distance.
- B. Align the bottom of the small O-ring on the "Deflection Force" scale with the zero mark.
- C. Place the tension tester squarely on the front drive belt at the center of the longest unsupported span (between the jacket water pump pulley and the crankshaft pulley). Apply inward force on the plunger perpendicular to the belt span until the bottom of the large O-ring is even with the top of the rear drive belt (see Figure 4.25-10).
- D. Remove the tension tester and read the force applied from the bottom of the small O-ring on the deflection force scale. The tension of the belts must be between 11.9 - 17.5 lb. (53 - 77 N·m).
- E. Check the rear belt tension in the same manner.

NOTE: If the tension tester is not available, moderate hand pressure should deflect the long part of the belt approximately 0.25 - 0.50 in. (6 to 13 mm) or as a general rule, 0.01562 in. (0.4 mm) per 1 in. (25.4 mm) of belt span measured from pulley center to pulley center. Belt span should be measured each time.

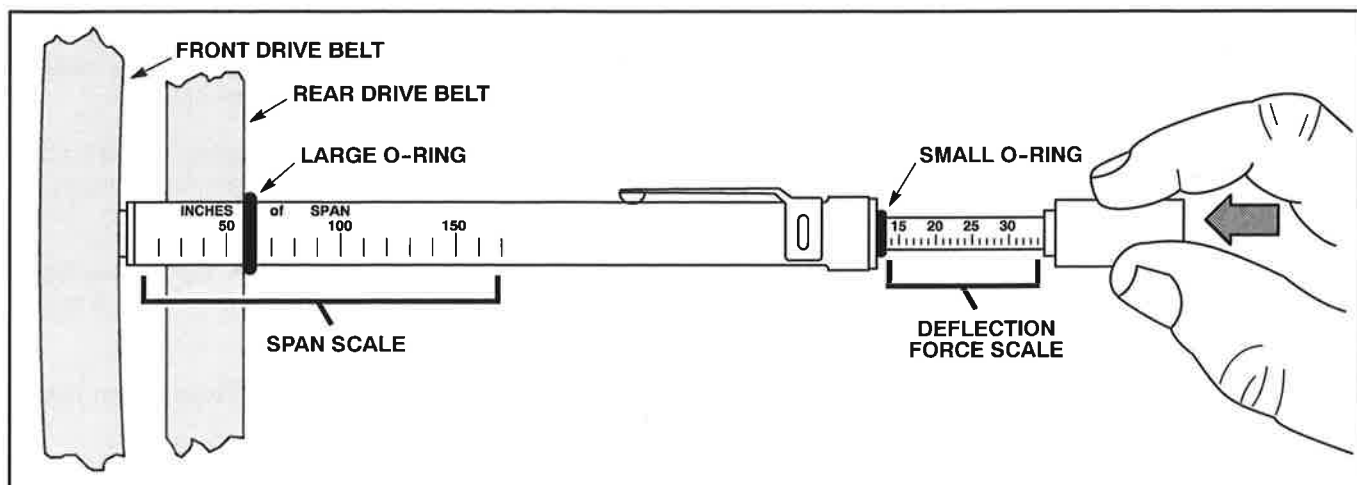


Figure 4.25-10. Drive Belt Tension Tester

COOLING SYSTEM MAINTENANCE

3. If belt tension adjustment is necessary, loosen the pivot bolt on which the idler pulley bracket turns (see Figure 4.25-11). Loosen the slotted bolt to unlock the position of the bracket. The belt tension is released as the idler pulley bracket rotates upward in a counter-clockwise direction.

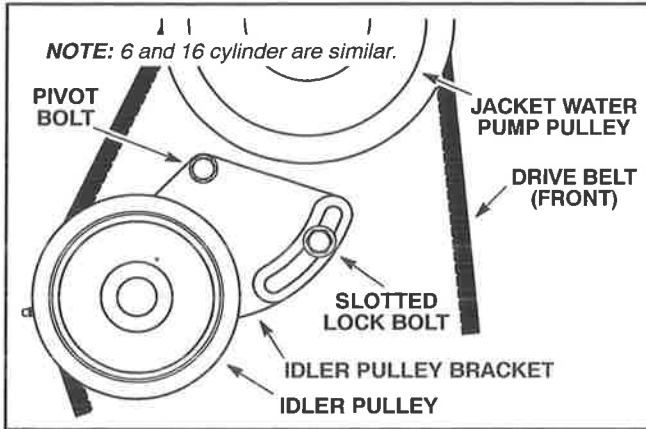


Figure 4.25-11. Jacket Water Pump Drive Belt Tensioning - 12 Cylinder Shown

CAUTION Belts that are too tight result in excessive stretching and overheating. Too much tension may also damage drive components, such as sheaves and shafts, and lead to premature failure of the idler pulley and/or water pump bearings. Disregarding this information could result in product damage and/or personal injury.

CAUTION Belts that are too loose result in belt slippage. Slippage causes burn spots, overheating, rapid wear and breakage. The vibration created by loose belts may also be sufficient to cause unnecessary wear of the pulley grooves. Disregarding this information could result in product damage and/or personal injury.

4. To reset the belt tension, insert a pry bar between the upper edge of the idler pulley bracket and the untapped boss on the left bank side of the water pump housing (see Figure 4.25-12). To tighten the drive belts, use the pad above the untapped boss for leverage and push up on the pry bar to move the idler pulley bracket downward (CW).

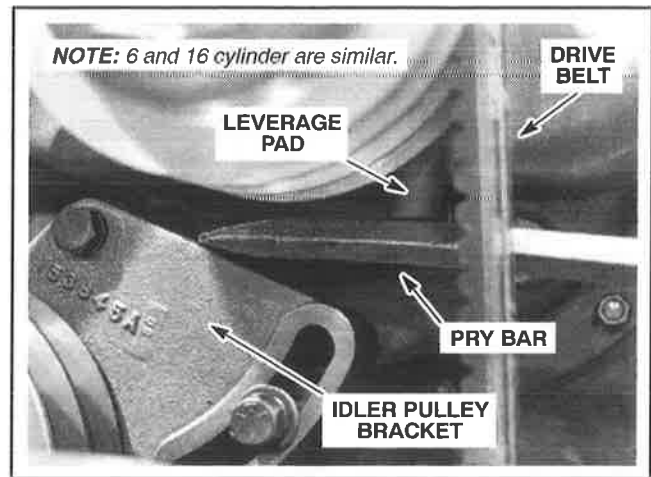


Figure 4.25-12. Jacket Water Pump Drive Belt Tension - 12 Cylinder Shown

5. Holding the pry bar in position, use the tension tester to apply inward pressure to the center of the longest unsupported span on the front drive belt (between the jacket water pump pulley and the crankshaft pulley).

6. Tension used belts between 11.9 and 17.5 lb.

NOTE: If the tension tester is not available, moderate hand pressure should deflect the long part of the belt approximately 0.25 - 0.50 in. (6 to 13 mm) or as a general rule, 0.01562 in. (0.4 mm) per 1 in. (25.4 mm) of belt span measured from pulley center to pulley center.

7. Tighten the slotted lock bolt on the idler pulley bracket when the proper belt tension is obtained (see Figure 4.25-11). Tighten the pivot bolt.

8. Inspect the belts for proper seating. V-belts should ride on the sides of the pulley sheaves, not on the bottom of the groove.

9. Verify that the tension of the front drive belt is between 11.9 and 17.5 lb. Verify the tension of the rear drive belt.

10. See *Auxiliary Water Pump Drive Belts Tension Adjustment*.

WARNING

Always install the safety guards after completing any service operation. Never operate the engine with the safety guards removed. Disregarding this information could result in product damage, severe personal injury or death.

11. Install the safety guards.

AUXILIARY WATER PUMP DRIVE BELT REPLACEMENT

WARNING

Always install the safety guards after completing any service operation. Never operate the engine with the safety guards removed. Disregarding this information could result in product damage, severe personal injury or death.

NOTE: 5115GL engines are not equipped with belts.

1. Remove the safety guard.

CAUTION An accumulation of dirt in the sheave grooves impairs traction and accelerates belt wear. Disregarding this information could result in product damage and/or personal injury.

2. Verify that the pulley sheaves are clean and completely free of grease, oil, dirt and grit.

3. Inspect the drive belts for fraying, cracks or wear. Belts must not be glazed, split, peeled or greasy. Replace as necessary.

4. If replacement is necessary, back the upper thin hex lock nut on the threaded rod away from the adjusting lever (see Figure 4.25-13 and Figure 4.25-14). The pivot point of the idler lever follows the adjusting lever. The movement of the idler pulley releases the drive belt tension.

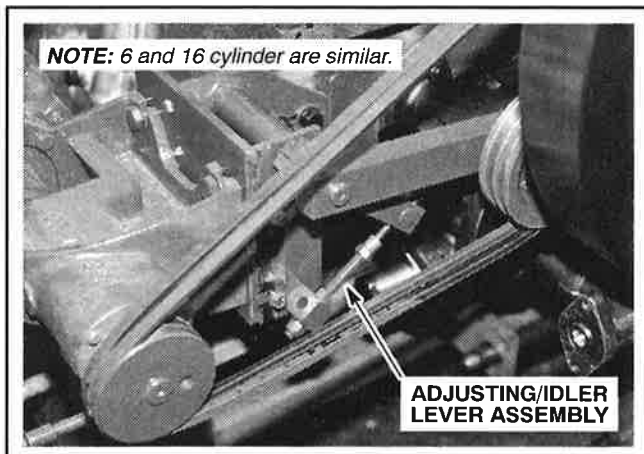


Figure 4.25-13. Adjusting/Idler Lever Assembly - 6 Cylinder Shown

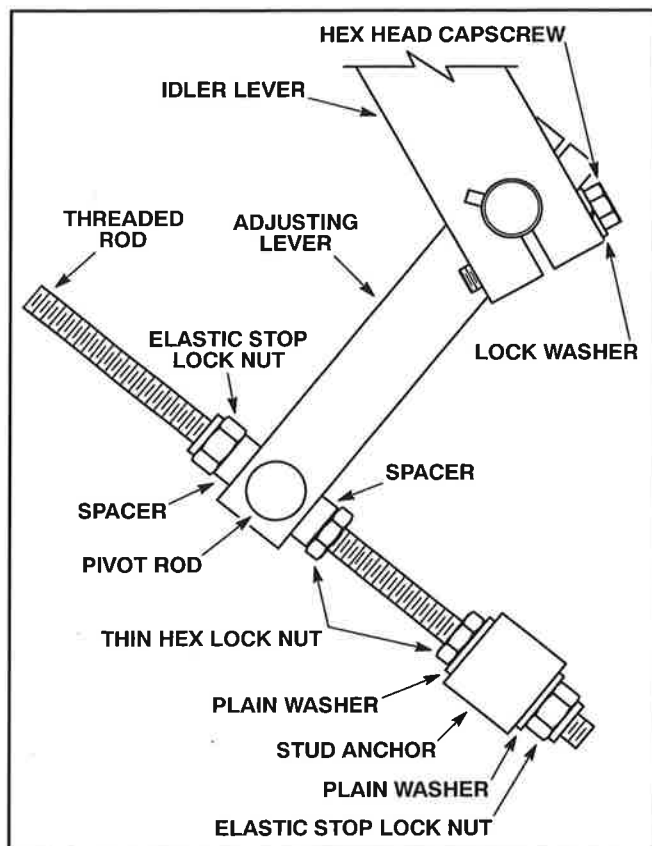


Figure 4.25-14. Adjusting/Idler Lever Assembly - 12 Cylinder

5. Remove the drive belts from the auxiliary water pump and idler pulleys (see Figure 4.25-13 and Figure 4.25-15). Remove the belts from the rear crankshaft pulley and discard.

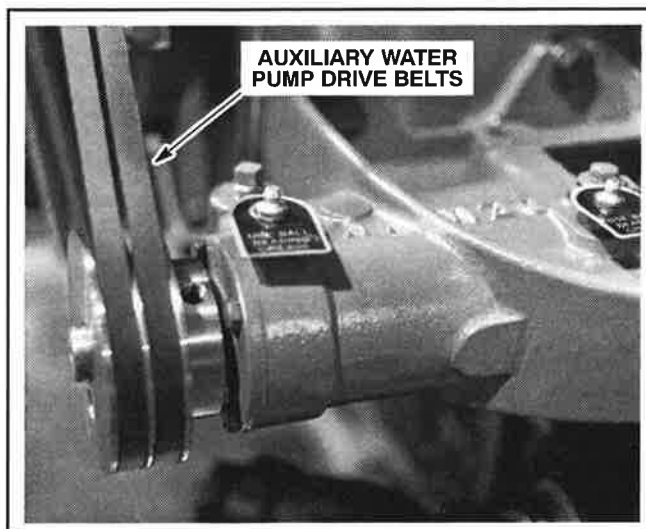


Figure 4.25-15. Auxiliary Water Pump Belts - 12 Cylinder

COOLING SYSTEM MAINTENANCE

CAUTION Belts are matched and tied in sets of two. Always replace the drive belts in pairs. Never replace just one drive belt even if only one belt is worn. Since the older belts are stretched during hours of engine operation, the circumference of new belts is slightly smaller. A difference in belt size will cause the new belt to carry the full load, resulting in rapid belt failure and possible damage to driven equipment. Disregarding this information could result in product damage and/or personal injury.

6. Inspect the condition of the new auxiliary water pump drive belts. Replace as necessary.

7. Place the new drive belts in the rear groove of the rear crankshaft pulley (directly in front of the first jacket water pump drive belt) (see Figure 4.25-16). Slip the belts into the grooves of both the auxiliary water pump and idler lever pulleys.

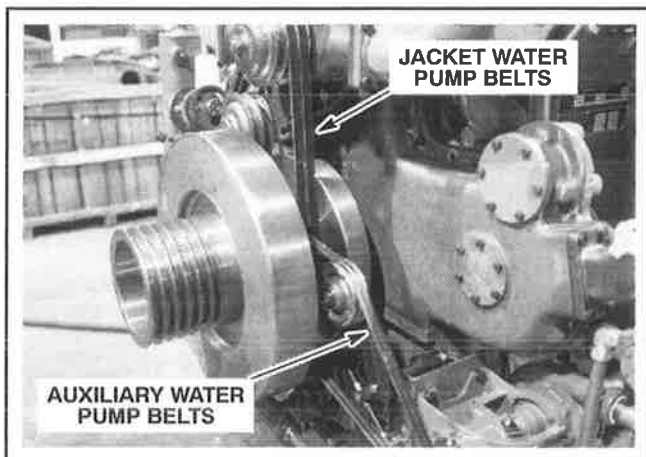


Figure 4.25-16. Jacket And Auxiliary Water Pump Belts - 12 Cylinder

8. To tighten the drive belts, thread the upper thin hex lock nut toward the adjusting lever. The pivot point of the idler lever follows the adjusting lever in a clockwise direction. The upward movement of the idler pulley increases the drive belt tension.

9. Refer to *Auxiliary Water Pump Drive Belt Tension Adjustment* to adjust the belts.

WARNING

Always install the safety guards after completing any service operation. Never operate the engine with the safety guards removed. Disregarding this information could result in product damage, severe personal injury or death.

10. Install the safety guards.

AUXILIARY WATER PUMP DRIVE BELT TENSION ADJUSTMENT

WARNING

Always install the safety guards after completing any service operation. Never operate the engine with the safety guards removed. Disregarding this information could result in product damage, severe personal injury or death.

NOTE: 5115GL engines are not equipped with belts.

1. Remove the safety guard.

CAUTION Be sure that the belts are cool when the tension is checked or adjusted. The thermal expansion of warm belts will result in a false tension reading. Disregarding this information could result in product damage and/or personal injury.

2. Using V-Belt Tension Tester (Tool P/N 474016), check the auxiliary drive belt tension.

- Measure the distance between the center lines of pulleys of the longest belt span. Align the bottom of the large O-ring on the "Inches of Span" scale to the measured distance.
- Align the bottom of the small O-ring on the "Deflection Force" scale with the zero mark.
- Place the tension tester squarely on the front drive belt at the center of the longest unsupported span. Apply inward force on the plunger perpendicular to the belt span until the bottom of the large O-ring is even with the top of the rear drive belt (see Figure 4.25-17).
- Remove the tension tester and read the force applied from the bottom of the small O-ring on the deflection force scale. The tension of the belts must be between 5 - 8 lb. (22 - 35.6 N-m).
- Check the rear belt tension in the same manner.

NOTE: If the tension tester is not available, moderate hand pressure should deflect the long part of the belt approximately 0.25 - 0.50 in. (6 to 13 mm) or as a general rule, 0.01562 in. (0.4 mm) per 1 in. (25.4 mm) of belt span measured from pulley center to pulley center.

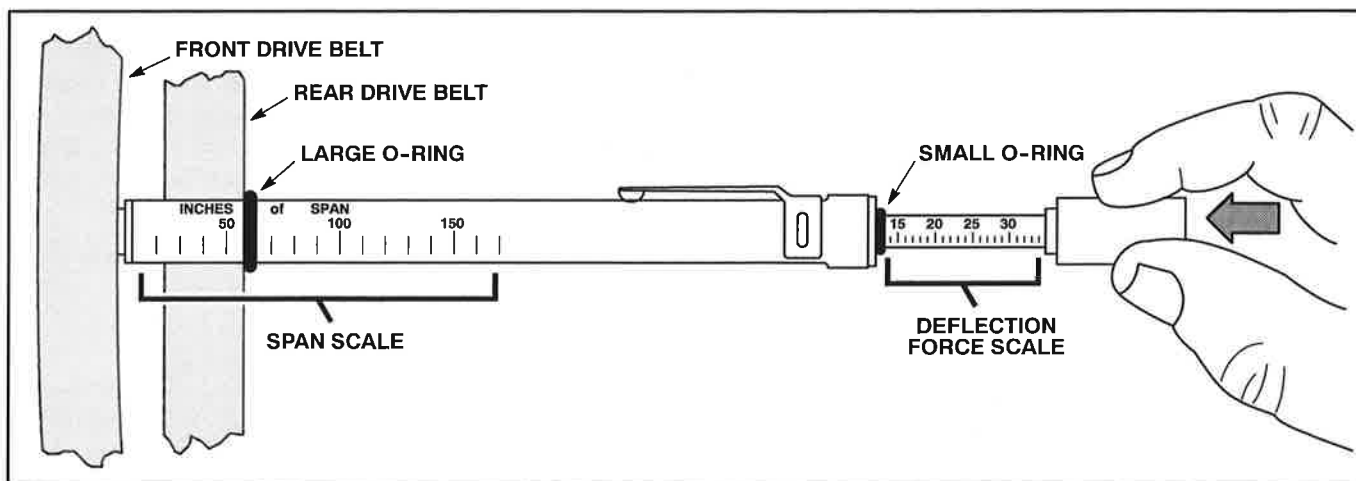


Figure 4.25-17. Drive Belt Tension Tester

CAUTION Belts that are too tight result in excessive stretching and overheating. Too much tension may also damage drive components, such as sheaves and shafts, and lead to premature failure of the idler pulley and/or water pump bearings. Disregarding this information could result in product damage and/or personal injury.

NOTE: Since the circumference of new belts is somewhat smaller, reuse of the setting established for the discarded drive belts will result in belts that are too tight.

3. To loosen the drive belts, back the upper thin hex lock nut on the threaded rod away from the adjusting lever. The pivot point of the idler lever follows the adjusting lever in a counter-clockwise direction. The downward movement of the idler pulley releases the drive belt tension.

4. When the correct tension is obtained, thread the 3/8 inch elastic stop lock on the upper end of the threaded rod toward the adjusting lever. Be sure that the lock nuts (thin hex and elastic stop) on each side of the adjusting lever are properly tightened.

5. Inspect the belts for proper seating. V-belts should ride on the sides of the pulley sheaves, not on the bottom of the groove.

6. Because of initial stretching, recheck the belt tension after 10 minutes run time. Check the belt tension again after the first 30 minutes run time and then every 250 hours thereafter.

CAUTION Belts that are too loose result in belt slippage. Slippage causes burn spots, overheating, rapid wear and breakage. The vibration created by loose belts may also be sufficient to cause unnecessary wear of the pulley grooves. Disregarding this information could result in product damage and/or personal injury.

7. To tighten the drive belts, back the elastic stop lock nut on the upper end of the threaded rod away from the adjusting lever. Use a 3/8 inch deepwell socket for best results.

8. Thread the upper thin hex lock nut toward the adjusting lever. The pivot point of the idler lever follows the adjusting lever in a clockwise direction. The upward movement of the idler pulley increases the drive belt tension.

9. When the correct tension is obtained, thread the elastic stop lock nut on the upper end of the threaded rod toward the adjusting lever. Be sure that the lock nuts (thin hex and elastic stop) on each side of the adjusting lever are properly tightened.

WARNING

Always install the safety guards after completing any service operation. Never operate the engine with the safety guards removed. Disregarding this information could result in product damage, severe personal injury or death.

10. Install the safety guards.

COOLING SYSTEM MAINTENANCE

JACKET/AUXILIARY WATER PUMP INSPECTION

Jacket Water Pump Inspection

5115GL engines jacket water pump inspection is limited to a visual inspection for leaks and visual inspection of the oil sight glass to determine if oil is contaminated with coolant. The location of the sight glass is similar to the sight glass location on the auxiliary water pump (see Figure 4.25-19).

WARNING

Always install the safety guards after completing any service operation. Never operate the engine with the safety guards removed. Disregarding this information could result in product damage, severe personal injury or death.

1. Remove the safety guard.
2. Inspect the "weep hole" in the casting directly below the water pump pulley (see Figure 4.25-18). The "weep hole" drains any coolant that leaks past the ceramic water pump seal.

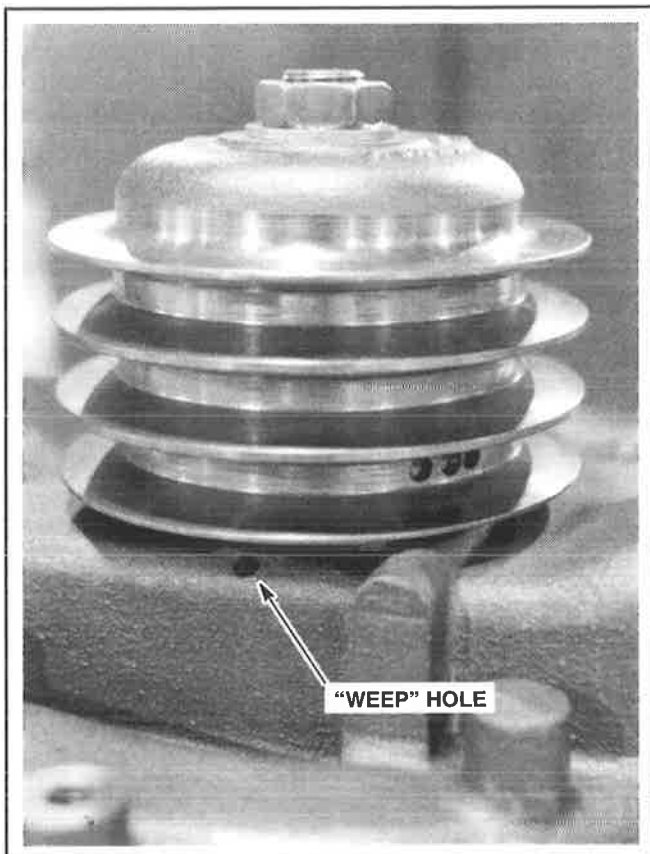


Figure 4.25-18. Jacket Water Pump "Weep" Hole - Water Pump Shown Removed

CAUTION

The presence of coolant at the "weep hole" indicates that the jacket water pump must be rebuilt. A defective water pump seal results in coolant loss and contamination of the inner ball bearing grease. Disregarding this information could result in product damage and/or personal injury.

3. Notify a Waukesha certified technician if any coolant leakage at the "weep hole" is observed.

WARNING

Always install the safety guards after completing any service operation. Never operate the engine with the safety guards removed. Disregarding this information could result in product damage, severe personal injury or death.

4. Install the safety guards.

Auxiliary Water Pump Inspection

Auxiliary water pumps should be visually checked for leaks. 5115GL engine auxiliary water pumps should be visually checked for leaks and visual inspection of the oil sight glass to determine if oil is contaminated with coolant (see Figure 4.25-19).

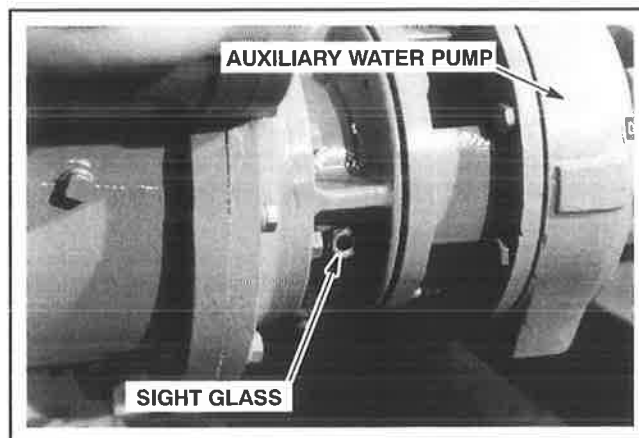


Figure 4.25-19. Auxiliary Water Pump - 5115GL

SECTION 4.30

LUBRICATION SYSTEM MAINTENANCE

LUBRICATION SYSTEM MAINTENANCE

Table 4.30-1. Lubrication System

	6 CYLINDER	12 CYLINDER *	5115GL	16 CYLINDER
Sump capacity, including filter and cooler*	72 gallons (272.5 litres)	99 gallons (375 litres)	99 gallons (376 litres)	165 gallons (625 litres)
Oil pan (Low level mark)	35 gallons (132.5 litres)	35 gallons (132.5 litres)	35 gallons (132.5 litres)	80 gallons (303 litres)
Oil pan (High level mark)	45 gallons (170.3 litres)	45 gallons (170.3 litres)	54 gallons (204.4 litres)	110 gallons (416 litres)
Lube Oil Filter Capacity	20 gallons (75.7 litres)	36 gallons (136.3 litres)	36 gallons (136.3 litres)	45 gallons (170 litres)
Oil Cooler Capacity	(8 in.) 6.9 gal. (26.1 L) (10 in.) 10 gal. (37.8 L)	(8 in.) 6.9 gal. (26.1 L) (10 in.) 10 gal. (37.8 L)	9.0 gallons (34.1 litres)	10 gallons (38 litres)

NOTE: * Does not include 5115GL model.

OIL FILL - INITIAL PROCEDURE

The oil capacities listed in Table 4.30-1 represent approximate amounts. Use the initial fill to determine the actual amount of oil required. Table 4.30-2 lists oil recommendations.

CAUTION The lube oil piping must be purged of all slag and debris before the engine is first started. Before proceeding with the oil fill procedure, refer to the purging instructions in this section. Disregarding this information could result in product damage and/or personal injury.

1. Remove the cap from the oil filler pipe on the lower rear left side of the engine (see Figure 4.30-2).
2. Refer to *Oil Filter Maintenance*, and fill the oil filter with the proper grade oil.
3. Insert the make-up line and add lube oil to the oil pan. Periodically remove the dipstick and take note of the reading.
4. Continue to add oil to the oil pan until the level reaches the "full" mark on the dipstick (see Figure 4.30-1).
5. Stop adding oil and start the prelube pump. The prelube pump must be run to fill the oil lines, oil cooler, the full-flow lube oil filter and oil strainer. It also ensures that the bearings, turbochargers and other moving parts of the engine are properly lubricated.

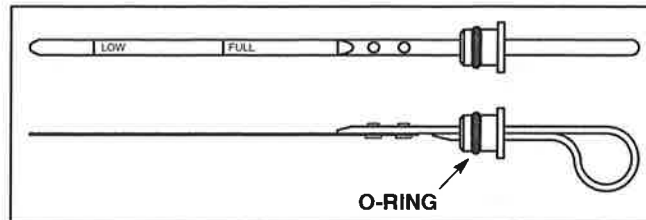


Figure 4.30-1. Dipstick

CAUTION Filter must be filled with lubricating oil before first start and after each element change. Disregarding this information could result in product damage.

6. Depress the bypass valve plunger inside filter to allow air to escape. Before first startup, vent air through the cover vent while the prelube pump is still running. A continuous flow of oil from the vent line is required and indicates that all air has been removed from the lube oil system.
7. Run the prelube pump until pressure is indicated on the oil pressure gauge. Stop the prelube pump, wait a few minutes for the oil to drain back into the crankcase, check the dipstick and add oil to the oil pan until the level returns to the "full" mark.

LUBRICATION SYSTEM MAINTENANCE

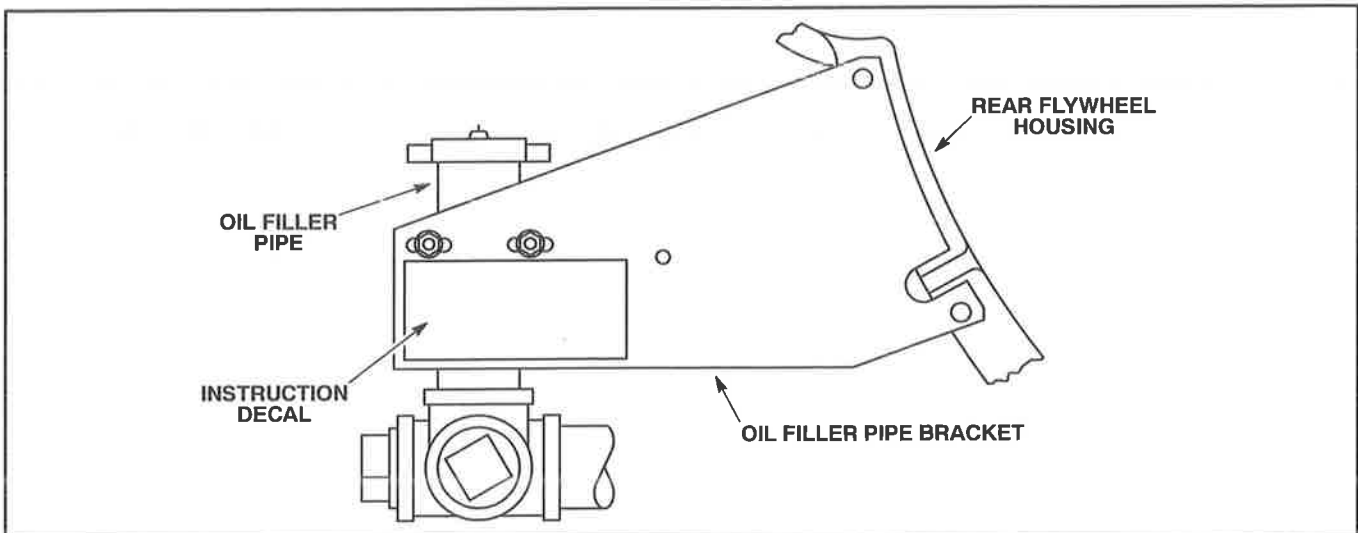


Figure 4.30-2. Oil Filler Pipe

8. Install the oil filler cap, start the engine and wait until the lube oil has warmed up to its normal operating temperature. Shut the engine down, wait for the oil to drain back into the pan and then check the level one more time. Add oil if the level is below the "full" mark.

9. Check the crankcase oil level daily before the engine is started. The blade of the dipstick is marked "low" and "full." Always maintain the oil level at the "full" mark. Both marks on the dipstick are "static lines." The dipstick does not indicate where the level of the oil should be when the engine is running.

OIL COOLER AND LUBE OIL FILTER INSTALLATION REQUIREMENTS

1. All piping connections to and from the engine and between lubrication system accessories are to be supplied by the customer. Place the lube oil filter and lube oil cooler assemblies as close to the engine as possible. All customer connections to the engine must be flexible.

2. Verify that all lines between the engine and the lube oil filter and lube oil cooler assemblies are clean and free from scale.

3. Filter must be filled with lubricating oil before first start and after element change. Depress bypass valve plunger inside filter to allow air to escape. Before first startup, vent air thru cover vent while prelube pump is running. A continuous flow of oil from the vent line is required, and indicates that all air has been removed from the system.

4. Refer to *Lube Oil Pressure Adjustment* and adjust the lube oil pressure.

PURGING THE LUBE OIL SYSTEM PIPING

The external lube oil piping must be purged of all dirt, weld spatter and slag. The purging procedure must be performed during the initial oil fill.

1. Remove the four capscrews and washers from the strainer head to detach the element housing (see Figure 4.30-3).

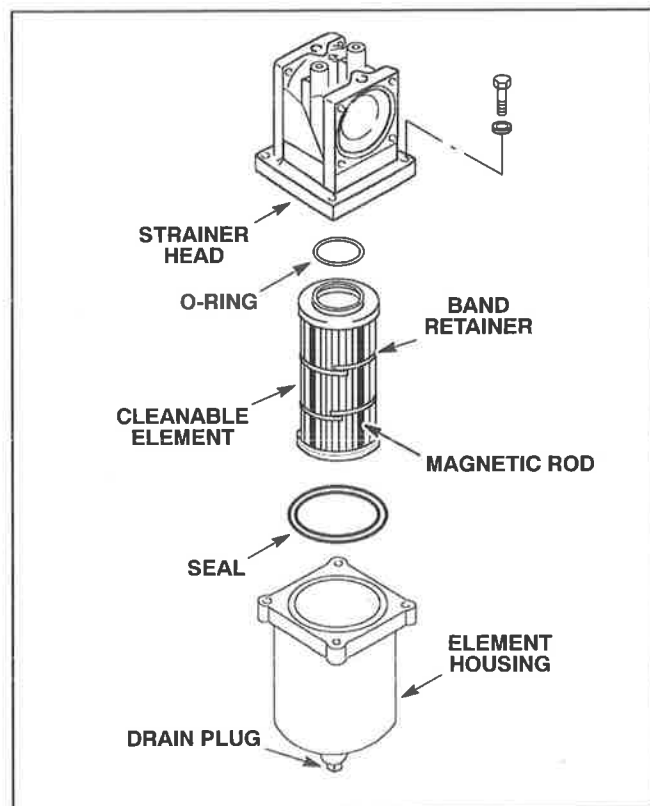


Figure 4.30-3. Lube Oil Strainer Assembly

2. Pull down on the stainless steel wire mesh element to detach it from the head. Install the paper element provided. The paper element has a nominal filter rating of 20 microns.
3. Fill the engine with oil (see *Initial Fill* in this section) and run the prelube pump for a minimum of one hour. During this period, use a ballpeen hammer and lightly tap on all pipe welds to dislodge any internal slag.
4. Remove the paper element from the strainer after the hour has elapsed.
5. Install the second paper element; run the prelube pump for a second hour (minimum).
6. Inspect the second paper element for cleanliness after the second hour has elapsed. Since all slag and debris should have been removed from the piping by the first paper element during the first hour the prelube pump was run, the second element should only be used to verify cleanliness. If the second element is dirty, install a new paper element and repeat the procedure until the element comes out clean.



CAUTION The paper element is only to be used for flushing the lubrication piping during initial startup of new and rebuilt engines. Install the stainless steel element after the purging procedure is completed. Do not run the engine with the paper element in place. The paper element cannot withstand engine operating pressures and will collapse, allowing unfiltered oil to enter the engine.

7. Remove the paper element after verifying cleanliness and discard.
8. Install the stainless steel wire mesh element, and element housing to the strainer head, with O-ring, seal, four capscrews and washers.

CRANKCASE OIL LEVEL CHECKING

Check the crankcase oil level daily before the engine is started. For convenience, a dipstick is located on both the right and left side of the oil pan (see Figure 4.30-1). The blade of the dipstick is marked "low" and "full." Always maintain the oil level at the "full" mark. Both marks on the dipstick are "static lines." The dipstick does not indicate where the level of the oil should be when the engine is running.

When checking the oil level, carefully examine the condition of the oil on the dipstick. Replace the oil any time it appears diluted, thickened by sludge or otherwise deteriorated. The useful life of the oil depends on a number of factors, which include the engine load, temperature, fuel quality, atmospheric dirt, moisture and

the level of maintenance. If oil performance problems arise, consult your oil supplier.

Always pay close attention to engine operating temperatures. If engine jacket water and oil temperatures are maintained according to engine specifications, particularly during periods of light load operation, the problems resulting from condensation of corrosive vapors in the crankcase can be minimized.

When using an engine oil for which there is no previous operating experience, a detailed oil analysis by qualified professionals is strongly recommended. A well monitored maintenance program also should be established for the first year of usage and the performance of the engine should be carefully observed against all external operating conditions. This procedure will help to determine if the selected oil is really suitable for your particular operation.

NOTE: If any questions arise with regard to the foregoing information, do not hesitate to call the WED Product Support or Application Engineering Departments. The engine operator may also wish to refer to Service Bulletin 12-1880V, or latest revision, for more information on lubricating oils.

OIL CHANGE



WARNING

Hot oil can cause severe burns. Allow oil to cool prior to working on lube oil system components. Wear protective equipment and use caution while working on lube oil system components. Failure to follow proper procedures could cause severe personal injury or death.

To change the oil, drain the oil pan and all lube oil system accessories; oil cooler, full-flow oil filter and lube oil strainer. Proceed as follows:

NOTE: Drain oil when warm for best results.

1. Oil pan: remove the 2 inch square head drain plug. For convenience, four drain plugs are provided, one at each corner of the oil pan. retain an oil sample for oil analysis. Install the drain plugs when the oil has drained.

NOTE: Installation of a customer-supplied ball valve and pump facilitates draining of the oil pan.

2. Oil Cooler: remove the drain plug at the bottom of the oil cooler shell midway between the inlet and rear bonnets. Install the drain plug when the oil has drained.

LUBRICATION SYSTEM MAINTENANCE

3. Full-Flow Lube Oil Filter: remove the upper drain plug from the oil filter housing to drain sludge and dirty oil from the filter element chamber. Remove the lower plug to drain oil from the clean oil chamber (see Figure 4.30-11). Install the drain plugs when the oil has drained.

4. Lube Oil Strainer: remove the drain plug (3/8 inch) at the bottom of the strainer element housing (see Figure 4.30-3). Install the drain plug when the oil has drained.

5. When the oil has drained, insure all the drain plugs are reinstalled.

6. Refer to *Oil Pan Maintenance*, and clean the oil pan.

CAUTION Filter must be filled with lubricating oil before first start and after each element change. Disregarding this information could result in product damage.

7. Refer to *Oil Filter Maintenance*, and replace the oil filter elements and fill the oil filter assembly with oil (see Table 4.30-1 and Table 4.30-2).

8. Refer to *Initial Fill Procedures*, and fill the engine with oil (see Table 4.30-1 and Table 4.30-2).

9. Refer to *Lube Oil System Air Bleed*, and bleed trapped air from the lube oil system.

OIL PAN MAINTENANCE

NOTE: Since it is necessary to drain the oil pan and lube oil system accessories, schedule the cleaning during a regular oil change interval.

NOTE: Drain oil when warm.

1. Drain the oil pan, oil cooler, full-flow oil filter and lube oil strainer (see *Oil Change* for more information).

2. Loosen the oil pan door clamp capscrews (see Figure 4.30-4 and Figure 4.30-5). Rotate the assembly about 45 degrees to remove the door from the access hole.

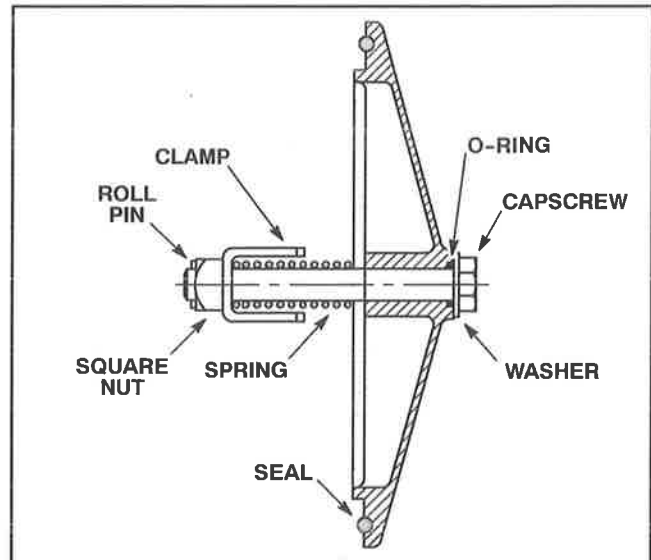


Figure 4.30-4. Oil Pan Door - Previous Production

Table 4.30-2. Oil Recommendations By Model And Fuel

MODEL/FUEL	OIL REQUIREMENTS
VHP 2895, 3521, 5108, 5790, 7042, 9390 G, GSI, (Rich Burn or Lambda 1) Naturally Aspirated and Turbocharged/ Natural Gas/HD-5 Propane ^{1 2 3 4}	NATURAL GAS - 0.35% ash minimum, oil specifically formulated for gas engines, using highly refined mineral oil base stocks, with a minimum of 0.35% sulfated ash by weight with both metallic and ashless additive systems. A maximum of 0.10% zinc is recommended.
VHP 2895, 5108, 5790 GL Turbocharged and Lean Burn (Lambda 1.5 - 2)/Natural Gas/HD-5 Propane ^{1 2 3 4}	NATURAL GAS - 0.35% ash minimum, oil specifically formulated for gas engines, using highly refined mineral oil base stocks, with a minimum of 0.35% sulfated ash by weight with both metallic and ashless additive systems. A maximum of 0.10% zinc is recommended.
VHP 3521, 5115, 7042, 9390 GL Turbocharged and Lean Burn (Lambda 1.5 - 2)/Natural Gas/HD-5 Propane ^{1 2 3 4}	NATURAL GAS - Oil with a <i>nominal</i> 1% sulfated ash by weight. This gas engine oil must use highly refined mineral oil base with a minimum of 0.9% and a maximum of 1.7% sulfated ash by weight with both metallic and ashless additive systems. A maximum of 0.10% zinc is recommended.

NOTE: ¹ See Table 4.30-11 and Table 4.30-12 for change intervals.

² See Table 4.30-8 for condemning limits.

³ Oil with 0.35% ash or less may be used in naturally aspirated and catalyst equipped naturally aspirated or turbocharged engines with the understanding that valve recession may occur, thus shortening the normally expected valve and seat life.

⁴ The quality of oil filtration will directly affect engine component life. Waukesha's basic filtration requirement is 90% efficient at 15 microns for all full flow elements, and 98% efficient at 25 microns for cleanable metal mesh elements. Waukesha's complete oil filter performance specification is shown in Waukesha specification sheets S08486 and S08486-1.

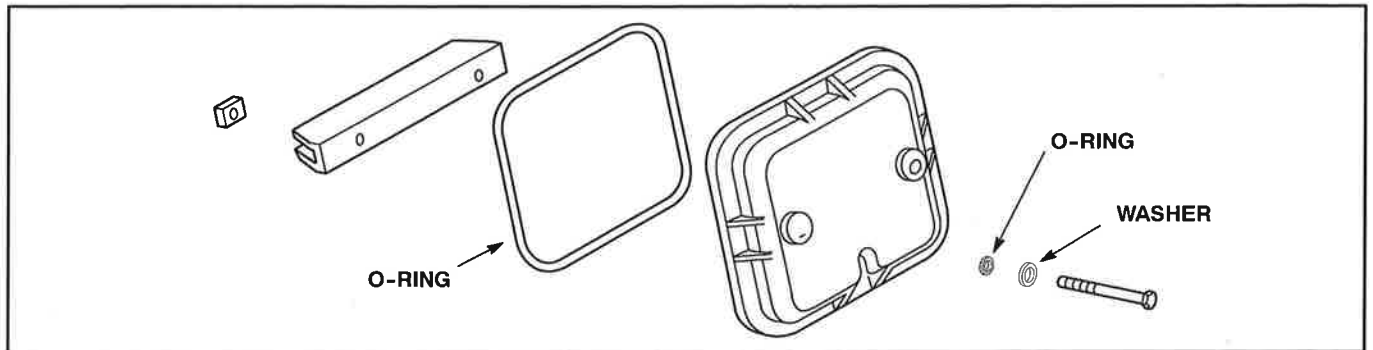


Figure 4.30-5. Oil Pan Door Assembly - Current Production

3. A small pool of oil about 3/4 inch deep will normally accumulate on each end of the oil pan where the casting is recessed. Only a thin film will cover the other internal surfaces. Using absorbant cloths, wipe the oil pan clean. Thoroughly clean the channel that connects the two recessed areas.

4. Clean the oil pickup screen (see *Oil Pickup Screen Maintenance*).

5. Install the oil pan doors. Hold each door so that the rear clamp is 45 degrees from the vertical position. Insert the clamp into the oil pan access hole. Holding the door against the face of the access hole, rotate the door until the clamp is in the horizontal position. Tighten the door clamp capscrew.

6. Refer to *Oil Change* and refill the engine with the proper quantity and grade of lubrication oil (see Table 4.30-1 and Table 4.30-2).

OIL PICKUP SCREEN MAINTENANCE

Oil Pickup Screen Removal - 6 Cylinder

1. Remove the four capscrews and lock washers to detach the pickup screen assembly from the oil elbow and cover bracket (see Figure 4.30-6).

2. Remove the pickup screen assembly from the oil pan.

3. Remove the baffle and oil tubes from the pickup screen.

4. Scrape the old gasket material from the oil tube flanges and baffle box. Old gasket material left on the mating surfaces may cause air or unfiltered oil to leak into the oil tubes.

5. Remove two capscrews, lock washers, gasket and oil elbow from the crankcase.

6. Remove two capscrews, lock washers and cover bracket from the crankcase.

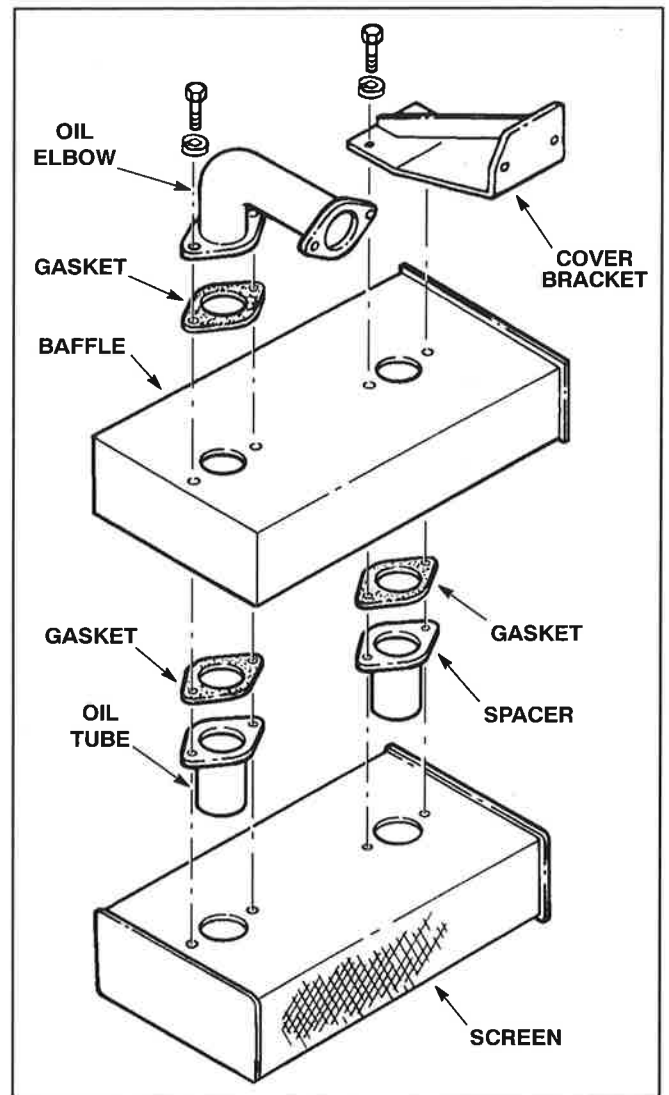


Figure 4.30-6. Oil Pickup Screen Assembly - 6 Cylinder

LUBRICATION SYSTEM MAINTENANCE

Oil Pickup Screen Cleaning And Inspection - 6 Cylinder

1. Clean all parts of the assembly in a non-volatile cleaning solution or solvent. Flush the screen from the inside out for best results.

WARNING

Compressed air can pierce the skin and cause severe injury. Never use your hand to check for leaks or to determine air flow rates. Wear safety glasses to shield your eyes from flying dirt and debris. Disregarding this information could result in severe personal injury or death.

2. Thoroughly dry all parts with low pressure compressed air.
3. Inspect the pickup screen for tears or holes. Replace the screen if damaged.
4. Inspect the baffle box for broken welds, split seams or cracks around the oil tube holes. Replace the baffle if damaged.

Oil Pickup Screen Installation - 6 Cylinder

1. Loosely install the cover bracket in the crankcase with two capscrews and lock washers.
2. Loosely install the oil elbow in the crankcase with gasket two capscrews and lock washers.
3. Apply a fast setting gasket adhesive, such as 3M Scotch-Grip™ Rubber And Gasket Adhesive, on the oil tube flanges. Position new gaskets on the flanges.
4. Scrape the old gasket material from the oil tube flanges and baffle box. Old gasket material left on the mating surfaces may cause air or unfiltered oil to leak into the oil tubes.
5. Install the oil tubes in the screening element. Place the baffle over the screen aligning the holes with those in the flange gaskets.
6. Obtain a new gasket for the elbow and apply gasket adhesive to one side. Press the sticky side of the gasket onto the baffle aligning the holes with those in the box.
7. To ensure proper alignment, install the four capscrews and lock washers to hold the pickup screen assembly together. After the unit is positioned in the oil pan, remove one capscrew. Slide the capscrew through the elbow or cover bracket and thread it back into the pickup screen assembly. Follow this procedure with the remaining three capscrews. Wrench tighten only after all capscrews are in place.

8. Tighten the four capscrews to secure the oil elbow and cover bracket to the crankcase.

Oil Pickup Screen Removal - 12 Cylinder

NOTE: 5115GL procedures are listed separately.

1. Remove the four capscrews and lock washers to detach the pickup screen assembly from the two oil elbows (see Figure 4.30-7).

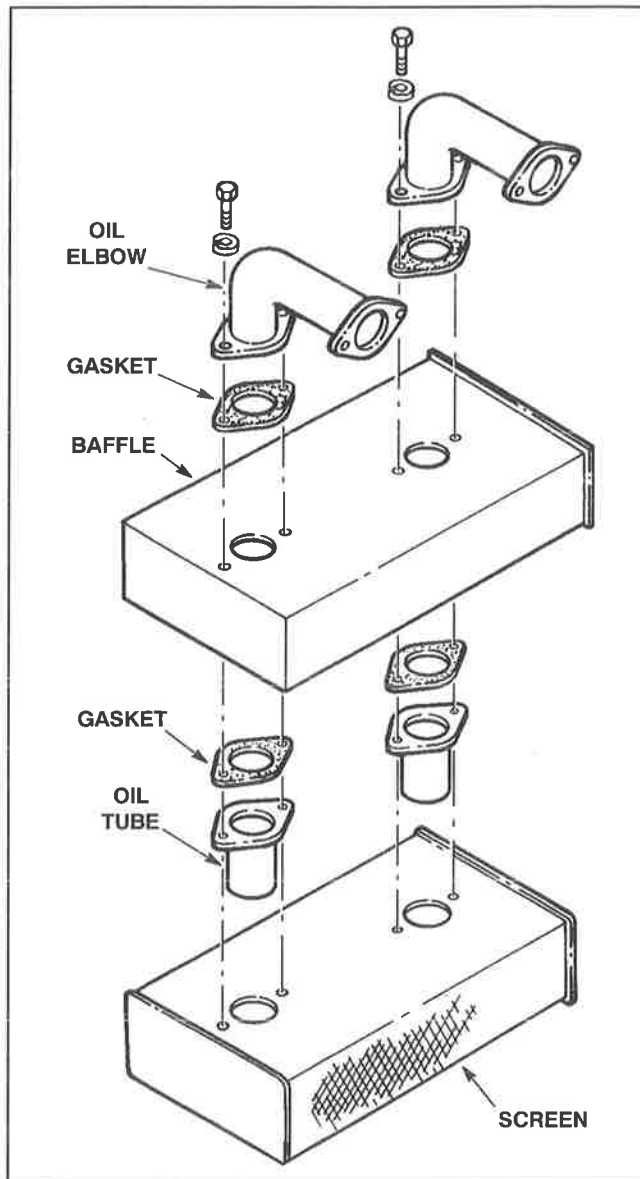


Figure 4.30-7. Oil Pickup Screen Assembly - 12 Cylinder

2. Remove the pickup screen assembly from the oil pan.
3. Remove the baffle and oil tubes from the pickup screen.

4. Scrape the old gasket material from the oil tube flanges and baffle box. Old gasket material left on the mating surfaces may cause air or unfiltered oil to leak into the oil tubes.

Oil Pickup Screen Cleaning And Inspection - 12 Cylinder

1. Clean all parts of the assembly in a non-volatile cleaning solution or solvent. Flush the screen from the inside out for best results.

WARNING

Compressed air can pierce the skin and cause severe injury. Never use your hand to check for leaks or to determine air flow rates. Wear safety glasses to shield your eyes from flying dirt and debris. Disregarding this information could result in severe personal injury or death.

2. Thoroughly dry all parts with low pressure compressed air.

3. Inspect the pickup screen for tears or holes. Replace the screen if damaged.

4. Inspect the baffle box for broken welds, split seams or cracks around the oil tube holes. Replace the baffle if damaged.

Oil Pickup Screen Installation - 12 Cylinder

1. Apply a fast setting gasket adhesive, such as 3M Scotch-Grip™ Rubber And Gasket Adhesive, on the oil tube flanges. Position new gaskets on the flanges.

2. Scrape the old gasket material from the oil tube flanges and baffle box. Old gasket material left on the mating surfaces may cause air or unfiltered oil to leak into the oil tubes.

3. Install the oil tubes in the screening element. Place the baffle over the screen aligning the holes with those in the flange gaskets.

4. Obtain two new gaskets for the elbows and apply gasket adhesive to one side. Press the sticky side of the gasket onto the baffle aligning holes with those in box.

5. Verify that the two elbow flanges are clean. Old gasket material or adhesive left on the mating surfaces may cause air or unfiltered oil to leak into the elbows.

6. To ensure proper alignment, install the four capscrews and lock washers to hold the pickup screen assembly together. After the unit is positioned in the oil pan, remove one capscrew. Slide the capscrew through the elbow and thread it back into the pickup screen assembly. Follow this procedure with the remaining three capscrews. Wrench tighten only after all capscrews are in place.

Oil Pickup Screen Removal - 5115

1. Remove the two nylok capscrews and washers to detach the pickup screen assembly from oil pan floor (see Figure 4.30-8).

2. Moving the pickup screen slightly from side to side while pulling back on the pickup screen assembly, pull the oil outlet tube and the pickup screen assembly. This should allow the pickup screen assembly to be removed from the oil pump suction manifold on the front of the oil pan.

3. With the pickup screen assembly still loose in the oil pan, remove four nylok capscrews, washers and the outlet tube from the pickup screen assembly.

4. Remove the pickup screen assembly and the oil outlet tube from the oil pan.

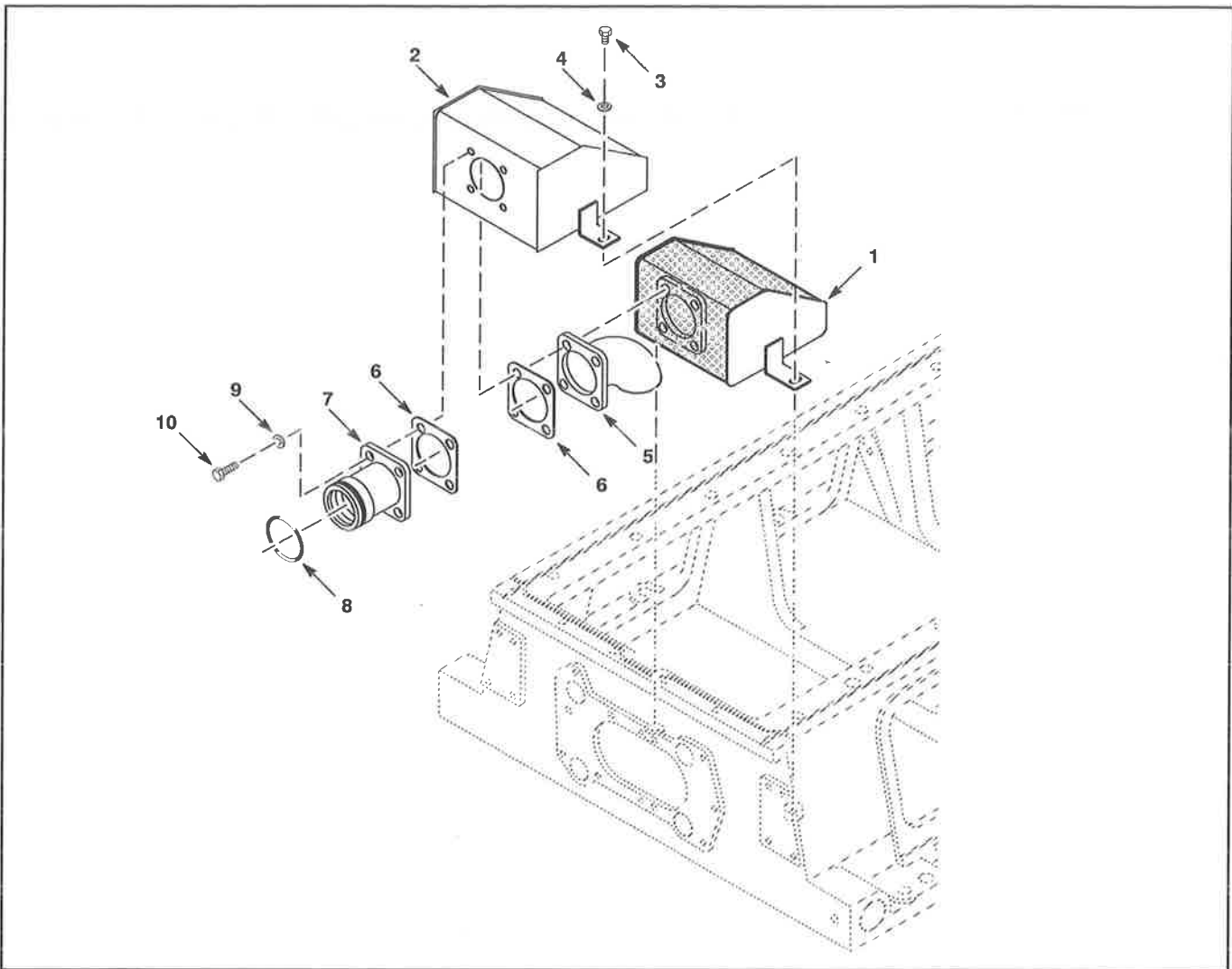
5. Remove the tube assembly from inside the pickup screen assembly.

6. Remove the screen from the baffle.

7. Scrape the old gasket material from the oil tube flanges and baffle box. Old gasket material left on the mating surfaces may cause air or unfiltered oil to leak into the oil tubes.

8. Remove and discard the O-ring from the oil outlet tube.

LUBRICATION SYSTEM MAINTENANCE



ITEM NUMBER AND DESCRIPTION

1	Oil Screen Asm.	4	Flat Washer	7	Outlet Tube Asm.	10	Nylok Capscrew
2	Oil Screen Baffle	5	Tube Asm.	8	O-ring		
3	Nylok Capscrew	6	Lube System Gasket	9	Flat Washer		

Figure 4.30-8. Oil Pickup Screen Assembly - 5115

Oil Pickup Screen Cleaning And Inspection - 5115

1. Clean all parts of the assembly in a non-volatile cleaning solution or solvent. Flush the screen from the inside out for best results.

2. Thoroughly dry all parts with low pressure compressed air.

3. Inspect the pickup screen for tears or holes. Replace the screen if damaged.

4. Inspect the baffle box for broken welds, split seams or cracks around the oil tube holes. Replace the baffle if damaged.

⚠ WARNING

Compressed air can pierce the skin and cause severe injury. Never use your hand to check for leaks or to determine air flow rates. Wear safety glasses to shield your eyes from flying dirt and debris. Disregarding this information could result in severe personal injury or death.

Oil Pickup Screen Installation - 5115

1. Apply a fast setting gasket adhesive, such as 3M Scotch-Grip™ Rubber And Gasket Adhesive, on the oil tube flanges. Position new gaskets on the flanges.
2. Scrape the old gasket material from the oil tube flanges and baffle box. Old gasket material left on the mating surfaces may cause air or unfiltered oil to leak into the oil tubes.
3. Obtain two new gaskets and apply gasket adhesive to one side. Press the sticky side of the gaskets on the inside and outside of the baffle, aligning the holes with those in the box.
4. Install a new O-ring on the oil outlet tube.
5. Install the oil tube in the screening element. Place the baffle over the screen aligning the holes with those in the flange gaskets.
6. Position the screen assembly in the oil pan.
7. Install the the oil outlet tube on the screen assembly with four nylok capscrews and washers.
8. Moving the pickup screen slightly from side to side while pushing forward on the pickup screen assembly, install the oil pickup assembly in the oil pump suction manifold on the front of the oil pan.

CAUTION Insure the oil outlet tube is completely seated in the oil pump suction manifold or damage to equipment could result.

9. Secure the pickup screen assembly to the oil pan with two nylok capscrews and washers. If the holes will not line up, it is an indication that the oil outlet tube is not completely seated in the oil pump suction manifold on the front of the oil pan.

Oil Pickup Screen Removal - 16 Cylinder

1. Remove two capscrews and washers to detach the baffle and screen flanges from the oil pan floor (see Figure 4.30-9).
2. Remove the two ferry head capscrews and lockwashers from the elbow outlet flange.
3. Clip and remove the lockwire from the two ferry head capscrews on the elbow inlet flange (see Figure 4.30-10). Loosen the capscrews and remove the pickup screen assembly from the oil pan.
4. Remove the elbow, tube and and baffle from the pickup screen. remove and discard all gaskets. Scrape off any old gasket material left on the mating surfaces, if necessary.

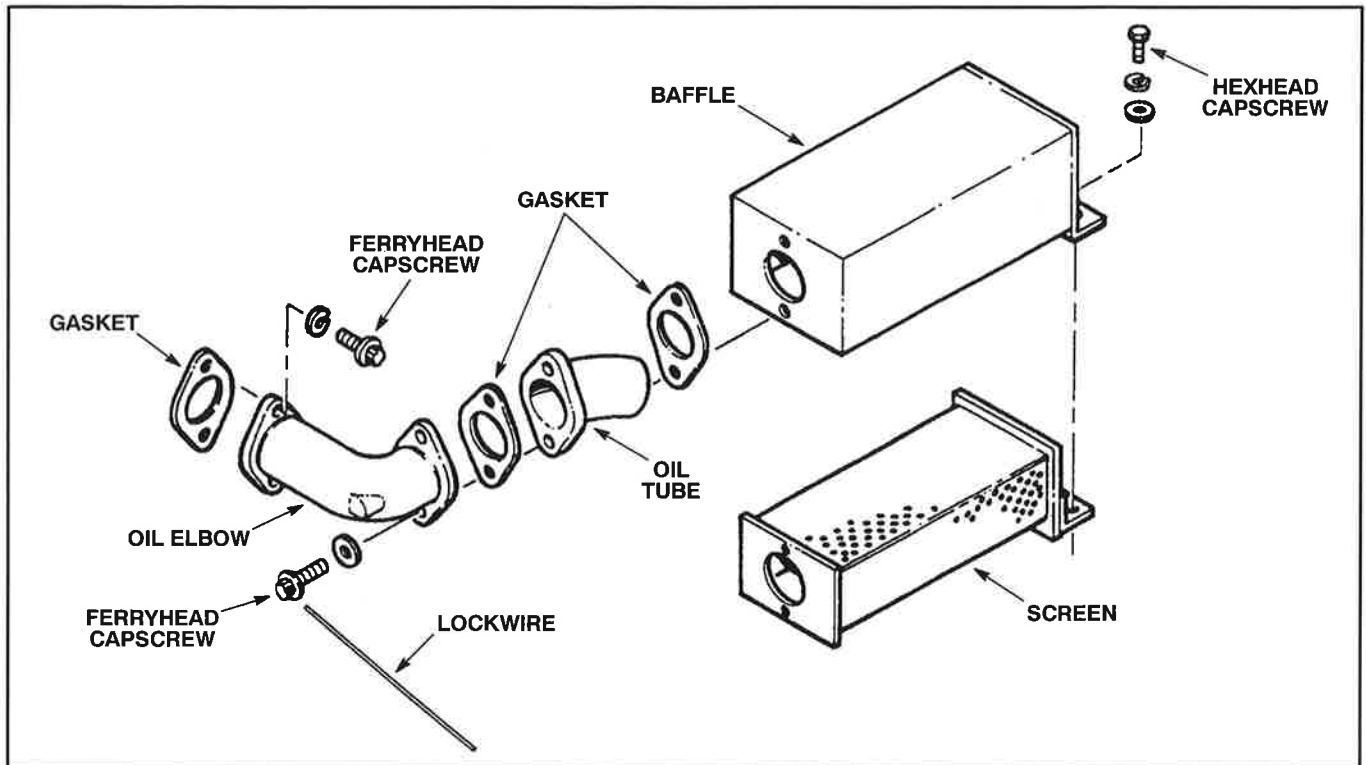


Figure 4.30-9. Oil Pickup Screen Assembly - 16 Cylinder

LUBRICATION SYSTEM MAINTENANCE

Oil Pickup Screen Cleaning And Inspection - 16 Cylinder

1. Clean all parts of the assembly in a non-volatile cleaning solution or solvent. Flush the screen from the inside out for best results.

WARNING

Compressed air can pierce the skin and cause severe injury. Never use your hand to check for leaks or to determine air flow rates. Wear safety glasses to shield your eyes from flying dirt and debris. Disregarding this information could result in severe personal injury or death.

2. Thoroughly dry all parts with low pressure compressed air.

3. Inspect the pickup screen for tears or holes. Replace the screen if damaged.

4. Inspect the baffle box for broken welds, split seams or cracks around the oil tube holes. Replace the baffle if damaged.

Oil Pickup Screen Installation - 16 Cylinder

1. Install a new gasket on the inlet side of the oil tube flange. Position the baffle over the screen and insert the tube.

2. Position a new gasket on the elbow inlet flange. Install the two ferry head capscrews and washers to hold all parts of the assembly together. Use the two screws with the head holes (see Figure 4.30-9) and finger tighten only.

3. Position the assembly in the oil pan. Position a new gasket on the elbow outlet flange and install the oil outlet flange on the side of the oil pan with with two ferry head capscrews and lockwashers.

4. Install the pickup screen to the oil pan floor with two capscrews and lock washers.

5. Wrench tighten the elbow inlet flange capscrews. Slide a new lockwire through the hole in the heads of the capscrews (see Figure 4.30-10). Twist the ends of the wire together until taut.

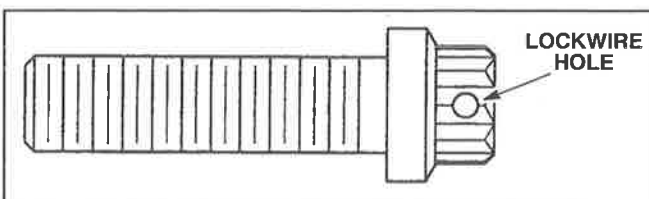


Figure 4.30-10. Ferry Head Capscrew - 16 Cylinder

OIL COOLER MAINTENANCE

Drain the oil from the oil cooler at each oil change.

Clean and inspect the oil cooler annually. Inspect the oil cooler sooner if an increase in oil temperature cannot be traced to a malfunctioning auxiliary water pump, loose belts, a faulty thermostat or excessive engine load. Plugged tubes or scale deposits inhibit the flow of coolant which reduces oil cooling effectiveness.

NOTE: Schedule the oil cooler cleaning during a regular oil change interval, since it is necessary to drain the oil pan and lube oil system accessories.

LUBE OIL SYSTEM AIR BLEED

Air bleed the lube oil system at least once each day. Proceed as follows:

NOTE: The petcock on the full-flow oil filter cover is the only air bleed through which the lube oil system may be purged of air pockets.

1. **Initial Bleed:** start the prelube pump and open the filter cover petcock.

2. Close the petcock when oil begins to flow out in a steady stream.

3. **Check Bleed:** start the engine and reopen the filter cover petcock.

4. Close the petcock when oil begins to flow out in a steady stream.

5. **Final Bleed:** once the engine is running at normal operating temperature, reopen the filter cover petcock.

6. Close the petcock when oil begins to flow out in a steady stream.

LUBE OIL FILTER MAINTENANCE

Lube Oil Filter Element Replacement

Full-flow lube oil filter elements should be replaced whenever the lube oil is changed and may often require more frequent replacement.

When the filter is new, the drop in oil pressure through the filter is around 2 - 3 psi (14 - 21 kPa) under normal operating temperatures. To determine the pressure differential, subtract the reading of the oil filter outlet pressure gauge from the reading of the inlet pressure gauge. When the pressure differential rises to 12 - 15 psi (83 - 103 kPa), the filter elements are clogged and must be replaced.

NOTE: If oil filter inlet and outlet pressure gauges are not provided, they may be ordered from this manufacturer.

1. Drain both chambers of the full-flow oil filter. Two drain plugs are provided in the oil filter housing (see Figure 4.30-11). Remove the upper plug to drain sludge and dirty oil from the filter element chamber. Remove the lower plug to drain oil from the clean oil chamber.

WARNING

The cover compresses powerful springs on the filter element posts. Use special care to remove the oil filter cover, to avoid severe personal injury or death.

NOTE: Based on environmental and engine operating conditions, the lubrication oil may require changes that are much more frequent than those recommended by this manufacturer. Many variables are involved in determining the proper time between oil changes, some of which may not even be known until after a problem develops. The oil type, the severity of the environment and the internal condition of the engine are only a few of many variables that have a direct effect on the frequency at which the oil must be changed.

2. To remove the oil filter cover safely, locate the longest bolts. The long bolts extend about 1-1/4 inches below the flange at the top of the oil filter housing. The short bolts are flush with the bottom of the flange (see Table 4.30-3).

Table 4.30-3. Oil Filter Capscrew Pattern

Engine	Oil Filter Shell ID	Number Of Short Bolts	Number Of Long Bolts	Distance Between Long Bolts
6 Cylinder	12"	6	2	180°
12 Cylinder	16"	9	3	120°
16 Cylinder	18"			

3. Leaving the longest bolts in place, remove the short bolts working in a clockwise direction.

WARNING

Alternately loosen the long bolts of the filter cover an equal amount of turn. Failure to follow this procedure could cause the filter cover to spring up, causing severe personal injury or death.

4. Loosen the long bolts giving each an equal amount of turn. Alternately loosen each of the long bolts to slowly ease the filter cover up. See Figure 4.30-11.

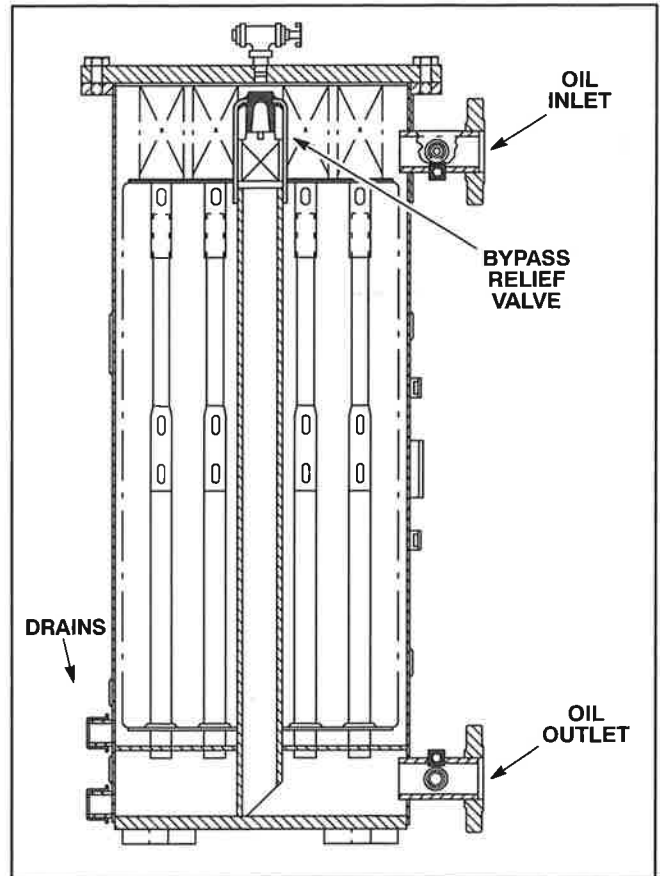


Figure 4.30-11. Lube Oil Filter

LUBRICATION SYSTEM MAINTENANCE

5. Remove the lube oil filter elements (see Figure 4.30-12). Inspect the bypass relief valve for wear. The oil filter has one relief valve. Refer to *Lube Oil Filter Relief Valve Inspection* for more information.

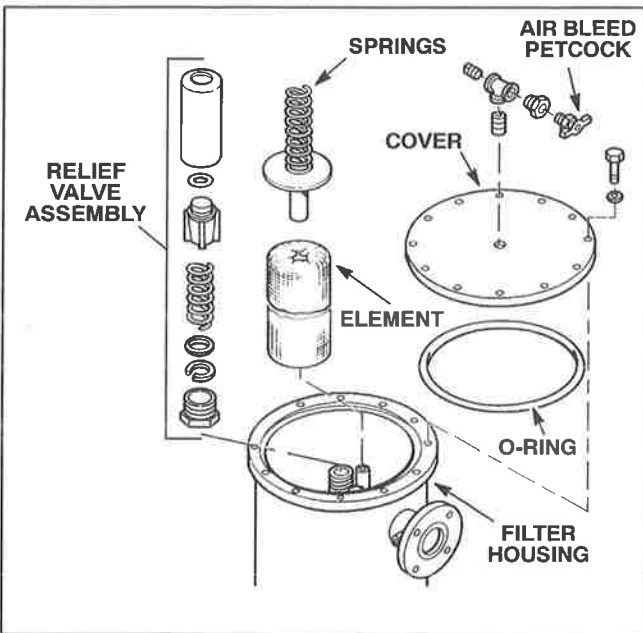


Figure 4.30-12. Full-Flow Lube Oil Filter

6. Install the new lube oil filter elements (see Table 4.30-4). Slide one 32 inch element over each filter element post (see Figure 4.30-13, Figure 4.30-14, and Figure 4.30-15).

Table 4.30-4. Engine Filter Elements

ENGINE	FILTER ELEMENT POSTS	32 INCH ELEMENTS REQUIRED	16 INCH ELEMENTS REQUIRED
6 Cylinder	4	4	8
12 Cylinder	7	7	14
16 Cylinder	10	10	20

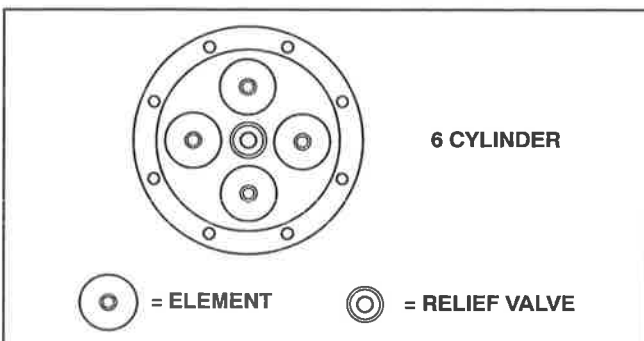


Figure 4.30-13. Filter Element/Relief Valve Configuration - 6 Cylinder

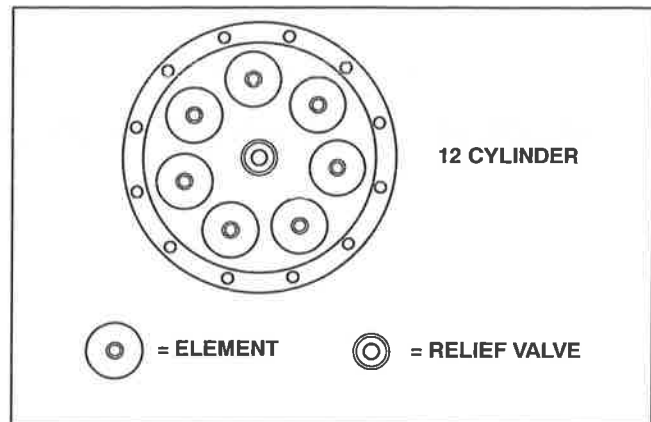


Figure 4.30-14. Filter Element/Relief Valve Configuration - 12 Cylinder

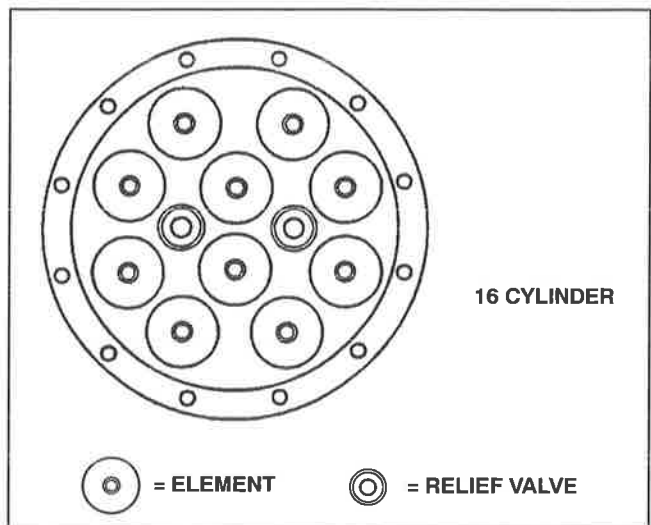


Figure 4.30-15. Filter Element/Relief Valve Configuration - 16 Cylinder

CAUTION Those filter elements that are stamped with an arrow must be installed with the arrow pointing down. Elements that have a band around the center may be installed with either end pointing down. Disregarding this information could result in product damage.

7. Replace the drain plugs in the oil filter housing.
8. Fill the filter assembly with clean lubricating oil, see Table 4.30-1 for capacities.
9. Allow air to escape by depressing the bypass relief valve piston(s).

10. Reinstall the lube oil filter cover. The filter cover O-ring should be replaced every 1500 hours, any time it has taken a permanent set or if it appears damaged, whichever comes first. Torque the filter cover capscrews to 35 - 37 ft-lb (47 - 50 N-m) in a crisscross pattern.

11. To release the remaining air, start the prelube pump and open the filter cover petcock. Close the petcock when oil flows out in a steady stream.

NOTE: Air bleed the lube oil circuit at least once each day. The petcock on the full-flow oil filter cover is the only location through which the lube oil system may be purged of air pockets (see Lube Oil Filter Air Bleed in this section for more information).

NOTE: Waukesha highly recommends adding a bypass filtration system to the standard full-flow lube oil filter, especially for those engines operating in harsh environments. In operation, a small portion of the lube oil is routed from the pump through special bypass filters and then back to the oil sump. Particles as small as one micron are effectively removed as the oil flows through the bypass filter elements. An orifice in the filter housing inlet controls the flow to approximately 10 percent of the rated flow to the engine. In an hour, this operation filters a quantity of oil equal to roughly five times the system capacity. Use of the bypass filtration unit does not alter the recommended oil change interval, since the filter is designed to reduce engine wear, not prolong lube oil life.

LUBE OIL FILTER RELIEF VALVE INSPECTION

The full-flow lube oil filter housing contains a bypass relief valve.

When the elements are new, the drop in oil pressure through the filter is minimal, around 2 - 3 psi (14 - 21 kPa) under normal operating temperatures. If the pressure differential reaches 28 - 32 psi (193 - 221 kPa), the relief valve begins to open and oil bypasses the filter elements enroute to the lube oil strainer. The relief valve is fully open at approximately 40 psi (276 kPa).

Inspect the relief valve(s) for wear at least once each year or after every 8,000 hours of operation, whichever comes first.

1. Remove the relief valve assembly from the bypass tube (see Figure 4.30-12).
2. Remove the reducing bushing from the relief valve body, if provided.
3. Remove the retaining ring, washer, spring and piston from the relief valve body (see Figure 4.30-16).

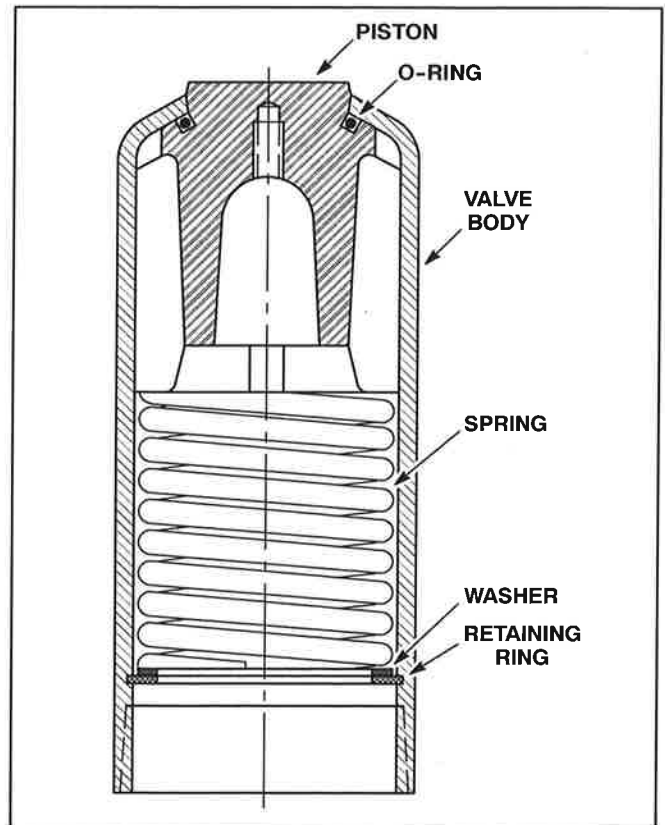


Figure 4.30-16. Lube Oil Filter Relief Valve Assembly

4. Remove the O-ring from the relief valve piston. Inspect the area above the O-ring for excessive wear. Replace if gouged or deeply scratched.
5. Install a new O-ring on the relief valve piston.
6. Install the piston, spring, washer and retaining ring in the relief valve body.
7. Install reducing bushing on the relief valve body.
8. Install the relief valve assembly on the bypass tube.

LUBRICATION SYSTEM MAINTENANCE

LUBE OIL STRAINER MAINTENANCE

Clean the lube oil strainer element at each oil change.

1. Remove the plug (3/8 inch) at the bottom of the element housing to drain the strainer assembly of oil (see Figure 4.30-17).

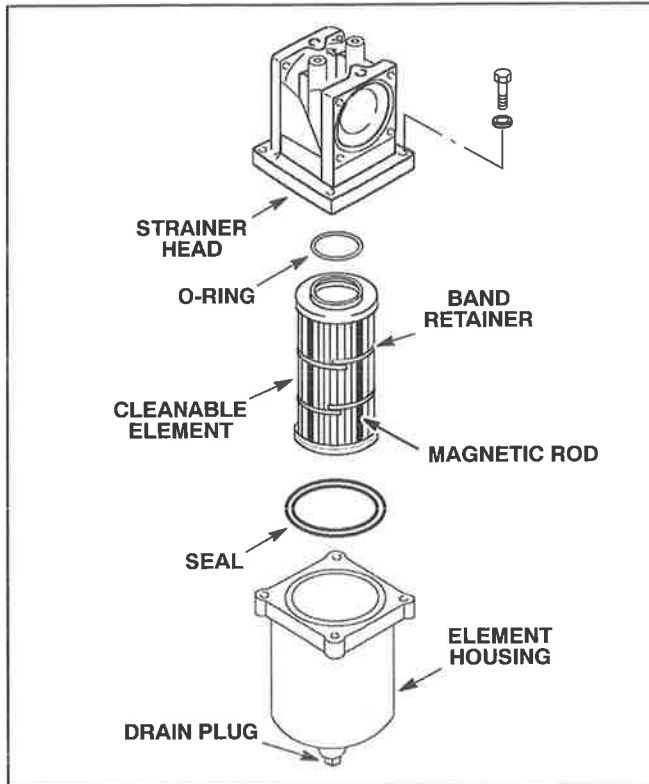


Figure 4.30-17. Lube Oil Strainer Assembly

2. Remove the four capscrews and washers from the strainer head to detach the element housing.

3. Remove the rubber seal from the inside groove at the top of the element housing.

4. Pull down on the stainless steel wire mesh element to detach it from the head.

5. Remove the two band retainers and the two magnetic rods externally mounted on the element.

6. Clean the element in solvent. Flushing the element from the inside out produces the best results.

CAUTION High pressure compressed air may damage the strainer element.

7. Drip dry the element or air blow dry from the inside out using low pressure compressed air.

8. Inspect the element for tears or holes. Replace the element if damaged.

9. Inspect the strainer element O-ring for cuts, tears or loss of elasticity. Replace if necessary. Place the O-ring in the inside groove at the top of the wire mesh element. Using a small paintbrush, lubricate the O-ring with clean engine oil.

10. Place the two magnetic rods in the element grooves and install the two band retainers.

11. Slide the element up onto the inside flange of the strainer head.

12. Inspect the element housing seal for cuts, tears or loss of elasticity. Replace if necessary. Place the seal inside the groove at the top of the element housing. Lubricate the O-ring with clean engine oil.

13. Install the drain plug (3/8 inch) in the bottom of the element housing.

14. Install the four capscrews and washers to secure the element housing to the strainer head.

CAUTION Special paper elements are required for initial startup of new and rebuilt engines. Disregarding this information could result in product damage.

NOTE: See Purging The Lube Oil System Piping for instructions.

MAGNETIC PLUG MAINTENANCE

Inspect and clean the magnetic plugs at each oil change. Proceed as follows:

1. Remove the magnetic plugs (see Figure 4.30-18). The number of magnetic plugs and their locations are as follows (see Table 4.30-5).

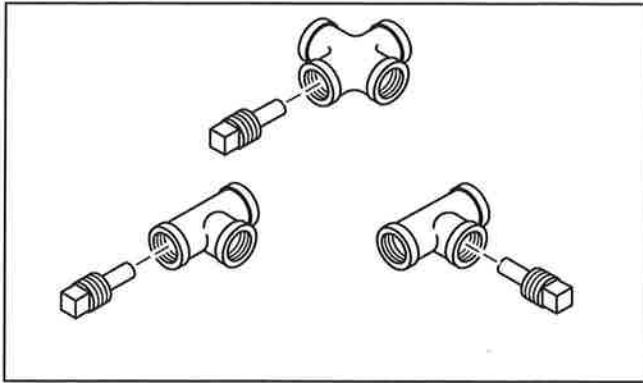


Figure 4.30-18. Magnetic Plugs

Table 4.30-5. Magnetic Plug Locations

ENGINE	PLUGS	SPECIFIC ENGINE LOCATION	
6 Cyl	1	Rocker arm oil header supply line	front left
	1	Turbocharger oil supply line	rear left
12 Cyl	1	Rocker arm oil header supply line	front vee
	1	Rocker arm oil header supply line	rear vee
	1	Turbocharger oil supply line	rear right
16 Cyl	1	Rocker arm oil header supply line	front vee
	1	Turbocharger oil supply line	center vee

2. Clean the magnetic plugs in solvent, if necessary. Wipe the plugs clean to ensure that all ferrous metal debris is removed.

3. Apply Perma Lok® Heavy Duty Pipe Sealant with Teflon® to the threads, and install the magnetic plugs into their locations and wrench tighten.

IN-LINE LUBRICATOR

Refer to Section 4.45, *In-line Lubricator* for information on this component.

LUBE OIL PRESSURE ADJUSTMENT

1. Run the engine until the lube oil reaches normal stabilized operating temperature. Take note of the oil header pressure as indicated by the panel mounted oil pressure gauge.
2. Locate the pressure regulating valve at the oil cooler outlet (see Figure 4.30-19). Loosen and back off the jam nut (1/2 inch) on the adjusting screw.
3. Adjust the pressure regulating valve to maintain an oil header pressure of 55 psi (380 kPa) for 6 and 12 cylinder engines, and 50 psi (345 kPa) for 16 cylinder engines, with the lube oil pressure stabilized at normal operating temperature of 180° F (82° C), and the engine fully loaded. Turn the adjusting screw in to increase the oil pressure. To decrease the oil pressure, turn the adjusting screw out.
4. Tighten the jam nut (1/2 inch) to lock the setting of the adjusting screw.

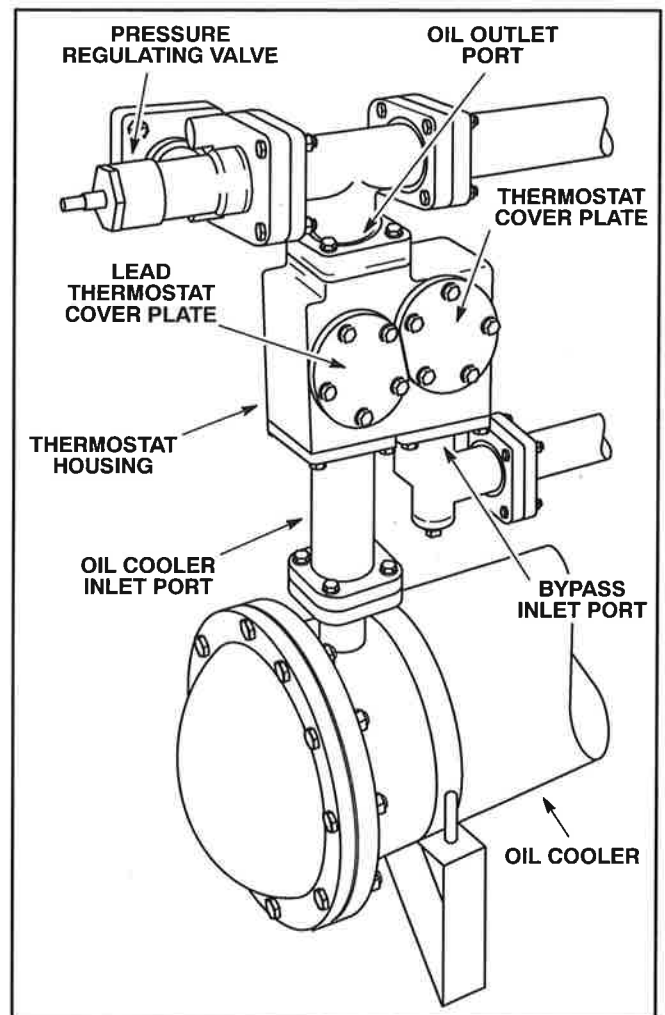


Figure 4.30-19. Lube Oil Temperature Control Valve

LUBRICATION SYSTEM MAINTENANCE

PRELUBE Y-STRAINER MAINTENANCE

Clean the Y-strainer screen at each oil change (see Figure 4.30-20). Proceed as follows:

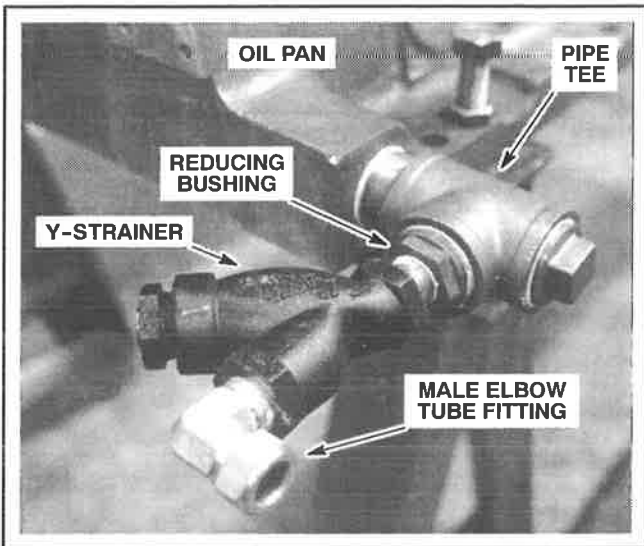


Figure 4.30-20. Y-Strainer - 12 Cylinder

1. Drain the oil pan and all lube oil system accessories, oil cooler, full-flow oil filter and lube oil strainer.
2. Locate the Y-strainer in the oil pan to prelube pump oil line.
3. Remove the plug from the Y-strainer (see Figure 4.30-21).

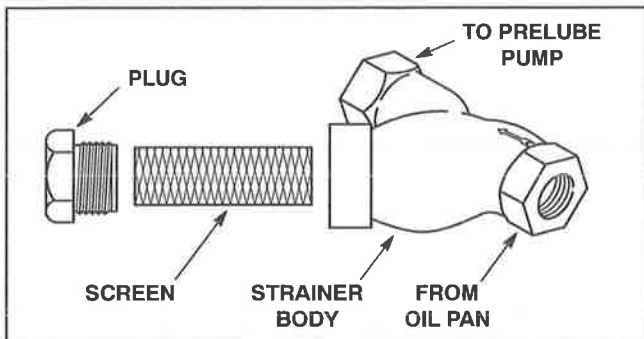


Figure 4.30-21. Prelube Y-Strainer

4. Pull out the cylindrical steel mesh screen.
5. Flush the screening element in a non-volatile cleaning solution or solvent.

⚠ WARNING

Compressed air can pierce the skin and cause severe personal injury or death. Never use your hand to check for leaks or to determine air flow rates. Wear safety glasses to shield your eyes from flying dirt and debris. Disregarding this information could result in severe personal injury or death.

⚠ CAUTION High pressure compressed air may damage the screening element. Disregarding this information could result in product damage and/or personal injury.

6. Drip dry the screen or use low pressure compressed air.
7. Inspect the screen for tears or holes. Replace if damaged.
8. Slide the screen back into the Y-strainer.
9. Apply Perma Loc[®] heavy duty pipe sealant or the equivalent onto the male threads of the plug and the female threads of the Y-strainer body.
10. Thread the plug into the Y-strainer and wrench tighten.

MICROSPIN™ MAINTENANCE

Initial centrifuge servicing should be about four weeks after startup, sooner if the oil is heavily contaminated. A maximum buildup of 0.75 in. (19.05 mm) is allowed on the centrifuge paper insert. Noting the buildup, will help in establishing a cleaning interval.

Centrifuge

⚠ WARNING

Solvents may be flammable and give off dangerous fumes. Read and follow the manufacture's recommendations to avoid severe personal injury or death.

Under normal operating conditions, the centrifuge should be cleaned and its paper insert removed, at every scheduled oil change, or as experience dictates. The centrifuge can be cleaned while the engine remains running provided the oil supply valve is shut off (see *Disassembly* for proper procedures).

Cleanable Filter Elements

The cleanable oil elements (see Figure 4.30-22), should be removed from the oil filtration canister, and cleaned in a solvent tank at every other regularly scheduled oil change, or when the oil pressure differential between the canister inlet and outlet, exceeds 15 psi (103 kPa). If an oil pressure differential of 2 - 15 psi (14 - 103 kPa), cannot be obtained after normal cleaning, the cleanable filter elements may be ultrasonically cleaned. It is recommended that an oil pressure gauge be installed, to monitor the oil "ΔP" pressure. The engine must be shutdown to service the cleanable oil filters.

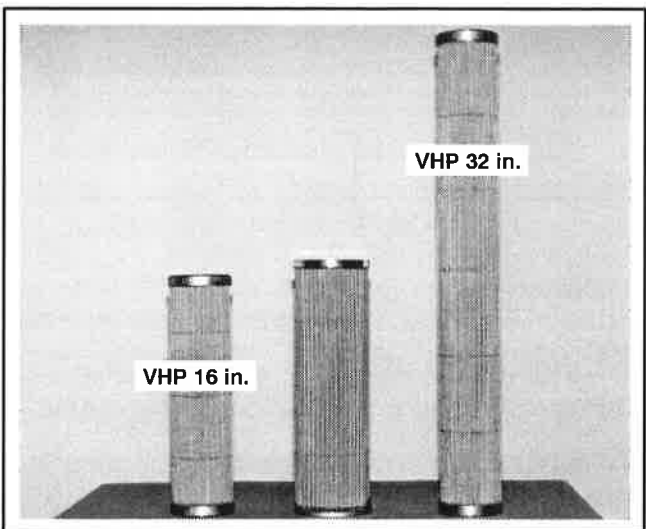


Figure 4.30-22. Cleanable Oil Filter Elements - All VHP, AT, F817G, F1197G, And VGF (Vee) Engines

Disassembly of MICROSPIN™ P/N 489189 Centrifuge

⚠ WARNING

The oil supply valve must be shut off before servicing the MICROSPIN™ centrifuge. Allow two minutes before proceeding with servicing the MICROSPIN™ centrifuge to allow the rotor to stop spinning and the oil pressure to drop to zero. Failure to shut off the oil supply valve can cause severe oil burns.

1. Shut off the oil supply valve and wait two minutes for the oil pressure to drop to zero and the rotor to stop spinning.

⚠ WARNING

Oil and parts may be extremely hot. Always use caution when servicing the unit to avoid severe personal injury or death.

2. Loosen and remove the side bell clamp (see Figure 4.30-23).
3. Turn the bell knob counterclockwise until it is free.
4. Grasp the top bell knob and remove the bell housing from the base (this will expose the rotor assembly).
5. Insert a screwdriver under the rotor assembly and raise the rotor assembly up 1 - 2 in. (25.4 - 50.8 mm) to allow oil to drain from the rotor into the body base. When the oil is drained from the rotor assembly, lift it straight up until it clears the base shaft.
6. Position the unit on a clean work table, and remove the knurled can nut from the rotor assembly.

⚠ CAUTION Use caution during disassembly to avoid damage to the brass bushings.

7. Invert the rotor assembly and place it on a clean work table.
8. Holding the rotor can with both hands, press down until the can separates from the rotor.
9. Clean the baffle screen assembly, rotor and jets. Replace the O-ring if necessary.

LUBRICATION SYSTEM MAINTENANCE

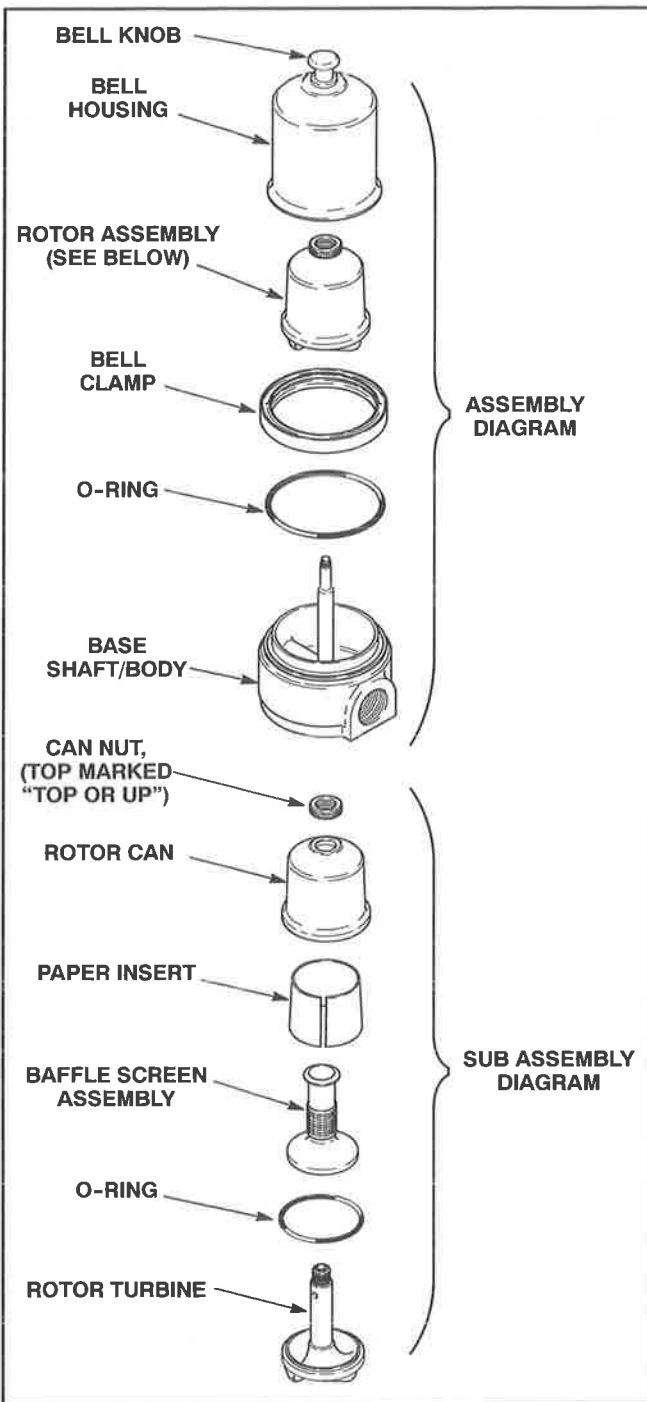


Figure 4.30-23. Service And Cleaning Of MICROSPIN™ P/N 489189 Centrifuge

MICROSPIN™ Centrifuge Cleaning - P/N 489189

1. Remove the paper insert from the rotor can by inserting a narrow flat tool between the paper insert and the rotor can. Run the tool around the inside of the can and remove the paper insert. Clean the contaminant build up in the rotor can, and insert a new paper insert.

⚠ WARNING

Solvents may be flammable and give off dangerous fumes. Read and follow the manufacturer's recommendations to avoid severe personal injury or death.

⚠ CAUTION Remove rubber O-rings prior to placing parts in the solvent tank, to prevent damage to equipment.

2. Clean the baffle screen assembly, rotor turbine, rotor can, covers and jets, in a suitable solvent tank.

MICROSPIN™ Centrifuge Assembly - P/N 489189

1. Install the baffle screen and new O-ring on the turbine rotor.

⚠ CAUTION The knurled can nut must be tightened hand tight only, or damage to equipment could result.

2. Position the rotor can with a new paper insert in place, (see Figure 4.30-23) on the turbine rotor. Insuring that the side of the knurled can nut marked "TOP" or "UP" is on top, (see Figure 4.30-24) tighten the knurled can nut, **hand tight only**, to secure the assembly.

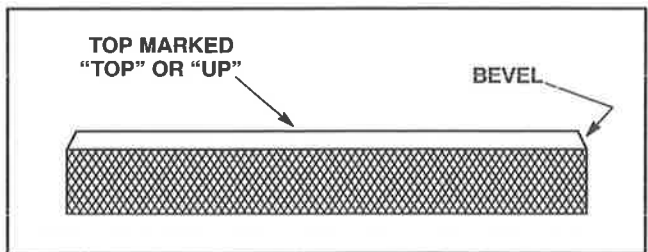


Figure 4.30-24. Can Nut - Side View

3. Position the turbine rotor assembly to the base, (over the base shaft). Check to insure that the rotor spins freely.
4. Install the bell housing to the base, using a new O-ring (if necessary) and hand tighten the bell nut.
5. Install and hand tighten the bell housing clamp finger tight.
6. Retighten the bell nut, hand tight.
7. Open the oil supply valve to start the centrifuge. Check for oil leaks.

OIL RECOMMENDATIONS

Waukesha recommends the use of oil formulated specifically for gas engines and meeting minimum ash requirements based on engine makes and models. The ash forming constituents in oil formulations provide detergency, corrosion protection and anti-wear protection. In addition, the ash produced during combustion of these additives will provide protection against valve face and seat recession. If you are experiencing excessive 0.002 in. (0.05 mm), or greater, per thousand hours, valve recession, a switch to a higher ash gas engine oil should be considered. Consult your oil supplier for appropriate recommendations.

Engines utilizing high ash oils which have had good operating experience on these oils may continue with Waukesha's previous oil recommendations.

Waukesha provides these current lubricating oil recommendations as a guideline.

LUBRICATING OIL PERFORMANCE

There are hundreds of commercial crankcase oils marketed today. Obviously, engine manufacturers or users cannot completely evaluate the numerous commercial oils. The current edition of the EMA Lubricating Oil Data Book, is available for purchase from Engine Manufacturers' Association, 401 North Michigan Ave, Chicago, IL 60611-4267, Phone (312) 644-6610, Fax (312) 321-5111. This document, provides a tabulation of lubricant producers and marketers, together with the performance classification for which the producers have indicated their products are qualified.

The performance of a lubricant, like that of any manufactured product, is the responsibility of the refiner and supplier.

The Waukesha Engine Warranty is limited to the repair or replacement of parts that fail due to defective material or workmanship during the warranty period. The Waukesha Warranty does not include responsibility for satisfactory performance of the lubricating oil.

With the exception of cogeneration and special or prototype installations, Waukesha Engine Division has made it a practice not to recommend oil by brand name.

OIL DESIGNATIONS

Oil is designated in several ways: American Petroleum Institute (API), Society of Automotive Engineers (SAE), American Society for Testing and Materials (ASTM), performance classifications, and Military Designation. Since no gas engine industry oil performance designations exist, it is the responsibility of the engine operator to verify with their oil supplier, that the oil they select has proven field performance in their specific engine make and model engine. This oil must also meet the minimum requirements specified by Waukesha as listed in Table 4.30-2.

OIL ADDITIVES

Quality oils formulated specifically for natural gas engines have sufficient additives to meet requirements. Waukesha does not recommend the addition of oil additives to these quality oils.

CATALYST CONTAMINANTS

The following contaminants are known catalyst deactivators and should be avoided when selecting lubricating oils for installations with catalysts since they contribute to shortened catalyst life: heavy and base metals such as lead, mercury, arsenic, antimony, zinc, copper, tin, iron, nickel, chrome, sulfur and phosphorus. These individual elements should not exceed 1 ppm or collectively exceed 5 ppm at the catalyst inlet. Specific exceptions: phosphorus or silicon compounds in the exhaust are not to exceed 1 ppm and sulfur compounds in the exhaust are not to exceed 100 ppm.

Do not confuse the concentration of these elements *AT THE CATALYST INLET* with the concentration of these elements in the lube oil itself.

OIL FILTRATION REQUIREMENT

The quality of oil filtration will directly affect engine component life.

Waukesha's basic filtration requirement is 90% efficient at 15 microns for all full flow elements, and 98% efficient at 25 microns for cleanable metal mesh elements.

Waukesha's complete oil filter performance specification is shown in Waukesha specification sheets S08486 and S08486-1.

LUBRICATION SYSTEM MAINTENANCE

WAUKESHA COGENERATION INSTALLATIONS - OIL RECOMMENDATIONS

Waukesha Engine Division does not ordinarily recommend lube oils by brand name. However, based on actual field experience, the oils listed in Table 4.30-6 are specified for cogeneration installations with forced hot water cooling systems 212° F - 265° F (100° C - 129° C) or ebullient cooling 250° F (121° C).

Table 4.30-6. Recommended Lube Oils For Cogeneration Applications - Using Pipeline Quality Gas

BRAND	TYPE	PERCENT OF SULFATED ASH
Chevron HDAX Low Ash	SAE 40	0.45
Estor Super Exxon Co. USA, Exxon Co. International	SAE 40	0.45
Estor Elite (Synthetic) Esso Imperial Oil, Exxon Co. USA	SAE 20 W40	0.45
Estor Select 40 Esso Imperial Oil, Exxon Co. USA	SAE 40	0.95
Mobil Pegasus 1 (Synthetic)	SAE 15 W40	0.48
Mobil Pegasus 80	SAE 40	0.48
Mobil Pegasus 89	SAE 40	0.99
Mobilgard 450	SAE 40	1.65
Mobil Pegasus 485	SAE 40	0.38
Petro Canada, CG40	SAE 40	0.73
Shell Mysella MA SIPC (Outside USA only)	SAE 40	0.90

It is especially important that the lube oils used in cogeneration applications utilize base stocks with good thermal stability. With a minimum of 4000+ hours of experience, the lube oils listed in Table 4.30-6 are known to give satisfactory performance in high temperature cooling systems' applications.

Additions to the list of approved oils may be made if substantiating data is provided for an oil meeting the following criteria:

- Used in similar applications 212° F (100° C) to 265° F (129° C) jacket water temperatures.
- Minimum of 12 months operation. Documented with engine inspection data.
- No signs of oil degradation or lacquering problems (based on normal oil change interval, the engine should be clean).

SOUR GAS, ALTERNATE FUEL GAS, AND LANDFILL GAS RECOMMENDATIONS



Waukesha Engine Division assumes no liability or responsibility for damage to the environment, or severe personal injury or death caused by using landfill gases or sour gases. It is the customer's sole responsibility to carefully analyze any gases they chose to use. Use of these gases is at the customer's own risk.

Alternate fuel sources are attracting increasing interest today as a low cost fuel or because of environmental concerns. Waukesha, being the leader in developing engine systems to accommodate these alternate fuels, is aware of problems due to sulfur compounds (H₂S, etc.), siloxanes and halide constituents in these fuels. Hydrogen sulfide (H₂S), siloxanes and total organic halide as chloride (TOH/Cl) bring with them totally different problems to the engine and lubricating oils.

Waukesha has limited fuel trace gases to the following:

- Sulfur bearing compounds (H₂S, etc.) content in fuel gas to 0.1%, (1000 ppm) by volume. However, it is not unusual to encounter biomass gas, or field gas, with much higher percentages of sulfur bearing compounds (H₂S, etc.). Gas exceeding 0.1% sulfur bearing compounds must be treated.
- Maximum organic halide content, expressed as chloride, (TOH/Cl) in landfill gas is limited to 150 micrograms per liter (µg/l).
- Maximum liquid fuel hydrocarbons at the coldest expected engine mounted regulator fuel outlet temperature are limited to 2% total by gaseous volume.
- Maximum permissible free hydrogen content is 12% by volume.
- Maximum total siloxanes for engine models with a prechamber fuel system is 25 µg/l. If greater than 25 µg/l total siloxanes are present at the inlet to the engine mounted fuel regulator, clean commercial quality natural gas must be supplied to the pre-chamber fuel system. Waukesha currently does not limit total siloxane content in the fuel gas to engines which do not have a prechamber fuel system.

When dealing with halogens or halogen compounds in landfill gas, the subject becomes far too complicated to address here as it relates to the selection of a lubricating oil, used oil analysis, and drain interval. It follows that those customers operating on landfill gas review Waukesha Engine's Fuel Specification S7884-6 to fully understand the ramifications of operating an engine on landfill gas. This document, as well as Service Bulletin 16-2701, prescribes specific

fuel gas sampling techniques, fuel gas analysis, handling of abrasive fuel constituents, and limitations on total organic halide as chloride, to achieve reasonable engine life. Lubricating oil requirements change as the TOH/Cl increases.

RECOMMENDED LUBE OILS FOR LANDFILL GAS APPLICATIONS

Waukesha recommends lubricating oils specifically formulated for landfill gas (see Table 4.30-7). However, care must be taken that oils formulated for a particular fuel type not be used beyond their recommendations. Some landfill gas formulated lube oils, can cause excessive build-up of abnormal ash deposits in the combustion chamber, when used outside of their recommendations. Landfill gas engine oils should only be used for engines applied to landfill gas operation, not digester gas operation.

Table 4.30-7. Recommended Lube Oils For Landfill Gas Applications

BRAND	TYPE	PERCENT OF SULFATED ASH
Mobil Pegasus 446	SAE 40	0.95
Chevron HDAX LGF	SAE 40	0.71

The best approach would be to filter or absorb corrosives in the fuel gas before they reach the engine. There are increasing claims for filtration and absorption by various companies manufacturing and promoting these types of product. Waukesha makes no endorsement of these products or service. Their performance is solely the responsibility of their manufacturers.

LUBRICATION SYSTEM MAINTENANCE

RECOMMENDATIONS FOR FUEL GAS FILTRATION OF SOLIDS AND LIQUIDS

Solid Particulate Removal:

Coalescer shall have an absolute rating of 5 microns (0.3 microns for landfill applications) for solid particulate removal.

Liquid and Aerosol Removal From Fuel Gas:

Coalescer shall remove entrained liquid and aerosol contaminants of 0.3 micron or larger.

- Fuel gas compressor lubricating oil carryover must be removed from the fuel stream. A coalescing filter with a 0.3 micron rating is adequate in most cases. Even though this oil is hydrocarbon based and combustible, it contains an additive package with calcium and other undesirable elements and compounds. Failure to remove this carryover oil can lead to fuel regulator problems, excessive spark plug and combustion chamber deposits, cylinder varnish, ring sticking, and other problems.
- Liquid water is not allowed in the fuel because it frequently results in fouling and corrosion. Particular attention must be paid to landfill and digester gasses since these gases are commonly received saturated with water. Due to extremely small clearances in the admission and check valves, absolutely no water can be tolerated in a prechamber fuel system. To insure that no liquid water forms in the fuel system, Waukesha specifies that the dew point of the fuel gas should be at least 20° F (11° C) below the measured temperature of the gas at the engine mounted regulator inlet. On engines without prechamber fuel systems, saturated, (100% relative humidity) fuel gas at the carburetor inlet is acceptable. A 0.3 micron coalescing filter will remove any liquid water droplets being carried along with the fuel stream. the water content of the gas can then be reduced to an acceptable level by several methods.

F. Condensation of excess moisture by refrigerating the fuel gas to no higher than 40° F (4° C) followed by reheating of the gas to 85° - 95° F (29° - 35° C). This process will also remove significant amounts of halogenated and heavy hydrocarbons and volatile siloxanes.

G. Selective stripping with a chemical process.

H. By heating: If the gas is 30° F (17° C) or more **above** the ambient temperature, it can be cooled by passing it through a heat exchanger or refrigeration system, then reheated, in manner similar to Step A. If the gas is 20° F (11° C) or more below the ambient temperature, it can be heated. In both cases, the fuel system after the heating operation should be insulated. Heating of

the fuel gas is limited to the maximum allowable temperature of 140° F (60° C).

- Glycol is not permitted in fuel gas because it can affect the engine in adverse ways. The lubricating qualities of the oil may be reduced, resulting in bearing failure, piston ring sticking, excessive wear, and other problems. A 0.3 micron rated coalescing filter will remove liquid glycol from the fuel stream.

Design Criteria:

Coalescer Filter Housing to be of the cylindrical type, vertically mounted. The housing shall contain two sump chambers, such that the lower sump collects heavier liquid dropouts immediately downstream of the gas inlet, while the upper sump collects liquids draining off the coalescer cartridge(s).

The coalescer design shall utilize an inside to outside gas flow path through the coalescer cartridge.

Recommended Coalescing Filter:

Pall Process Filtration Company
Model CC3LG7A

The following recommendations will minimize corrosion problems normally encountered with fuel gas containing H₂S and TOH/Cl:

• Recommendation #1

Select a gas engine lubricating oil with a high alkalinity reserve, 7 to 13 TBN (Total Base Number). Alkalinity reserve in the lube oil is measured in TBN. The higher the TBN, the more reserve.

Contact your oil supplier or consult the EMA Lubricating Oils Data Book for an appropriate choice. Also follow the appropriate ash content percent by weight for the specific engine model.

• Recommendation #2

Used oil analysis is mandatory for alternate fuel applications. Lube oil change periods are determined by TBN, TAN (Total Acid Number), oxidation and nitration level in the used oil samples. The user must change the oil when the TBN level falls to 30% of the new oil value or TAN increases by 2.0 above the new oil value. The method of measuring TBN in used oil must be ASTM-D2896.

DEXSIL[®] Corporation, has developed the Q2000 field test kit, as a test for chlorine contamination of engine oil exposed to chlorine containing fuels, as in landfill gas. This field test kit is highly accurate, and allows the operator to obtain timely test results in the field. The oil must be sampled every 50 hours, in order to establish a "trend". Waukesha has experienced good results with this kit. Order information may be obtained from DEXSIL[®] Corporation, One Hamden Park Drive, Hamden, CT 06517.

CAUTION TOH/CI does not affect TBN levels the same as sulfur compounds. Therefore, the 30% of new oil TBN value, as an indicator of a change interval only applies to the applications where fuel gas does not contain halides. Disregarding this information could result in product damage.

Recommendation #3

Increase the jacket water temperature to 210° - 235° F (99° - 113° C) and lube oil temperatures to 185° - 200° F (85° - 93° C). Increased temperatures will reduce condensation, which will reduce the concentration of acids within the crankcase. High temperature thermostats are available for most models.

If you have any question on lubricants to be used with alternate fuel gases, contact the Product Support Department or Application Engineering Department prior to selecting a lubricating oil.

LUBE OIL CONDEMNING LIMITS

WARNING

Engine oil is extremely hot and is under pressure. Use caution when sampling engine oil for analysis. Failure to follow proper procedures could cause severe personal injury or death.

Lubricating oil condemning limits are established by the engine manufacturer's experience and/or used oil testing.

Laboratory testing will determine the used oil's suitability for continued use. Used oil testing should cover the data shown in Table 4.30-8.

Table 4.30-8. Used Oil Testing And Condemnation

TEST	CONDEMNING LIMIT
Viscosity	-20/+30% Change
Flash Point	Below 356° F (180° C)
Total Base Number (TBN) (ASTM-D2896)	30% of New Oil Value (Not applicable to TOH/CI)
Total Acid Number (TAN)	2.0 Rise Above New Oil Value
Oxidation (Abs/Cm)	25
Nitration (Abs/Cm)	25
Water Content	Above 0.10% Wt.
Glycol	Any Detectable Amount
Wear Metals	Trend Analysis
Chlorine	900 ppm

CAUTION Actual oil change intervals to be determined by engine inspection and oil analysis in conjunction with the condemning limits. Disregarding this information could result in product damage.

In the interest of developing a reasonable life expectancy for Waukesha engines operating on fuel gas laden with some level of halogens, our experience dictates the following:

- To achieve the life expectancy of an engine operating on pipeline quality natural gas, remove all halogen compounds (as well as abrasives) from the fuel gas.
- Reasonable life can be expected if Total Organic Halide as Chloride Concentration (TOH/CI) of the fuel does not exceed 150 micrograms per liter (µg/l). Total Organic Halide as Chloride (TOH/CI) equals the sum of all halogenated compounds expressed as chloride in micrograms/litre as chloride (µCl/L) at STP (Standard Temperature and Pressure). Reasonable life can also be expected with increased maintenance and operating adjustments to the engine.
- Typical changes in maintenance and operation at this level are:
 - Decreased oil change interval (150 hours to start)
 - Condemn oil when 900 ppm chlorine level in used oil is reached. This will aid in establishing an oil change interval.
 - Lubricating oil analysis each 50 hours maximum
 - Elevated jacket water temperature 212° F - 235° F (100° C - 113° C)
 - Elevated lube oil temperature to 185° F - 200° F (85° C - 93° F)
 - Use of high TBN oil (7.0 - 13.0)
 - Bypass lubrication oil filtration. Waukesha Engine has announced the introduction of the MICROSPIN® cleanable lube oil filtering system. The MICROSPIN® system utilizes the cleaning capabilities of a centrifuge, coupled with cleanable filter elements. The MICROSPIN® system utilizes Waukesha's current lube oil filtration canister for the cleanable elements. The centrifuge is installed as a bypass system, working in conjunction with the cleanable filter elements.
- TOH/CI above 150 micrograms chloride/litre require pre-treatment of the fuel in order to make it suitable for use in a reciprocating engine.

DEXSIL® Corporation, has developed the Q2000 field test kit, as a test for chlorine contamination of engine oil

LUBRICATION SYSTEM MAINTENANCE

exposed to chlorine containing fuels, as in landfill gas. This field test kit is highly accurate, and allows the operator to obtain timely test results in the field. The oil must be sampled every 50 hours, in order to establish a "trend". Waukesha has experienced good results with this kit. Order information may be obtained from DEXSIL® Corporation, One Hamden Park Drive, Hamden, CT 06517.

OIL VISCOSITY SELECTION

The operating temperature of the oil in the sump or header is the best guide for selecting the proper SAE grade of oil. When the oil temperature is unknown, add 120° F (67° C) to the ambient temperature to obtain the estimated sump oil temperature (see Table 4.30-9).

Table 4.30-9. Sump And Header Temperatures And SAE Number

1000 CU. IN. (16.4 L) DISPLACEMENT AND LARGER		
Sump Temperatures	Header Temperature	SAE Number
160° - 230° F (71° - 110° C)	160° - 210° F (71° - 99° C)	40
Below 160° F (71° C)	Below 160° F (71° C)	30

NOTE: Engines of 1000 cu. in. (16.4 L) displacement and above, should not be operated with header oil temperature below 140° F (60° C). Engines of this type which exceed 195° F (91° C) header temperature or 215° F (102° C) sump temperature should have reduced oil change intervals.

MULTI-VISCOSITY OILS

Use multi-viscosity oils only for engines in cold starting applications. Multi-viscosity oil may deteriorate in continuous operation, allowing the oil to lose viscosity through shearing. In this state, the oil may not supply sufficient lubricating films and/or pressure. Therefore, utilize an oil analysis program to determine the oil change intervals.

SYNTHETIC OILS

Based on developments by Exxon Corporation and Mobil Oil Corporation and the release of their synthetic lubricating oils, Waukesha Engine Division now recognizes these products as being suitable for all Waukesha stoichiometric and lean burn gas engines. Table 4.30-6 lists the synthetic oils available.

When synthetic lubricating oils are selected, it is suggested that you contact Waukesha Engine Division for change interval recommendations. Typically, synthetic oil change intervals are 3 to 5 times longer than those of mineral oils. Oil filter change intervals remain at 1000 to 1500 hours of operation.

Synthetic oils are not recommended for alternate fuel gas applications without prior approval by Waukesha Engine Division.

LOW AMBIENT TEMPERATURE OPERATION

At low ambient temperatures, use an oil which will provide proper lubrication when the engine is hot and working. For engines of 1000 cu. in. (16.4 L) and above, operating at ambients below 50° F (10° C) lube oil and jacket water heaters are required to warm oil and water for fast starting and loading of engines. Waukesha Engine Division will supply information on these starting devices upon request.

LUBE OIL CONSUMPTION RATES

Typical lube oil consumption rates have been updated for all Waukesha engines (see Table 4.30-10).

Table 4.30-10. Oil Consumption

MODEL	LBS/HP-HR	GRAMS/HP-HR	GRAMS/KW-HR
All	0.0002 - 0.002	0.091 - 0.910	0.121 - 1.22

NOTE: Lube oil consumption rates given above are a general guide and not meant to be used for Condemning Limits or determining overhaul requirements.

FORMULAS FOR DETERMINING OIL CONSUMPTION RATES

The following formulas may be useful in determining whether the oil consumption rate of the engine is normal.

$$\frac{\text{LBS}}{\text{HP} - \text{HR}} = \frac{7.3 \times \text{Number of Gallons of Oil Used}}{\text{HP} \times \text{Hours of Operation}}$$

$$\frac{\text{LBS}}{\text{HP} - \text{HR}} = \frac{1.82 \times \text{Number of Quarts of Oil Used}}{\text{HP} \times \text{Hours of Operation}}$$

$$\frac{\text{Grams}}{\text{HP} - \text{HR}} = \frac{875 \times \text{Number of Litres of Oil Used}}{\text{HP} \times \text{Hours of Operation}}$$

$$\frac{\text{Grams}}{\text{kW} - \text{HR}} = \frac{875 \times \text{Number of Litres of Oil Used}}{\text{kW}(\text{corrected}) \times \text{Hours of Operation}}$$

RECOMMENDED OIL CHANGE INTERVALS

CAUTION The use of some types of oil, as well as dusty environment, marginal installation, internal engine condition and/or operating the engine with malfunctioning carburetion or injection equipment may require more frequent oil changes. Waukesha Engine recommends the lubricating oil be monitored with a professional oil analysis program. Extended oil change intervals may cause varnish deposits, oil oxidation, or sludge conditions to appear in the engine, which an oil analysis cannot detect. Contact your local Waukesha Distributor for periodic engine maintenance. Disregarding this information could result in product damage.

Table 4.30-11. Recommended Oil Change Intervals For Engines Receiving Normal Maintenance

ENGINE MODEL	ISO STANDARD OR CONTINUOUS POWER RATING	ENGINES OPERATED IN EXCESS OF ISO STD. POWER	LIGHT LOAD OPERATION	EBULLIENT COOLED OR HOT WATER SYSTEM WITH ENGINE WATER TEMPERATURE 200° F (93° C) OR ABOVE *	STANDBY DUTY
For Engines Operating With Oil Header Temperatures 195° F (91° C) Or Below					
* Natural Gas HD-5 Propane	1500 hours	500 hours	1500 hours	500 5115GL = 1500 hours *	250 hours or annually

NOTE: Change lube oil filter elements when lube oil is changed.
* 5115GL rated at 220° F (104° C).

Table 4.30-12. Recommended Oil Change Intervals For Engines Receiving Normal Maintenance And Using Gaseous Fuel Containing H₂S In Excess Of Published Limits.

ENGINE MODEL	ISO STANDARD OR PRIME POWER RATING	ENGINES OPERATED IN EXCESS OF ISO STD. POWER	LIGHT LOAD OPERATION	EBULLIENT COOLED OR HOT WATER SYSTEM WITH ENGINE WATER TEMPERATURE 200° F (93° C) OR ABOVE *	STANDBY DUTY
For Engines Operating With Elevated Oil Sump Temperature					
VHP Series	360 hours	250 hours	360 hours	360 hours	250 hours or annually

NOTE: Change lube oil and fuel filter elements when lube oil is changed.

Table 4.30-13. Duty Cycle Definitions

ISO Standard Or Continuous Power Rating:	The highest load and speed which can be applied 24 hours a day, 7 days a week, 365 days per year, except for normal maintenance. It is permissible to operate the engine at up to ten percent overload or maximum load indicated by the intermittent rating, whichever is lower, for two hours in each 24 hour period.
Generator Standby Power Rating:	In a system used as a backup or secondary source of electrical power, this rating is the output the engine will produce continuously (no overload), 24 hours per day, for the duration of the prime power source outage.
Intermittent Power Rating:	This rating is the highest load and speed that can be applied in variable speed mechanical system application only. Operation at this rating is limited to a maximum of 3500 hours per year.
Generator Peak Shaving:	Peak shaving is operation of an engine for a limited time to meet short term peak power requirements. Speed, loading, and hours per year of operation will affect the recommended oil change interval.
Light Load Operation:	25% or less of the continuous duty rating.

LUBRICATION SYSTEM MAINTENANCE

SECTION 4.35

EXHAUST SYSTEM MAINTENANCE

EXHAUST SYSTEM MAINTENANCE

EXHAUST SYSTEM BACKPRESSURE MEASUREMENT

Monitor the exhaust system backpressure daily. The maximum backpressure must not exceed specification. Refer to Table 4.35-1 for exhaust system backpressure values.

1. Drill and tap a hole (1/4 inch NPT) in the customer supplied exhaust piping. Place the hole 12 in. (305 mm) downstream from the mating flange of the Waukesha supplied flexible exhaust connection. The measurement must be taken before the silencer or catalytic converter, if provided, and should be away from any bend or elbow in the exhaust piping.
2. Install a tubing connector in the hole. Use only non-corroding stainless steel fittings.
3. Connect one end of a water manometer to the connector and vent the free end to the atmosphere. The manometer line fitting must not protrude beyond the inner surface of the exhaust pipe or an inaccurate reading may result.
4. Measure the exhaust backpressure at rated speed and load. Corrective action must be taken if the backpressure exceeds the specified limit.
5. Excessive exhaust backpressure may be due to one or more of the following conditions:
 - A. Undersized piping
 - B. Elbows, bends or sudden enlargements in the piping
 - C. Plugged catalytic converter
 - D. Pipe obstructions
 - E. Exit losses

EXHAUST SYSTEM TEMPERATURE MONITORING

Exhaust temperatures can be an important diagnostic tool. A very high exhaust temperature might indicate that the air/fuel ratio is too rich. A very low temperature may mean that a cylinder is not firing.

The maximum exhaust temperature variation (on an engine running at rated speed and load on natural gas fuel) between cylinders on the same bank is approximately 100° F (47° C). The maximum exhaust temperature variation between respective cylinders on different banks (1R versus 1L, 2R versus 2L, etc.) is approximately 50° F (23.5° C).

Normal exhaust temperatures are 650° to 670° F (343° to 354° C). Higher exhaust temperatures might indicate that the air/fuel ratio is too rich. Lower temperatures may mean that a cylinder is not firing.

NOTE: *Since air/fuel ratio, ambient air temperature and many other factors may affect exhaust gas temperatures, call the Waukesha Engine Division, Field Service Department, if additional information is required.*

Check engine exhaust temperatures for each cylinder daily. Monitor the exhaust temperatures when the engine is running at rated speed and load.

EXHAUST SYSTEM INSPECTION

1. Inspect the exhaust manifolds and exhaust piping for leaks.
2. Record the exhaust manifold temperatures for reference.

EXHAUST SYSTEM MAINTENANCE

Table 4.35-1. Maximum Allowable Exhaust Backpressure And Reductions For Speed And Load

NATURALLY ASPIRATED VHP G MODELS
<p>The maximum allowable exhaust backpressure for a VHP G model is 18 in. (457.2 mm) of water column pressure (4.5 kPa) at the highest load at the highest speed that the engine will experience during operation. At reduced load and/or speed, the backpressure on the engine will decrease by the operating characteristic of the exhaust system.</p>
STOICHIOMETRIC, TURBOCHARGED AND INTERCOOLED, VHP GSI* MODELS
<p>The maximum allowable exhaust backpressure for a VHP GSI* model is 18 in. (457.2 mm) of water column pressure (4.5 kPa) at 180 BMEP at 1200 rpm. This pressure must be reduced by 1.5 in. (38 mm) of water column (0.37 kPa) for every 100 rpm that the maximum rated speed is below 1200 rpm and reduced by 1.5 in. (38 mm) of water column (0.37 kPa) for every 10 BMEP that the maximum rated load is below 180 BMEP. Allowable backpressure is not reduced below 4.0 in. (101.6 mm) of water column pressure (1 kPa). At reduced load and/or speed the backpressure on the engine will decrease by the operating characteristic of the exhaust system.</p> <p>Max Exhaust Backpressure = $18.0 - 1.5 \times [(1200 - \text{rpm})/100] - 1.5 \times [(180 - \text{BMEP})/10]$ In. H₂O</p> <p>* This applies only to VHP GSI engines with the ejector style breather system. For other models, contact the Waukesha Applications Engineering Department.</p>
LEAN BURN, TURBOCHARGED AND INTERCOOLED, VHP GL MODELS (EXCEPT 5115GL)
<p>The maximum allowable exhaust backpressure for a VHP GL model (except 5115GL) is 13.5 in. (342.9 mm) of water column pressure (3.4 kPa) at 160 BMEP at 1200 rpm. This pressure must be reduced by 1.0 in. (25.4 mm) of water column (0.25 kPa) for every 100 rpm that the maximum rated speed is below 1200 rpm and reduced by 1.0 in. (25.4 mm) of water column (0.25 kPa) for every 10 BMEP that the maximum rated load is below 160 BMEP. Allowable backpressure is not reduced below 4.0 in. (101.6 mm) of water column pressure (1 kPa). At reduced load and/or speed the backpressure on the engine will decrease by the operating characteristic of the exhaust system.</p> <p>Max Exhaust Backpressure = $13.5 - [(1200 - \text{rpm})/100] - [(160 - \text{BMEP})/10]$ in. H₂O</p>
VHP 5115GL MODELS
<p>The maximum allowable exhaust backpressure for a VHP 5115GL model is 13.5 in. (342.9 mm) of water column pressure (3.4 kPa) at 165 BMEP at 1500 rpm. This pressure must be reduced by 1.0 in. (25.4 mm) of water column (0.25 kPa) for every 100 rpm that the maximum rated speed is below 1500 rpm and reduced by 1.0 in. (25.4 mm) of water column (0.25 kPa) for every 10 BMEP that the maximum rated load is below 165 BMEP. Allowable backpressure is not reduced below 4.0 in. (101.6 mm) of water column pressure (1 kPa). At reduced load and/or speed the backpressure on the engine will decrease by the operating characteristic of the exhaust system.</p> <p>Max Exhaust Backpressure = $13.5 - [(1500 - \text{rpm})/100] - [(165 - \text{BMEP})/10]$ In. H₂O</p>

SECTION 4.40

CRANKCASE BREATHER SYSTEM MAINTENANCE

CRANKCASE BREATHER SYSTEM MAINTENANCE

NOTE: After cleaning, servicing or replacing any component of the crankcase breather system, recheck the crankcase pressure to verify that it is within specification and that all system components are functioning properly.

SEPARATOR SCREEN MAINTENANCE

6 and 12 cylinder engines have a crankcase separator screen. On six cylinder engines, the separator screen is located in the firing deck of the crankcase at the rear of the engine (see Figure 4.40-1). On 12 cylinder engines, the separator screen is located in the rear right side of the engine on the cylinder firing deck. 16 cylinder engines do not have separator screens.

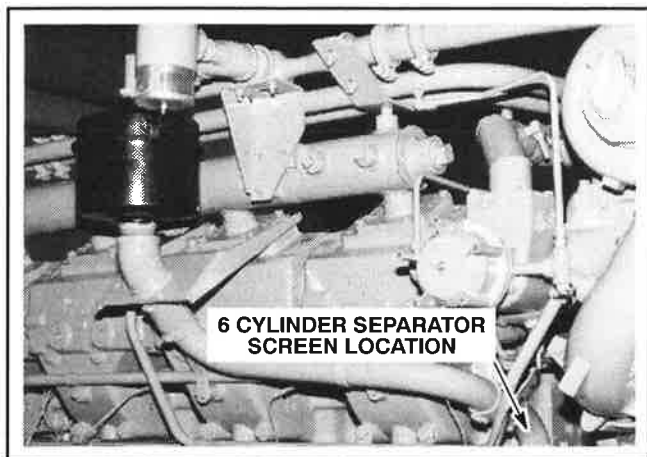


Figure 4.40-1. Crankcase Separator Screen - 6 Cylinder

Crankcase Separator Screen Removal

1. Disconnect the separator screen tubing from the oil separator (see Figure 4.40-1, Figure 4.40-2, Figure 4.40-3 and Figure 4.40-4).
2. Remove the capscrews, lock washers, and gaskets and the separator screen assembly from the top of the cylinder block.

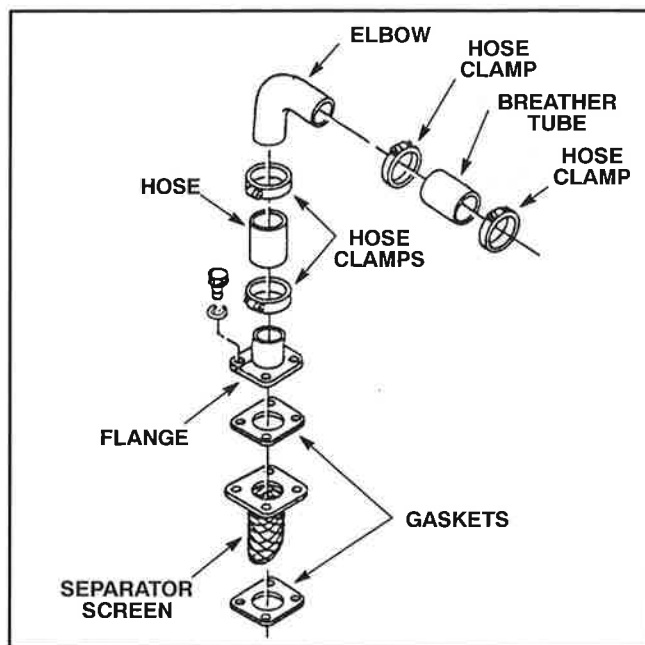


Figure 4.40-2. Crankcase Separator Screen - 6 Cylinder

CRANKCASE BREATHER SYSTEM MAINTENANCE

Crankcase Separator Screen Cleaning And Inspection

⚠ WARNING

Always use approved cleaning solvents in a well ventilated area. Avoid contact with skin. Disregarding this information could result in severe personal injury or death.

1. Wash the screen in a non-volatile cleaning solution or solvent, if necessary.
2. Remove the separator screen and breather transition assembly.

⚠ WARNING

Compressed air can pierce the skin and cause severe injury. Never use your hand to check for leaks or to determine air flow rates. Wear safety glasses to shield your eyes from flying dirt and debris. Disregarding this information could result in severe personal injury or death.

3. Dry the screening element from the inside out using low pressure compressed air.

Crankcase Separator Screen Assembly

1. Position a new gasket over the rectangular hole on the top of the cylinder block (rear right corner) (see Figure 4.40-1, Figure 4.40-2, Figure 4.40-3 and Figure 4.40-4). Verify that the gasket surfaces are clean and completely free of grease and oil.
2. Install the separator screen in the cylinder block.
3. Install a new gasket on top of the separator screen.
4. Fasten the separator screen and breather transition assembly to the top of the cylinder block lock washers and capscrews.
5. Install the oil separator tubing.

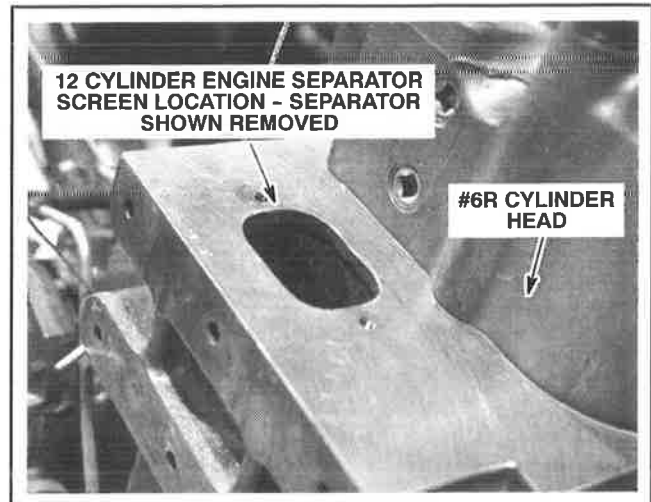


Figure 4.40-3. Crankcase - Rear Right

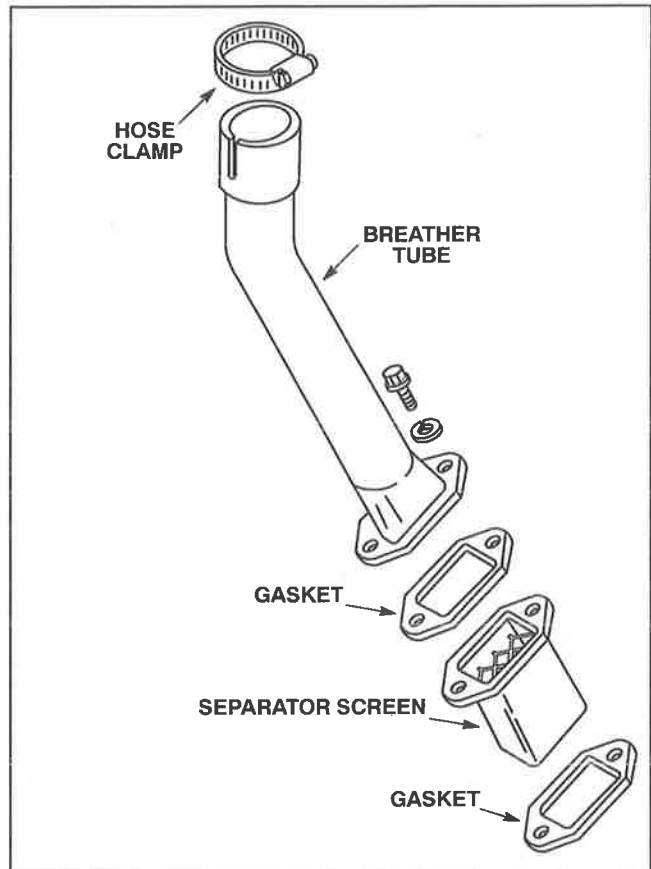


Figure 4.40-4. Crankcase Separator Screen Assembly - 12 Cylinder GL Shown

OIL SEPARATOR(S) MAINTENANCE

6 cylinder and 12 cylinder G engines, have one oil separator located at the rear of the engine (see Figure 4.40-5).

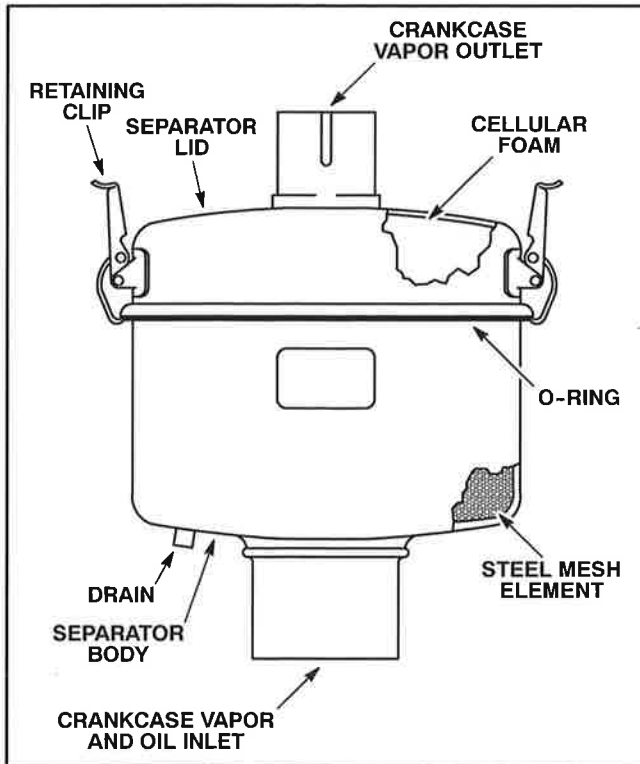


Figure 4.40-5. Oil Separator 6 And 12 Cylinder Engine

The 5115GL engine and 12 cylinder GSI and GL engines have two oil separators. One oil separator is connected by an elbow to the vent in the gear housing cover on the front left side of the engine. The second oil separator is mounted above the crankcase at the rear right side of the engine (see Figure 4.40-6). This oil separator is connected by a breather tube to the crankcase separator screen in the top of the crankcase.

16 cylinder engines have one oil separator located on the rear of the engine directly above the flywheel.

Oil Separator Cleaning And Inspection - 6 And 12 Cylinder

Clean the oil separator at each oil change.

NOTE: Current production separators have elongated indentations along the circumference of the cover. This indicates that the upper foam filter is removable.

1. Disconnect the breather plumbing from the separator as required and remove the oil separator from the engine. Release the two latches on the separator and remove the cover (see Figure 4.40-5 and Figure 4.40-6).

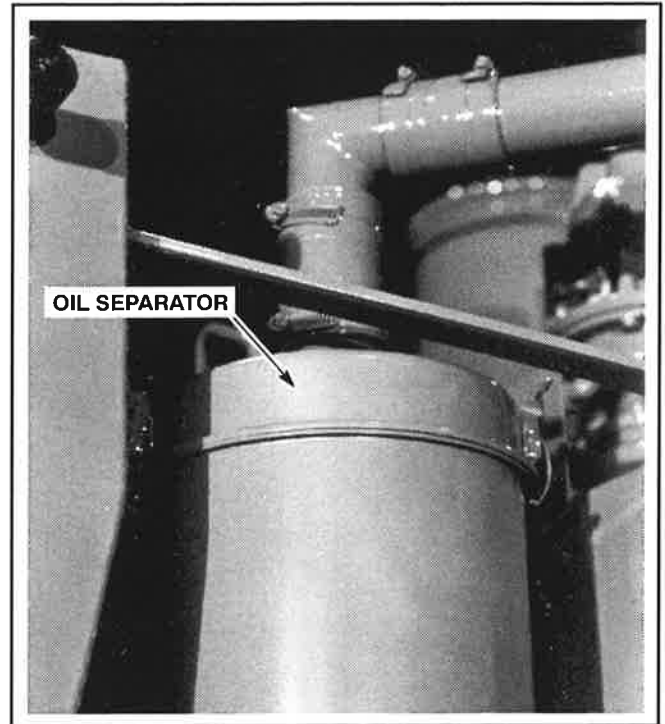


Figure 4.40-6. Oil Separator Assembly - 5115GL Engine Rear Right

2. Remove the O-ring from the cover.
3. Pry the screen out of the cover and remove the foam (see Figure 4.40-7). Remove the upper screen from the inside of the cover.

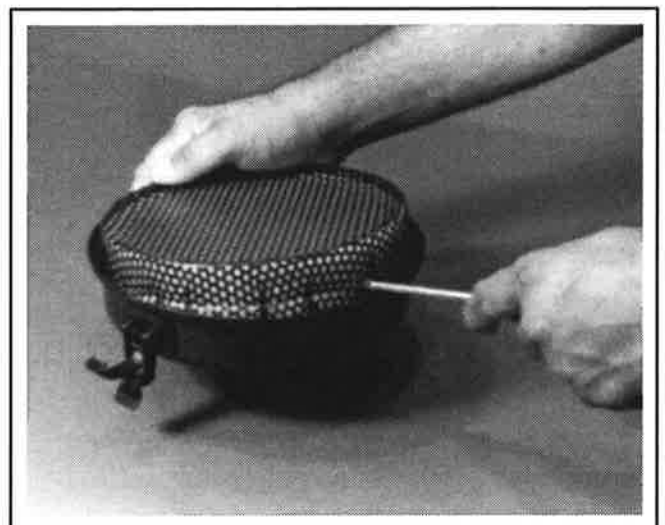


Figure 4.40-7. Pry Screen From Cover

CRANKCASE BREATHER SYSTEM MAINTENANCE

4. Wash the foam in a detergent solution and wring dry by hand (see Figure 4.40-8). Do not use a mineral based solvent

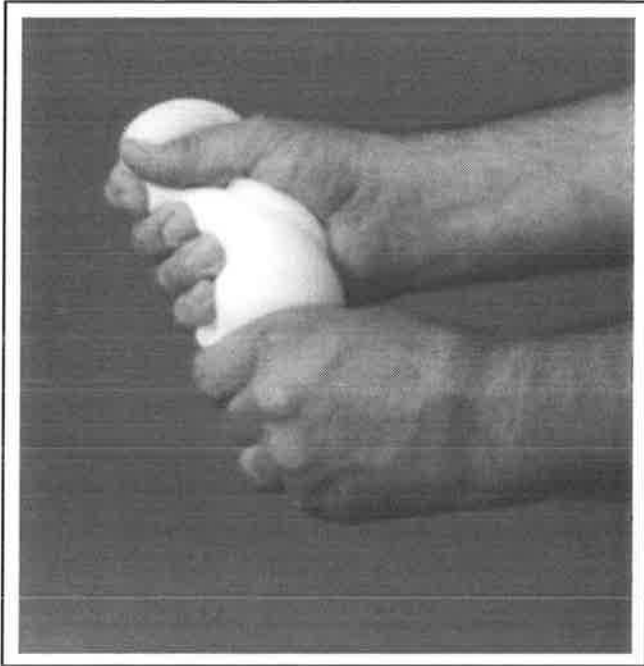


Figure 4.40-8. Wring Foam Dry

5. Wipe the inside of the cover clean.
6. Install the upper screen to the inside of the cover.
7. Place the foam into place in the retaining screen (see Figure 4.40-9).

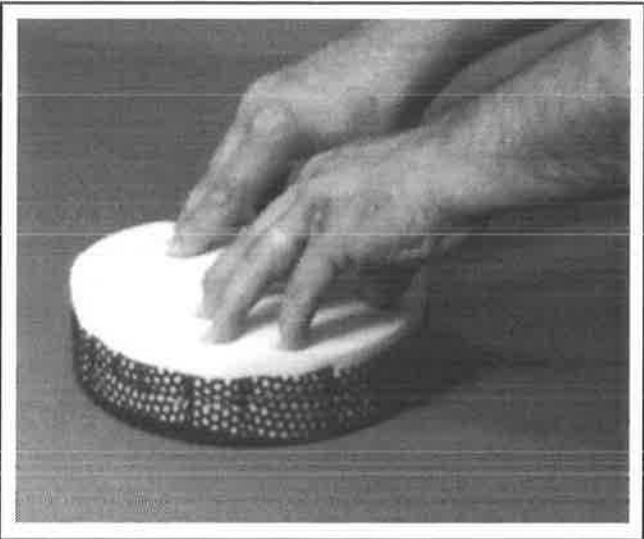


Figure 4.40-9. Install Foam In Screen

8. Press the retaining screen and foam into the cover (see Figure 4.40-10).



Figure 4.40-10. Press Screen Into Cover

9. Install the O-ring on the cover.
10. Clean the lower separator body in a solvent tank. Allow the separator to dry (see Figure 4.40-11).



Figure 4.40-11. Wash Separator With Solvent

11. Install the separator on the engine. Connect the drain tube to the separator (if equipped).
12. Install the cover on the separator. Install the breather plumbing as required.

Oil Separator Cleaning And Inspection - 16 Cylinder

1. Remove the oil separator from the engine.
2. Loosen the retaining clamp and remove the lid from the body of the oil separator (see Figure 4.40-12 and Figure 4.40-13).

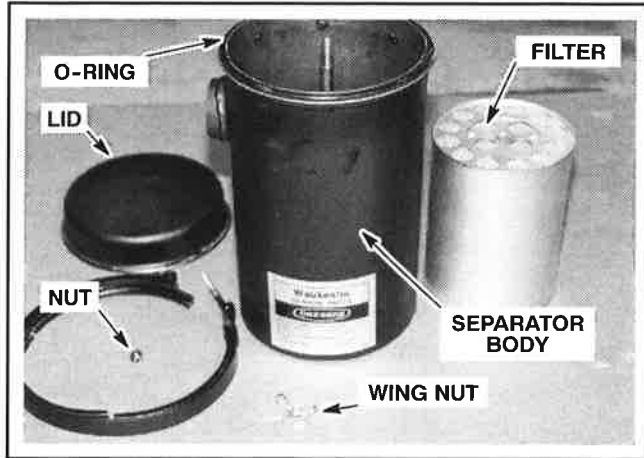


Figure 4.40-12. Oil Separator - 16 Cylinder Engine

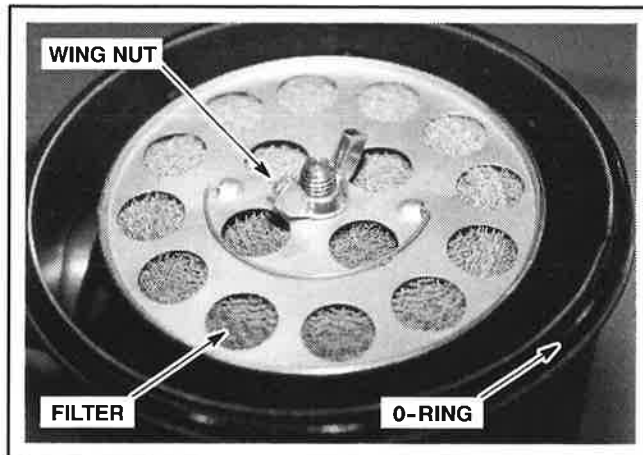


Figure 4.40-13. Oil Separator - 16 Cylinder Engine

3. Remove the rubber O-ring seal from the inside rim of the lid. Inspect the seal for cuts, tears or loss of elasticity. Replace when necessary.
4. Remove wing nut and lift the filter assembly from the separator body.
5. Thoroughly wash the body and filter element in a non-volatile cleaning solution or solvent.

⚠ WARNING

Compressed air can pierce the skin and cause severe injury. Never use your hand to check for leaks or to determine air flow rates. Wear safety glasses to shield your eyes from flying dirt and debris. Disregarding this information could result in severe personal injury or death.

⚠ CAUTION High pressure compressed air can easily damage the light metal filter mesh element causing breather system restriction and the resultant excessive crankcase pressure condition.

6. Dry the lid, body, and filter element with low pressure compressed air.
7. Install the filter element in the separator body with the handle on the filter facing up, and hand tighten the wing nut.
8. Place the rubber O-ring seal on the inside rim of the lid.
9. Position the lid and clamp on the separator body and secure by tightening the nut on the clamp.

CRANKCASE PRESSURE CHECK

A negative crankcase pressure of 0 - 1 in. (25.4 mm) H₂O must be maintained.

NOTE: Measure the crankcase pressure at least once every 3 months (2160 hours).

Proceed as follows:

1. Remove the pipe plug from the oil level gauge support and install a tube connector in the hole (1/8 inch NPT) (see Figure 4.40-14).

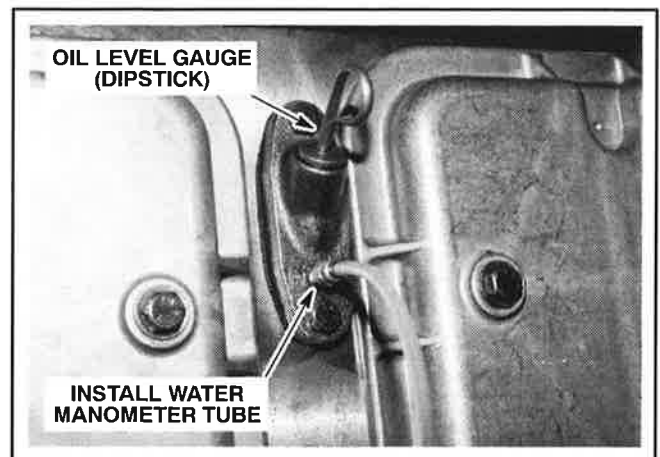


Figure 4.40-14. Install Water Manometer Tube Connector

CRANKCASE BREATHER SYSTEM MAINTENANCE

2. Connect one end of a water manometer to the connector and vent the free end to the atmosphere; the manometer line must not protrude beyond the inner surface of the gauge support or an inaccurate reading may result (see Figure 4.40-15).

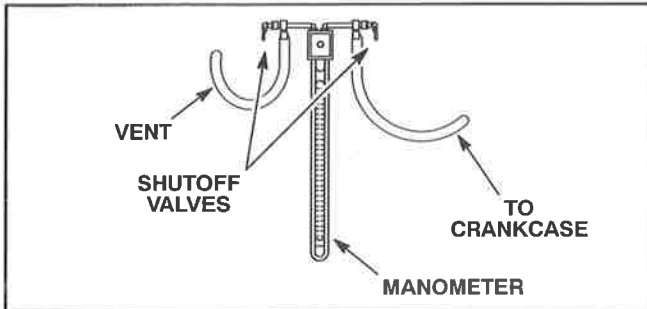


Figure 4.40-15. Water Manometer

3. Measure the crankcase pressure and perform all pressure adjustments while the engine is operating at rated speed and load (see *Crankcase Pressure Adjustment*)

4. Remove the manometer line and tube connector. Install the pipe plug.

CRANKCASE PRESSURE ADJUSTMENT CONTROLS

All engines are provided with manual crankcase pressure adjustment. The adjustment is accomplished by admitting more or less outside air into the breather system. All manual adjustment devices are externally controlled and easily accessible.

6 Cylinder Engine Crankcase Pressure Adjustment Controls

On 6 cylinder models, crankcase pressure is adjusted with either a venturi/adjusting screw assembly (see Figure 4.40-16), an ejector breather/adjusting valve assembly (see Figure 4.40-17) or vacuum valve (see Figure 4.40-18).

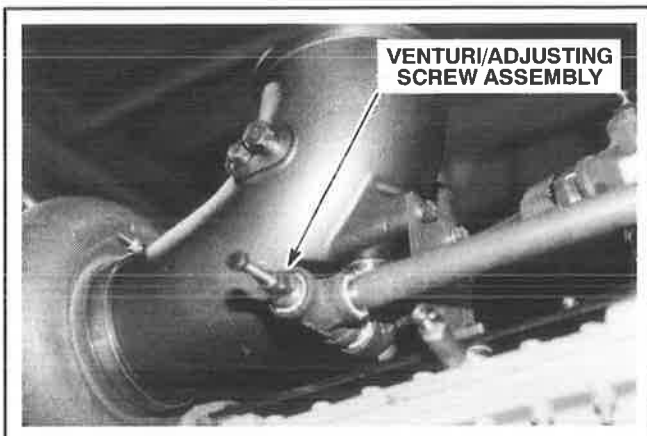


Figure 4.40-16. Venturi/Adjusting Screw Assembly - 6 Cylinder GSI Shown

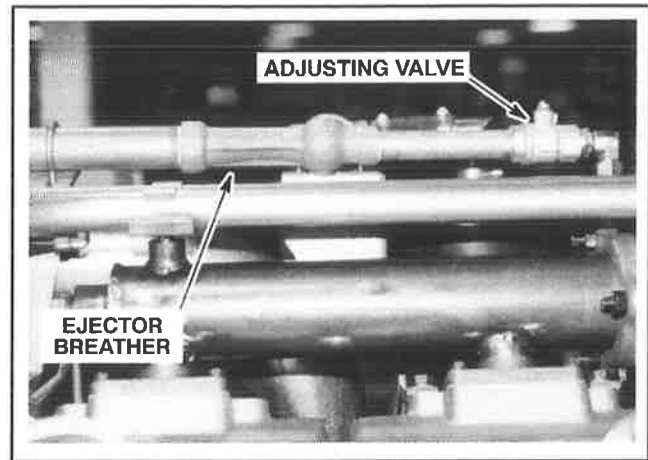


Figure 4.40-17. Ejector Breather/Adjusting Valve Assembly - 6 Cylinder Shown

12 Cylinder Engine Crankcase Pressure Adjustment Controls

On 12 cylinder models that are not equipped with venturi extractor, the crankcase pressure is adjusted with a vacuum valve assembly of which there are different configurations. (see Figure 4.40-18 and Figure 4.40-19). On 12 cylinder models equipped with a venturi extractor, a choke valve is located on the end of the venturi extractor (see Figure 4.40-20).

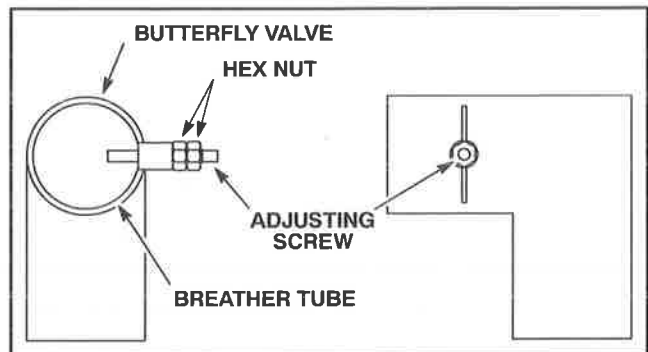


Figure 4.40-18. Vacuum Valve Assembly

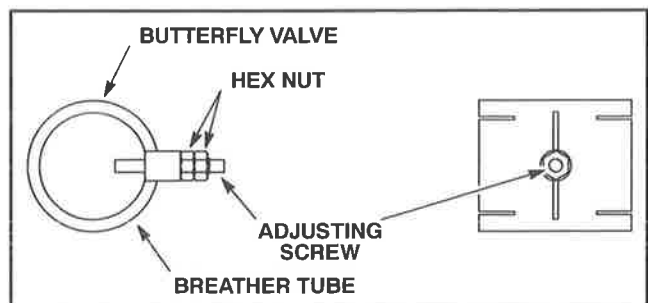


Figure 4.40-19. Vacuum Valve Assembly

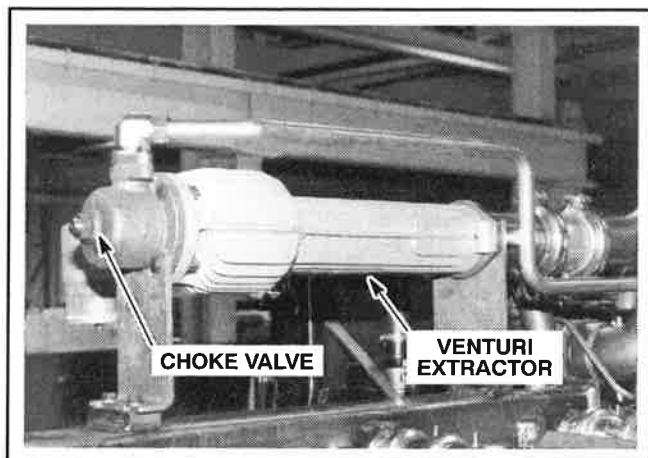


Figure 4.40-20. Venturi Extractor/Choke Valve Assembly - 12 Cylinder GL Shown

16 Cylinder Engine Crankcase Pressure Adjustment Controls

On 16 cylinder engines, the crankcase pressure is adjusted with a vacuum valve that is similar in appearance to the valve shown in Figure 4.40-16, or a venturi extractor/choke valve assembly similar to the one shown in Figure 4.40-20.

CRANKCASE PRESSURE ADJUSTMENT

1. Run the engine at rated speed and load.

NOTE: A negative pressure of 0 - 1 in. (25.4 mm) H₂O is desirable at all speeds and loads.

2. Refer to *Crankcase Pressure Check* and install a water manometer to monitor crankcase pressure.

3. Loosen the hex nut and turn the adjusting screw while monitoring the water manometer, until the recommended negative crankcase pressure is obtained.

4. Remove the engine load.

5. Measure the crankcase pressure again. Readjust if it is not within specification.

6. Retest at rated speed and load. If the crankcase pressure is within specification, tighten the hex nut to hold the setting.

7. If adjustment of manual control devices fails to properly regulate crankcase pressure:

- A. Clean the crankcase separator screen.
- B. Clean the crankcase oil separators.
- C. Clean all breather tubes.
- D. Clean and inspect the crankcase breather regulator assembly.

- E. Clean and inspect the venturi extractor assembly.
- F. Inspect the air cleaner prefilter pads and main filter elements. Clean or replace as necessary.
- G. Measure the exhaust backpressure. Excessive backpressure reduces breather system effectiveness.

NOTE: After cleaning, servicing or replacing any component of the crankcase breather system, recheck the crankcase pressure to verify that it is within specification and that all system components are functioning properly.

CRANKCASE BREATHER REGULATOR MAINTENANCE

The crankcase breather regulator assembly is above the water manifold and connected to the venturi extractor through a tee and pipe nipple arrangement (see Figure 4.40-21).

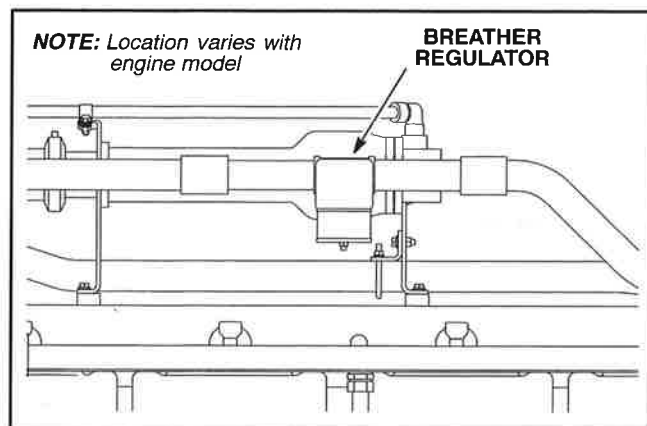


Figure 4.40-21. Breather Regulator

While there is no manual adjustment of the crankcase breather regulator, it should be inspected annually for an accumulation of dirt or grit. Harsh environments may dictate more frequent attention.

CRANKCASE BREATHER SYSTEM MAINTENANCE

CRANKCASE BREATHER REGULATOR - CLEANING AND INSPECTION

⚠ WARNING

Compressed air can pierce the skin and cause severe injury. Never use your hand to check for leaks or to determine air flow rates. Wear safety glasses to shield your eyes from flying dirt and debris. Disregarding this information could result in severe personal injury or death.

1. Thoroughly wash all parts in a non-volatile cleaning solution or solvent to remove accumulations of dust, dirt, grease and grit (see Figure 4.40-22). Dry with low pressure compressed air.

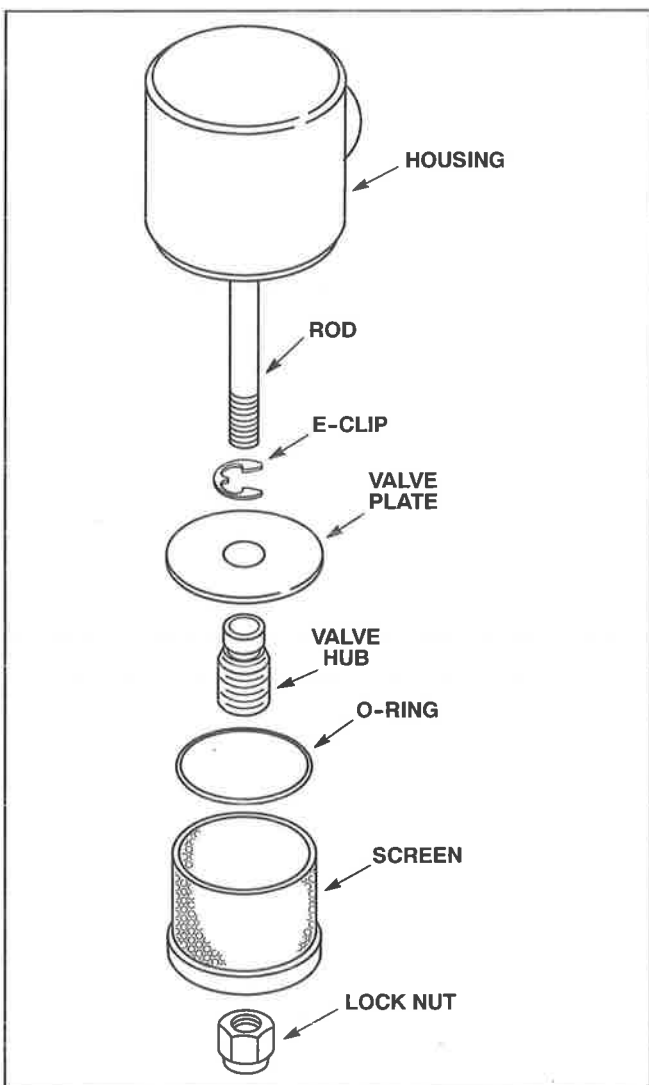


Figure 4.40-22. Breather Regulator Assembly

2. Inspect the regulator housing for cracks.
3. Inspect the regulator rod for scratches or burrs.
4. Inspect the O-ring for cuts, tears or loss of elasticity.

5. Inspect the valve plate for nicks, cracks or damage.

⚠ CAUTION If replacement of the breather regulator housing or valve assembly is necessary, be sure to order the correct part numbers. Since air flow requirements vary between engine models and applications, the housings and valves are sized or weighted differently and are not interchangeable. Disregarding this information could result in product damage.

6. Replace any parts of the assembly that are damaged or worn.

CRANKCASE PRESSURE RELIEF VALVES MAINTENANCE

To ensure that they are in proper working condition, the crankcase pressure relief valves should be exercised and inspected annually (see Figure 4.40-23). If removed, replace crankcase pressure relief valves in the same positions as received from the factory.

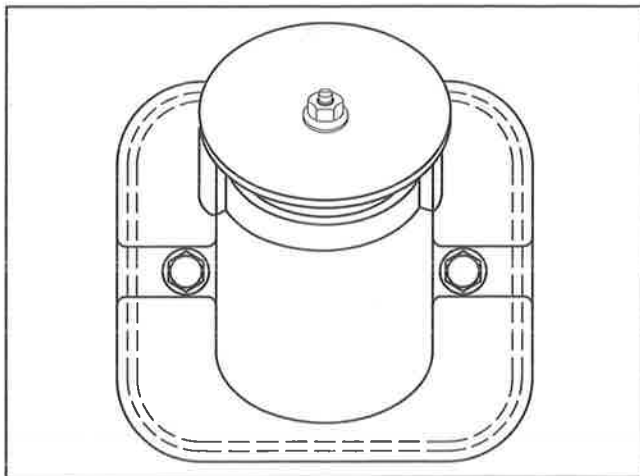


Figure 4.40-23. Crankcase Pressure Relief Valve

1. Shut down the engine and allow it to cool.
2. Lift the valve off its seat to verify that the plate is free to move.

⚠ WARNING

The number of pressure relief valves used on the engine depends on the volume of the crankcase. Never operate the engine without all valves on the engine. The ability of the system to function is dependent upon the proper number of relief valves. Operation without the proper type and number of relief valves, or if the relief valves are not properly maintained, can result in severe personal injury or death.

SECTION 4.45

PRELUBE AND STARTING SYSTEM MAINTENANCE

PRELUBE AND STARTING SYSTEM MAINTENANCE

⚠ WARNING

From the bulkhead, all gas vented from the system must be piped to a safe area in conformance with all applicable codes. Failure to comply could result in severe personal injury or death.

ELECTRIC STARTER SYSTEM MAINTENANCE

⚠ WARNING

Always disconnect electrical power during inspection of electrical components. Failure to comply could result in severe personal injury or death.

Inspect the starter motor and wiring for loose connections or frayed insulation (see Figure 4.45-1).

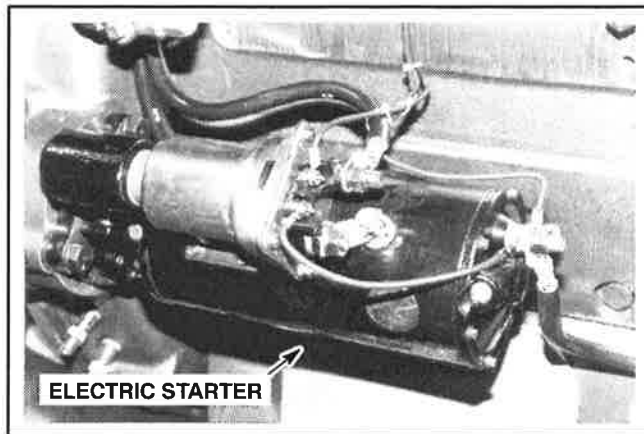


Figure 4.45-1. Electric Starter

AIR/GAS STARTER LUBRICATION RESERVOIR MAINTENANCE

1. Prior to each start check the air/gas starter reservoir for lubricant (see Figure 4.45-2 and Figure 4.45-3).

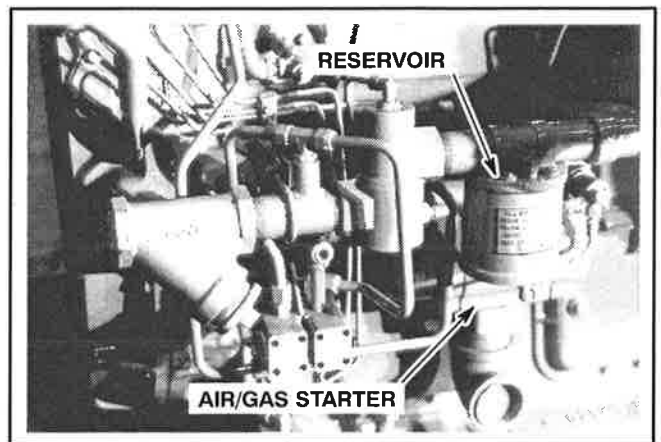


Figure 4.45-2. Air/Gas Starter

2. Remove the plug and fill the reservoir. DO NOT OVERFILL. Use the proper grade of oil. Add SAE 10W oil at 32° F (0° C) and above. Use No. 2 Diesel Oil when ambient temperatures fall below 32° F (0° C).

3. Replace the plug.

PRELUBE AND STARTING SYSTEM MAINTENANCE



Figure 4.45-3. Air/Gas Starter Reservoir

IN-LINE LUBRICATOR

⚠ WARNING

If high pressure gas is used to drive the air/gas prelude pump motor, vent the motor exhaust to a safe area in conformance with all applicable codes. Improper venting may result in severe personal injury or death.

NOTE: The air/gas starting system also has a lubrication reservoir. See Starting Systems for information.

The in-line lubricator injects oil into a stream of compressed air/gas to provide the internal lubrication of the air/gas operated prelude pump motor (see Figure 4.45-4).

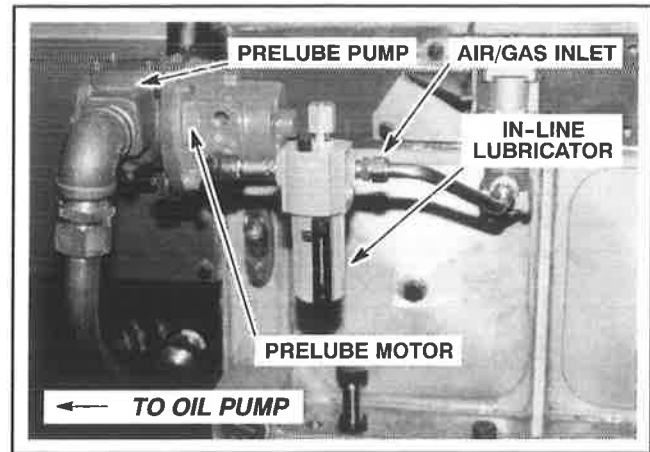


Figure 4.45-4. In-line Lubricator And Prelude Motor/Pump Assembly

⚠ CAUTION The lubricator is intended for systems using dry, clean natural gas. Any appreciable amount of hydrogen sulfide (H_2S), particularly when combined with moisture, will cause corrosion and adversely effect the lubricator and its operation. Disregarding this information could result in product damage and/or personal injury.

⚠ CAUTION From the point of use, some oil mist may escape into the surrounding atmosphere. Users are referred to OSHA safety and health standards for limiting oil mist contamination and use of protecting equipment. Disregarding this information could result in product damage and/or personal injury.

⚠ CAUTION The maximum operating temperature of the lubricator is 175° F (79° C). Disregarding this information could result in product damage and/or personal injury.

Oil Fill

Check the level of the in-line lubricator daily. The oil level must always be visible in the sight glass. Refill as follows:

1. With the inlet pressure shut off, slowly loosen the oil fill plug in the lubricator housing cover (see Figure 4.45-5). Loosening the plug exposes a bleed orifice that reduces pressure in the oil reservoir.

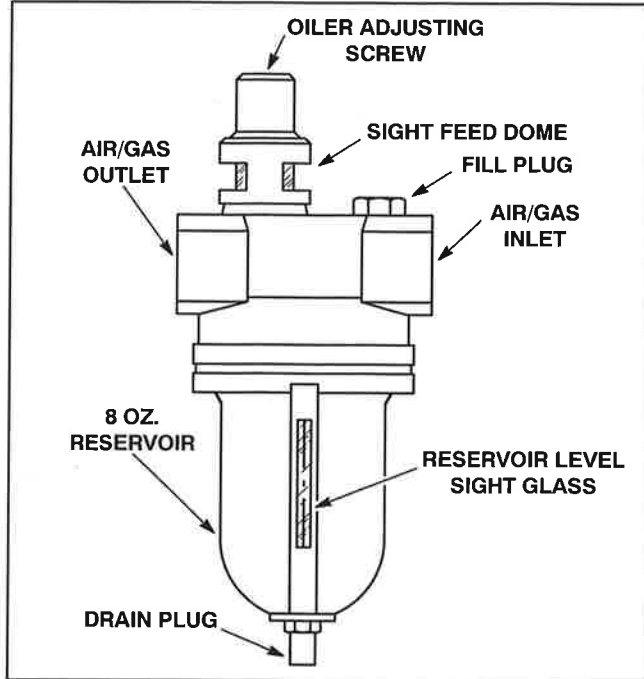


Figure 4.45-5. In-line Lubricator

CAUTION Insure that oil level of the in-line lubricator is always visible in the sight glass. **DO NOT OVERFILL** the reservoir. Failure to follow proper procedures could result in product damage and/or personal injury.

2. Remove the plug and fill the reservoir to the proper level. **DO NOT OVERFILL**. The oil level must always be visible in the sight glass. Use the proper grade of oil. Add SAE 10W oil at 32° F (0° C) and above. Use No. 2 Diesel Oil when ambient temperatures fall below 32° F (0° C).
3. Inspect the O-ring on the neck of the oil fill plug for tears, cuts or general deterioration. Replace as necessary.
4. Install the plug in the lubricator housing cover.

Adjustments

Periodically check the lubricator drip rate. If the prelube pump motor exhaust is oil-free or contains an excessive amount of oil, manual adjustment is necessary.

1. Locate the oiler adjusting screw at the top of the sight feed dome on the lubricator housing cover.
2. Pull the lock ring on the adjusting screw upward to release the drip rate setting.
3. Adjust the drip rate only when there is a constant rate of air/gas flow through the lubricator. Oil drops are

atomized by the air/gas flowing through the lubricator throat. Monitor the drip rate through the sight feed dome. All of the drops visible in the dome are delivered to the prelube pump motor.

4. Adjust the lubricator to provide a light oil vapor at the prelube motor exhaust (about 4 to 5 drops per minute). Turn the adjusting screw clockwise to decrease the drip rate, turn the screw counterclockwise to increase it.
5. Push the lock ring on the adjusting screw downward to lock the drip rate setting.
6. Monitor the prelube pump motor for a few days following the adjustment. Readjust the drip rate if necessary.

Cleaning

Clean the in-line lubricator monthly.

1. With the inlet pressure shut off, slowly loosen the oil fill plug in the lubricator housing cover. Loosening the plug exposes a bleed orifice that reduces pressure in the oil reservoir. Remove the oil fill plug.
2. Remove the drain plug at the bottom of the reservoir. Drain the oil.
3. Unthread the reservoir from the lubricator housing cover.
4. Inspect the O-ring on the upper lip of the reservoir for tears, cuts or general deterioration. Replace as necessary.

WARNING

Compressed air can pierce the skin and cause severe injury. Never use your hand to check for leaks or to determine air flow rates. Wear safety glasses to shield your eyes from flying dirt and debris. Disregarding this information could result in severe personal injury or death.

5. Clean the reservoir using soap and water. Dry parts and blow out internal body passages using clean, dry compressed air.
6. Inspect all parts carefully. Replace any parts that appear damaged.
7. Install the reservoir onto the lubricator housing cover and fully tighten the reservoir until it stops (approximately 5 turns). Unscrew the reservoir no more than one full turn to position the sight glass for best visibility.
8. Inspect the O-ring on the neck of the oil fill plug for tears, cuts or general deterioration. Replace as necessary. Install the plug in the lubricator housing cover.
9. Install the drain plug at the bottom of the lubricator reservoir.
10. Fill the lubricator reservoir with the proper grade and amount of oil (see Table 4.30-1 and Table 4.30-2).
11. Periodically check the drip rate. Readjust if necessary (see *In-line Lubricator, Adjustments*).

PRELUBE AND STARTING SYSTEM MAINTENANCE

SECTION 4.50

ENGINE PROTECTION SYSTEM MAINTENANCE

ENGINE PROTECTION SHUTDOWN SYSTEM MAINTENANCE

Maintenance of the engine protection shutdown system is generally limited to visual inspection of components.

WARNING

Switches for alarms and automatic engine shutdown must be supplied by the customer. The sensors provided are for measuring and monitoring temperatures and WILL NOT shut the engine down if potentially harmful temperatures are reached. Waukesha will not be responsible for any property damage, severe personal injury or death, due to the failure to follow these instructions.

K-TYPE THERMOCOUPLES INSPECTION

CAUTION Thermocouples can be extremely hot. Allow engine to cool prior to handling thermocouple. Failure to follow these procedures could result in severe personal injury.

1. Inspect the thermocouples (see Figure 4.50-1) to insure they are securely seated.

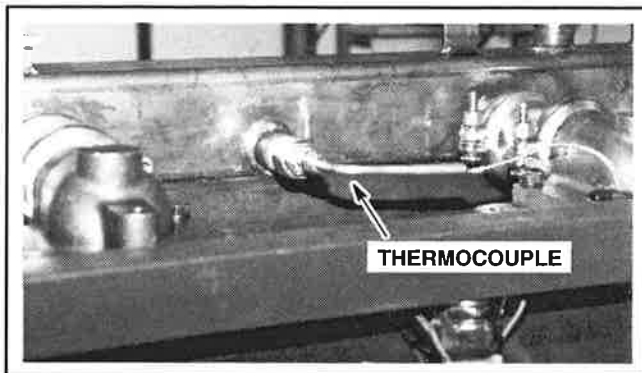


Figure 4.50-1. Jacket Water Temperature Sensor - 5115GL Engine Shown

2. Inspect connecting cables and wires for loose connections, broken wires or insulation.

MANUAL SHUTDOWN LEVER MAINTENANCE

WARNING

Always insure that the fuel gas valve(s) are closed after engine shutdown. Failure to close fuel gas valve(s) could cause severe personal injury or death.

1. Inspect the manual shutdown lever for proper operation (see Figure 4.50-2). With the engine running under no load, move the lever to the CLOSED position, the engine should return to idle speed.

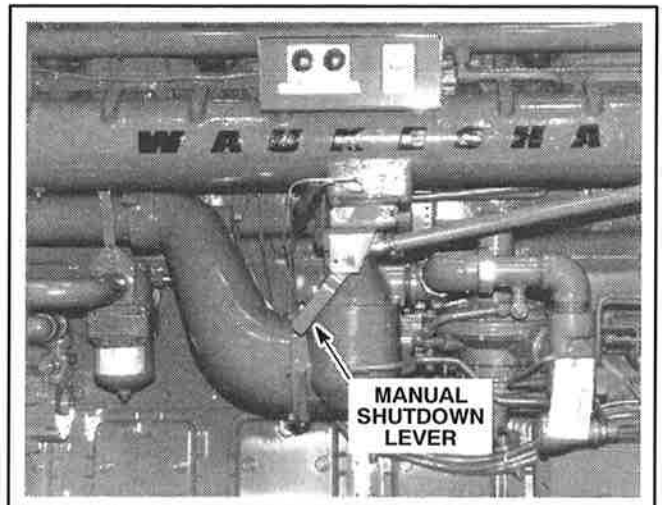


Figure 4.50-2. Manual Shutdown Lever - 12 Cylinder VHP GL Shown

PRESSURE AND TEMPERATURE SWITCHES CALIBRATION

Calibrating and testing pressure and temperature switches, should be performed by qualified service technicians every 90 days.

OPTIONAL INSTRUMENT PANEL

Inspect the instrument panel to insure the gauges are operating.

ENGINE PROTECTION SYSTEM MAINTENANCE

DETONATION SENSING MODULE AND SENSORS

CAUTION Sensors can be extremely hot. Allow engine to cool prior to handling sensors. Failure to follow these procedures could result in severe personal injury.

1. Inspect the detonation sensors to insure they are seated (see Figure 4.50-3). Refer to Form 6268, *DSM Custom Engine Control® Detonation Sensing Module Installation, Operation, And Maintenance Manual* for further information.




Figure 4.50-3. Detonation Sensor - VHP Series

SECTION 4.55

VALVE ADJUSTMENT

VALVE ADJUSTMENT


INTAKE AND EXHAUST VALVES - ADJUSTMENT - 5115GL ENGINES ONLY

 **CAUTION** In any procedure where the rocker arms may have been removed or disturbed, the cylinder head replaced, or if it is suspected that the valves may have been adjusted incorrectly, do not rotate the crankshaft until all rocker arm adjusting screws have been completely backed off. Failure to back off the adjusting screws in these situations, may cause collision between valves and pistons, and severe engine damage.

NOTE: The 5115GL engine uses solid valve lifters.

This section describes the proper procedure to adjust the valve clearance on 5115GL engines. The correct valve clearance setting is 0.016 in. (0.406 mm) on the intake valves and 0.036 in. (0.914 mm) on the exhaust side valves. The valves will be set in the order listed in Table 4.55-1.

To compensate for slight differences in wear between the valves and valve seats, adjust the valves every 3 months (2160 hours). Install new rocker arm cover gaskets when the valve adjustments are performed.

 **CAUTION** Shut the engine down and allow it to cool for at least one hour before adjusting the valves. Disregarding this information could result in product damage and/or personal injury.

1. Refer to Section 4.10 - Ignition System Maintenance, *Spark Plug Maintenance*, and remove the spark plug cables from the ignition coils and pull out the spark plug extensions.

Table 4.55-1. Valve Settings - 5115GL Engines Only

SET VALVES ON CYLINDER	WHEN VALVES OVERLAP ON MATING CYLINDER
Column A	Column B
1R	6R
6L	1L
5R	2R
2L	5L
3R	4R
4L	3L
6R	1R
1L	6L
2R	5R
5L	2L
4R	3R
3L	4L

Column A shows the cylinder firing order.

NOTE: A special tool (Tool P/N 494287) may be used for removing the rocker arm cover capscrews. The same tool can also be used for loosening the valve lifter capscrews and rocker arm adjusting screws, enabling the operator to perform multiple operations without switching tools.

2. Remove the rocker arm cover capscrews, washers and spark plug cable clips (2 capscrews per cover).

3. Remove the rocker arm covers. Use a rubber mallet to loosen the covers, if necessary.

NOTE: Right bank and left bank are determined by standing at the flywheel end of the engine facing the flywheel (see Figure 4.55-1). The cylinders farthest from the flywheel on the right and left side are the #1R and #1L cylinders, respectively. Those closest to the flywheel are the #6R and #6L cylinders.

VALVE ADJUSTMENT

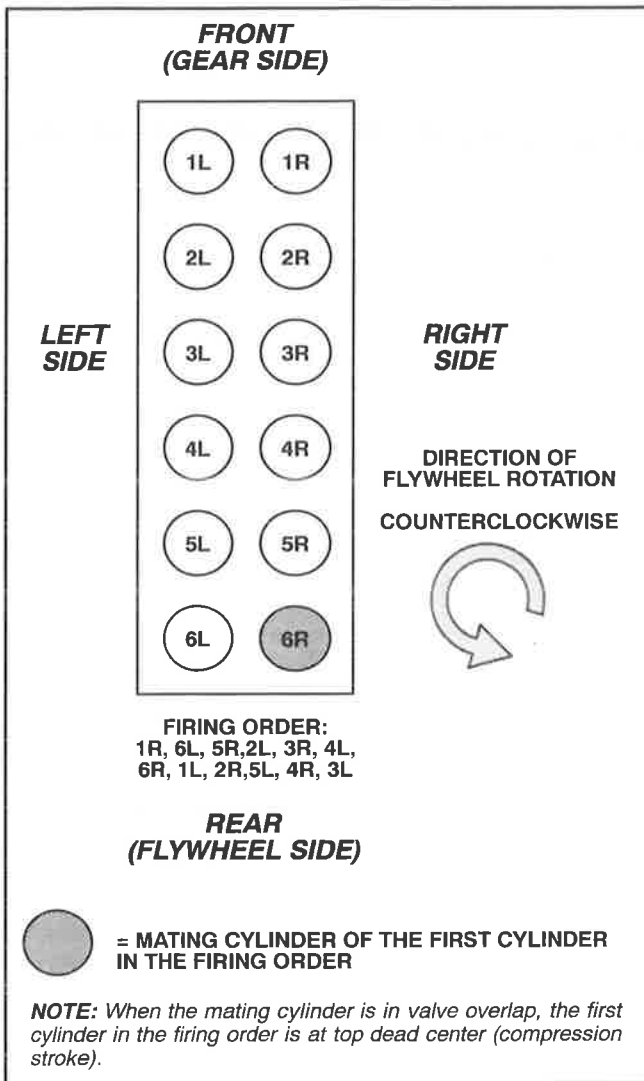


Figure 4.55-1. Engine Firing Order And Direction Of Rotation - 5115GL Engine

NOTE: Set the valves in the order that the engine fires (see Table 4.55-1). The cylinder firing order also appears on the nameplate on the left front side of the engine below the intake manifold (see Figure 4.55-3). Each piston must be brought into top dead center position, compression stroke.

4. Using the engine barring device (see Figure 4.55-2), bar the engine over in a counter-clockwise direction (facing the flywheel) until the piston of the first cylinder in the firing order, which is the #1R cylinder, is at top dead center (compression stroke) (see Table 4.55-1).

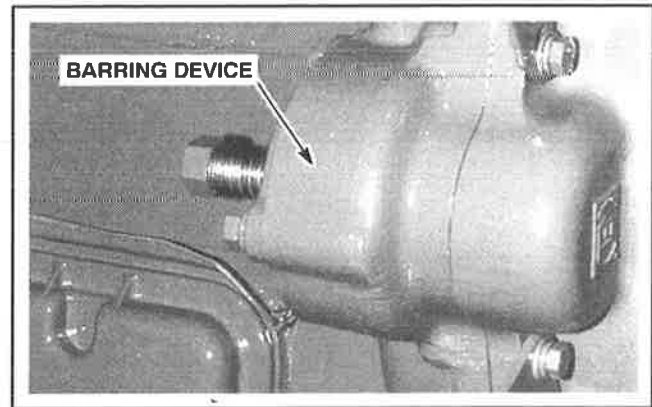


Figure 4.55-2. Engine Barring Device


To determine when this piston is at top dead center (compression stroke), watch the rocker arms and valves on its mating cylinder (see Table 4.55-1 and Figure 4.55-1). As the exhaust valves on the mating cylinder are closing, the intake valves begin to open. At this point, the mating cylinder is in valve overlap (all four valves partially open). This means that all four valves on the #1R cylinder, are fully closed. The #1R cylinder is now at top dead center (compression stroke).

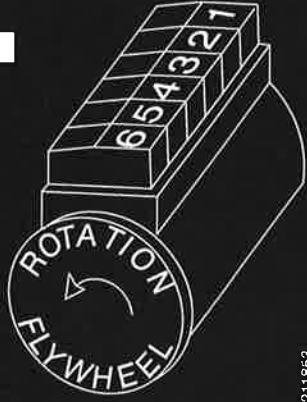
CAUTION Insure that adequate side clearance is allowed for between the rocker arm supports and the rocker arm assemblies, when tightening the rocker arm support capscrews, to prevent the rocker arm assemblies from binding. Failure to allow for adequate clearance, may cause damage to equipment.

NOTE: To obtain the proper end clearance between the intake and exhaust rocker arms and the support, place a feeler gauge 0.015 - 0.020 in. (0.381 - 0.508 mm) for the exhaust rocker arm, and 0.010 - 0.015 in. (0.254 - 0.381 mm) for the intake rocker arm, between one end of the rocker arm and the support. The adjusting screw tappets should be centered on the valve stem tips. If the tappets are not properly centered, loosen the two hex head capscrews and slightly shift the rocker arm support. After the best position is obtained, torque the rocker arm support capscrews to 55 - 60 ft-lb (75 - 81 N·m).

5. Insure that the two fixed screws (see Figure 4.55-4) are fully seated. The fixed screws must be torqued to 55 - 60 ft-lb (75 - 81 N·m). These are fixed position screws and are not used in this valve adjustment procedure.

6. Loosen the lock nuts and adjusting screws at all four valve stem tips (see Figure 4.55-4).

MODEL	<input type="text"/>	Waukesha WAUKESHA ENGINE DIVISION DRESSER INDUSTRIES INC. WAUKESHA, WISCONSIN U.S.A. 	SAA #	<input type="text"/>	SERVICE TYPE	<input type="text"/>
SERIAL NUMBER	<input type="text"/>		DATE	<input type="text"/>		
COMP. RATIO	<input type="text"/>					
THIS ENGINE IS FACTORY EQUIPPED AS LISTED. HP (kW) ARE PER ISO 3046/1. CONSULT A W.E.D. AUTHORIZED DISTRIBUTOR OR W.E.D. APPLICATION ENGINEERING FOR ADDITIONAL INFORMATION.						
	PRIMARY	SECONDARY		ALTITUDE LIMIT FT/m		
FUEL	<input type="text"/>	<input type="text"/>		<input type="text"/>		
MIN. W.K.I. TM	<input type="text"/>	<input type="text"/>		<input type="text"/>		
IGN. TIMING ° BTDC	<input type="text"/>	<input type="text"/>		GOVERNED SPEED RPM	<input type="text"/>	
CARB ADJ.	<input type="text"/>	<input type="text"/>		VALVE CLEARANCE IN. /mm	INTAKE	EXHAUST
SERVICE HP/kW	<input type="text"/>	<input type="text"/>		<input type="text"/>	<input type="text"/>	<input type="text"/>
OVERLOAD HP/kW	<input type="text"/>	<input type="text"/>		<input type="text"/>	<input type="text"/>	<input type="text"/>
FIRING ORDER	<input type="text"/>					



P/N 211853

Figure 4.55-3. Nameplate - Current Production

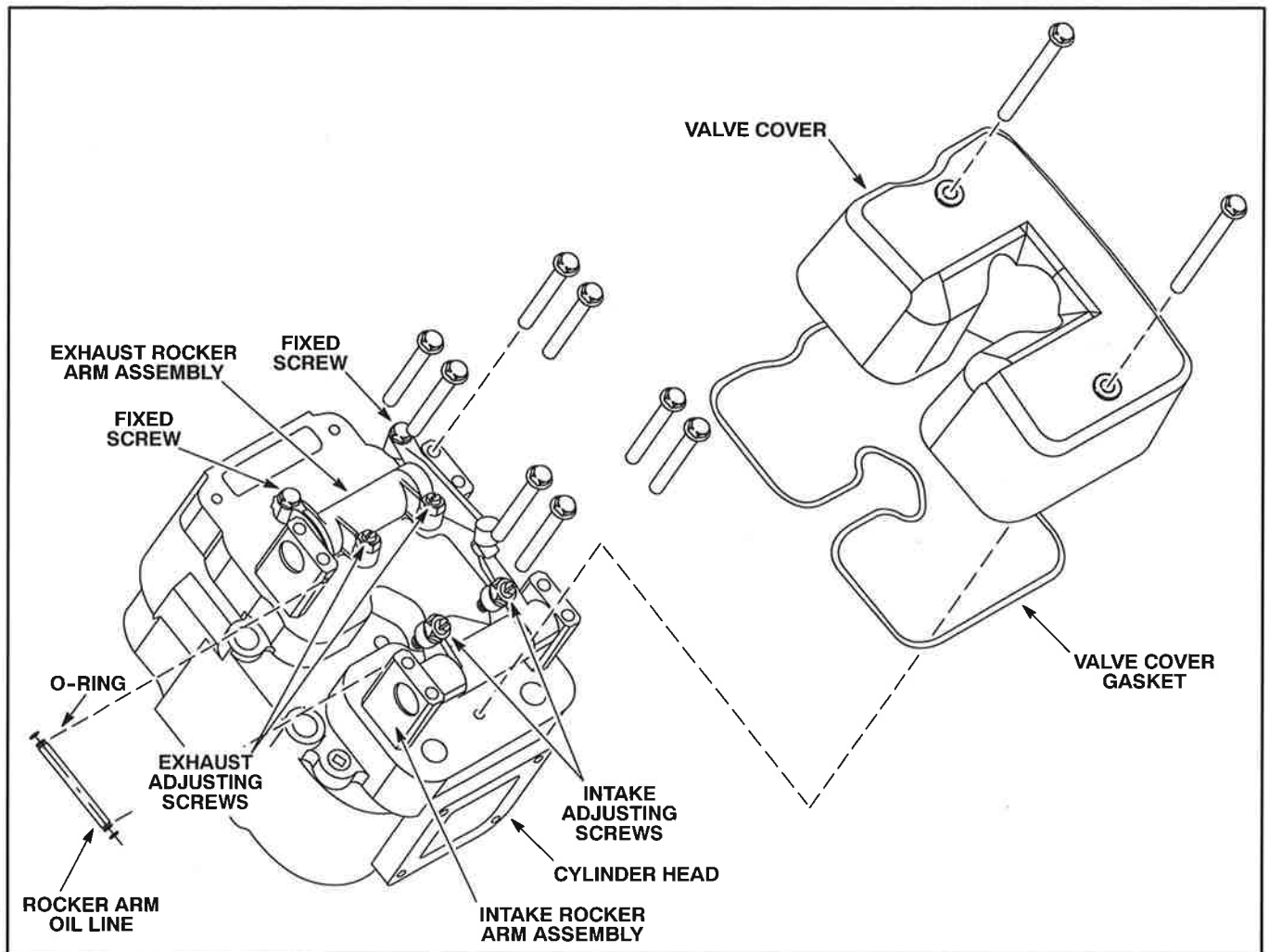


Figure 4.55-4. Rocker Arm Assembly - All Engines Similar

VALVE ADJUSTMENT

7. Insert 0.016 in. (0.406 mm) feeler gauges (see Figure 4.55-5 and Figure 4.55-6) between the intake valve adjusting screws and the valve stem tips. Use a screwdriver to turn the valve adjusting screws down until a slight drag is felt when trying to remove the feeler gauges. Hold the adjusting screws in this position while using a wrench to lock the adjusting screw nuts. Recheck the clearance to insure that the adjusting screws did not rotate while locking the adjusting screw lock nuts.

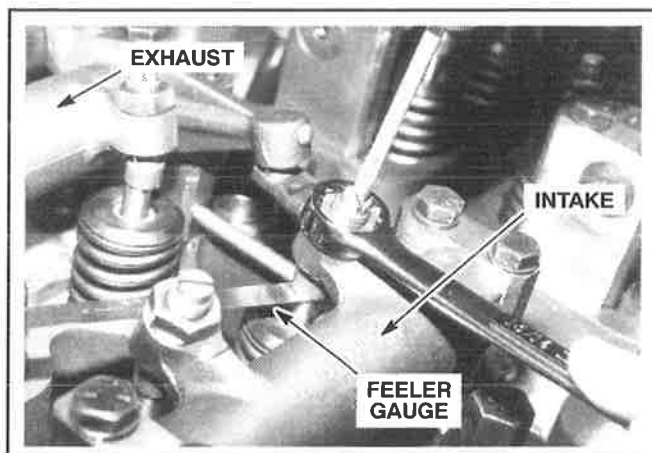


Figure 4.55-5. Rocker Arms

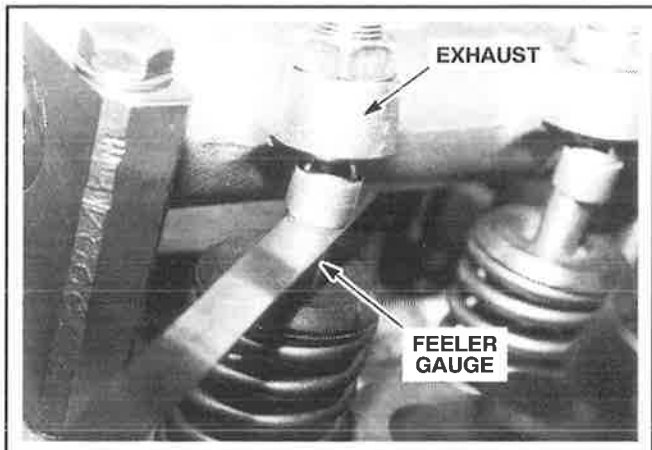


Figure 4.55-6. Rocker Arms

8. Insert 0.036 in. (0.914 mm) feeler gauges between the exhaust valve adjusting screws and the valve stem tips. Use a screwdriver to turn the valve adjusting screws down until a slight drag is felt when trying to remove the feeler gauges. Hold the adjusting screws in this position while using a wrench to lock the adjusting screw nuts. Recheck the clearance to insure that the adjusting screws did not rotate while locking the adjusting screw lock nuts.

9. Rotate the engine counter - clockwise to the next cylinder in the firing order, top dead center (compression stroke). Repeat the above procedures for each cylinder

in the firing order (see Table 4.55-1). Watch each mating cylinder for valve overlap.

10. After all valves are adjusted and before starting the engine. Use the engine barring device to manually rotate the engine in a counter-clockwise direction, to be certain that no oversights have occurred which might cause valve and piston interference.

11. Scrape the old gasket material from the valve covers.

12. Scrape the old gasket material from the cylinder heads.

13. Verify that the rocker arm cover and cylinder head gasket surfaces are clean and completely free of grease and oil.

14. Place new gaskets on the rocker arm covers.

CAUTION Carefully check the cylinder head for any old gasket debris before installing the rocker arm covers. Failure to clean off old gasket debris could cause oil leaks.

15. Position the rocker arm covers on the cylinder heads. Install the washers, spark plug cable clips and rocker arm cover capscrews (2 capscrews per cover).

16. Torque the rocker arm cover capscrews 30 - 35 ft-lb (41 - 47 N·m) oiled.

17. Refer to *Spark Plug Installation* and install the spark plugs, spark plug extension, recess covers, and spark plug cables.

**INTAKE AND EXHAUST VALVES -
ADJUSTMENT - 6, 12 AND 16 CYLINDER VHP
GAS ENGINES - EXCLUDING 5115GL**

CAUTION In any procedure where the rocker arms may have been removed or disturbed, the cylinder head replaced, or if it is suspected that the valves may have been adjusted incorrectly, do not rotate the crankshaft until all rocker arm adjusting screws have been completely backed off. Failure to back off the adjusting screws in these situations, may cause collision between valves and pistons, and severe engine damage.

NOTE: All VHP gas engines, with the exception of 5115GL engines, use hydraulic valve lifters.

To compensate for slight differences in wear between the valves and valve seats, adjust the valve clearance every 3 months (2160 hours). Install new rocker arm cover gaskets when the valve adjustments are performed.

CAUTION Shut the engine down and allow it to cool for at least one hour before adjusting the valves. Disregarding this information could result in product damage and/or personal injury.

1. Refer *Spark Plug Removal* and remove the spark plug cables from the ignition coils and pull out the spark plug extensions.

2. Remove the rocker arm cover capscrews, washers and spark plug cable clips (2 capscrews per cover).

NOTE: A special tool (Tool P/N 494287) may be used for removing the rocker arm cover capscrews. The same tool can also be used for loosening the valve lifter capscrews and rocker arm adjusting screws, enabling the operator to perform multiple operations without switching tools.

3. Remove the rocker arm covers. Use a rubber mallet to loosen the covers, if necessary.

Table 4.55-2. Valve Settings 6, 12, And 16 Cylinder VHP Gas Engines - Excluding 5115GL

6 CYLINDER ENGINE		12 CYLINDER ENGINE		16 CYLINDER ENGINE		
SET VALVES ON CYLINDER	WHEN VALVES OVERLAP ON MATING CYLINDER	SET VALVES ON CYLINDER	WHEN VALVES OVERLAP ON MATING CYLINDER	SET VALVES ON CYLINDER	WHEN VALVES OVERLAP ON MATING CYLINDER	
Column A	Column B	Column A	Column B	Column A	Column B	
1	6	1R	6R	1R	8R	
5	2	6L	1L	1L	8L	
3	4	5R	2R	3R	6R	
6	1	2L	5L	3L	6L	
2	5	3R	4R	7R	2R	
4	3	4L	3L	7L	2L	
Column A Shows the cylinder firing order. Value in column A added to value in column B always equals 7.		6R	1R	5R	4R	
		1L	6L	5L	4L	
		2R	5R	8R	1R	
		5L	2L	8L	1L	
		4R	3R	6R	3R	
		3L	4L	6L	3L	
			2R	7R		
			2L	7L		
			4R	5R		
			4L	5L		
			Column A Shows the cylinder firing order. Value in column A added to value in column B always equals 7.		Column A Shows the cylinder firing order. Value in column A added to value in column B always equals 9.	

NOTE: On 12 and 16 cylinder engines, right bank and left bank are determined by standing at the flywheel end of the engine facing the flywheel. The cylinders farthest from the flywheel on the right and left side are the #1R and #1L cylinders, respectively. On 6 cylinder engines, the cylinder farthest from the flywheel is the #1 cylinder, the closest, the #6 cylinder.

VALVE ADJUSTMENT

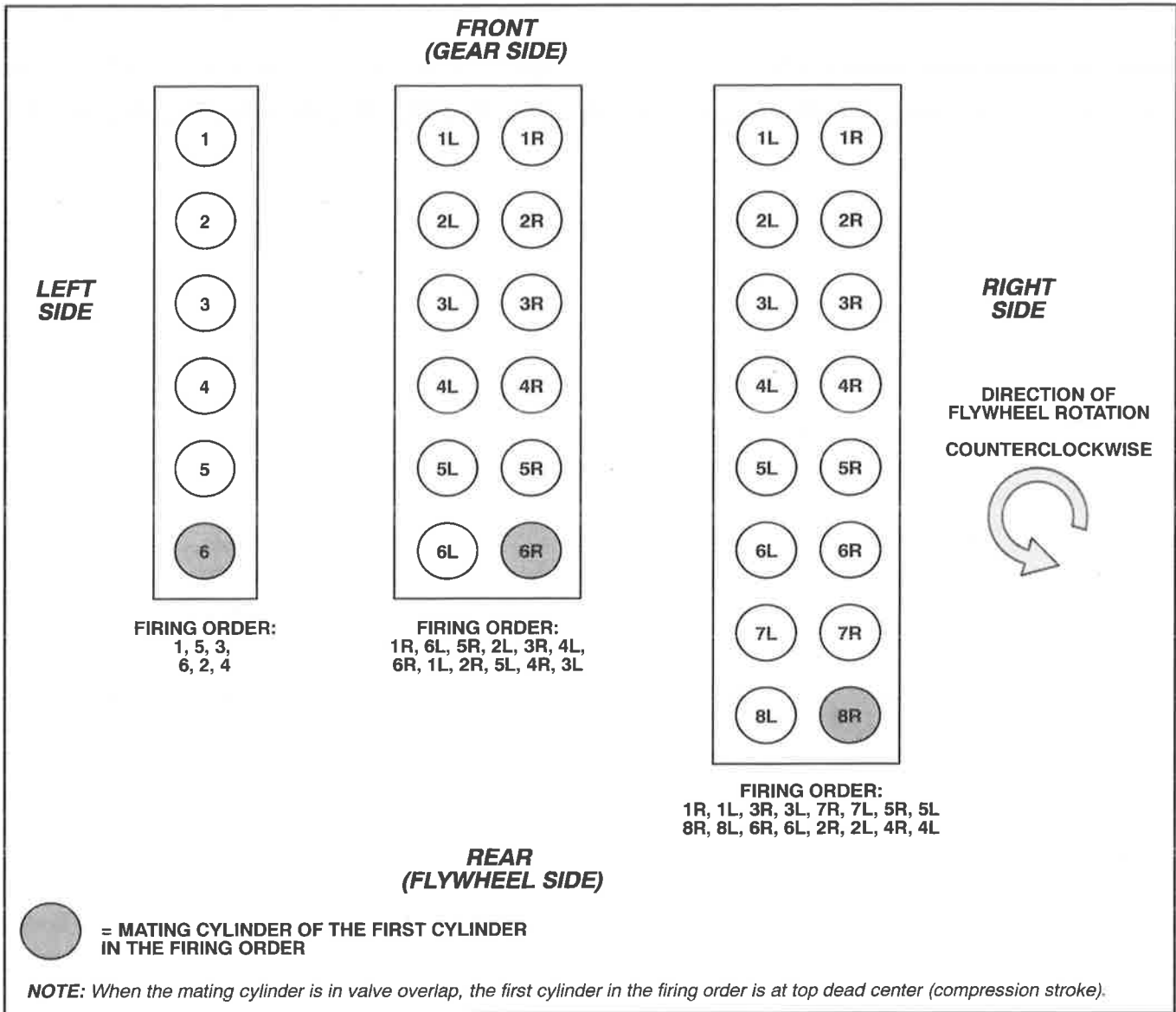

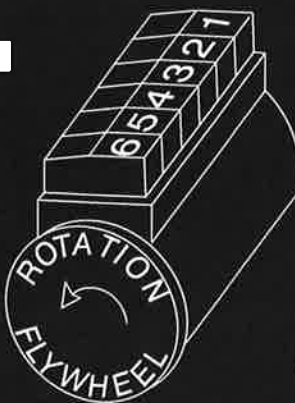


Figure 4.55-7. Engine Firing Order And Direction Of Rotation - 6, 12, And 16 Cylinder Engine, Excluding 5115GL

MODEL	<input type="text"/>	Waukesha WAUKESHA ENGINE DIVISION DRESSER INDUSTRIES INC. WAUKESHA, WISCONSIN U.S.A. 	SAA #	<input type="text"/>	SERVICE TYPE	<input type="text"/>
SERIAL NUMBER	<input type="text"/>		DATE	<input type="text"/>		
COMP RATIO	<input type="text"/>					
THIS ENGINE IS FACTORY EQUIPPED AS LISTED. HP(kW) ARE PER ISO 3046/1. CONSULT A W.E.D. AUTHORIZED DISTRIBUTOR OR W.E.D. APPLICATION ENGINEERING FOR ADDITIONAL INFORMATION.						
	PRIMARY	SECONDARY		ALTITUDE LIMIT FT/m		
FUEL	<input type="text"/>	<input type="text"/>		<input type="text"/>		
MIN. WKT ¹⁰	<input type="text"/>	<input type="text"/>		<input type="text"/>		
IGN. TIMING ° BTDC	<input type="text"/>	<input type="text"/>		GOVERNED SPEED RPM	<input type="text"/>	
CARB ADJ.	<input type="text"/>	<input type="text"/>		VALVE CLEARANCE IN. /mm		
SERVICE HP/kW	<input type="text"/>	<input type="text"/>		INTAKE	<input type="text"/>	<input type="text"/>
OVERLOAD HP/kW	<input type="text"/>	<input type="text"/>		EXHAUST	<input type="text"/>	<input type="text"/>
FIRING ORDER	<input type="text"/>					



P/N 211953

Figure 4.55-8. Nameplate - Current Production

NOTE: Set the valves in the order that the engine fires (see Table 4.55-2). The cylinder firing order appears on the engine nameplate (see Figure 4.55-8). Each piston must be brought into top dead center position, compression stroke.

4. Using the engine barring device (see Figure 4.55-9), bar the engine over in a counter-clockwise direction (facing the flywheel) until the piston of the first cylinder in the firing order, is at top dead center (compression stroke) (see Table 4.55-2).

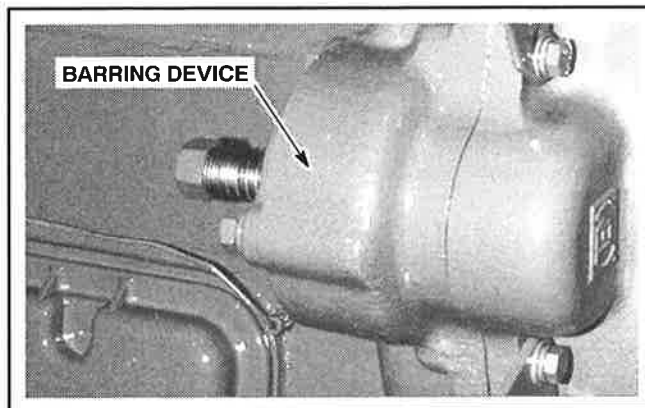


Figure 4.55-9. Engine Barring Device

To determine when this piston is at top dead center (compression stroke), watch the rocker arms and valves on its mating cylinder (see Table 4.55-2 and Figure 4.55-7). As the exhaust valves on the mating cylinder are closing, the intake valves begin to open. At this point, the mating cylinder is in valve overlap (all four valves partially open). This means that all four valves

on the first cylinder in the firing order, are fully closed. The first cylinder in the firing order is now at top dead center (compression stroke).

CAUTION Insure that adequate side clearance is allowed for between the rocker arm supports and the rocker arm assemblies, when tightening the rocker arm support capscrews, to prevent the rocker arm assemblies from binding. Failure to allow for adequate clearance, may cause damage to equipment.

NOTE: To obtain the proper end clearance between the intake and exhaust rocker arms and the support, place a feeler gauge 0.015 - 0.020 in. (0.381 - 0.508 mm) for the exhaust rocker arm, and 0.010 - 0.015 in. (0.254 - 0.381 mm) for the intake rocker arm, between one end of the rocker arm and the support. The adjusting screw tappets should be centered on the valve stem tips. If the tappets are not properly centered, loosen the two hex head capscrews and slightly shift the rocker arm support. After the best position is obtained, torque the rocker arm support capscrews to 55 - 60 ft-lb (75 - 81 N·m).

VALVE ADJUSTMENT

5. Loosen the lock nuts and adjusting screws at all four valve stem tips (see Figure 4.55-10).

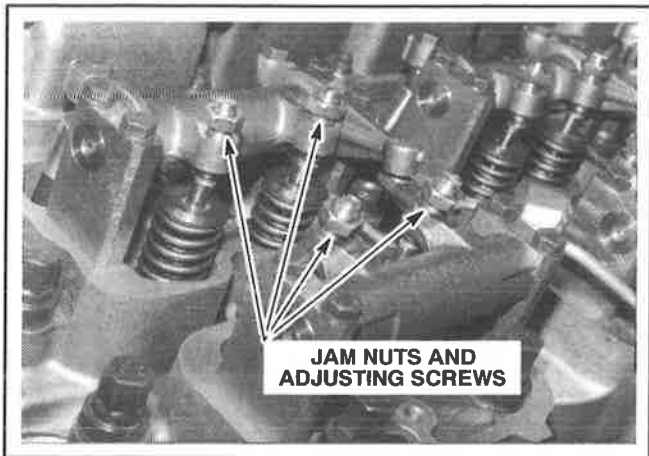


Figure 4.55-10. Rocker Arms

6. Look for cracks or breakage around the ball and tappet insert of the rocker arm adjusting screws (see Figure 4.55-11 and Figure 4.55-12). Verify that the ball rotates freely in all directions without binding. Replace the adjusting screw, if necessary.

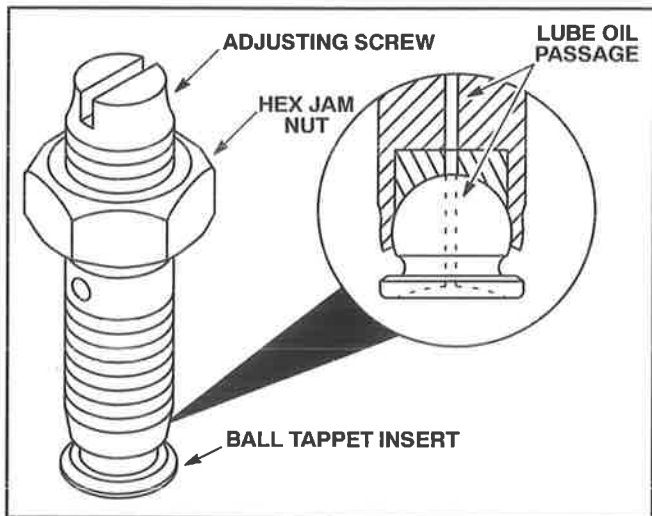


Figure 4.55-11. Previous Rocker Arm Adjusting Screws

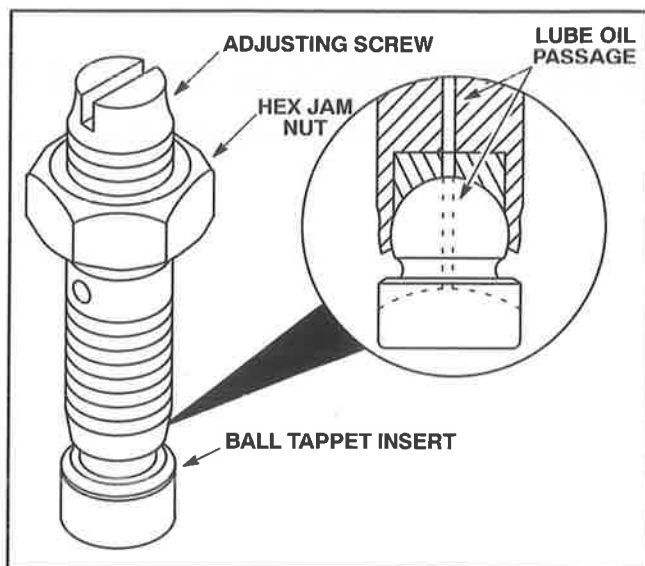


Figure 4.55-12. Current Rocker Arm Adjusting Screws

7. Mark the two fixed valve lifter screws (see Figure 4.55-14). Back out the fixed screws 1/2 turn to remove the preload from the hydraulic lifters. Verify that the hydraulic lifter plunger is fully extended up against the C-clip (see Figure 4.55-13).

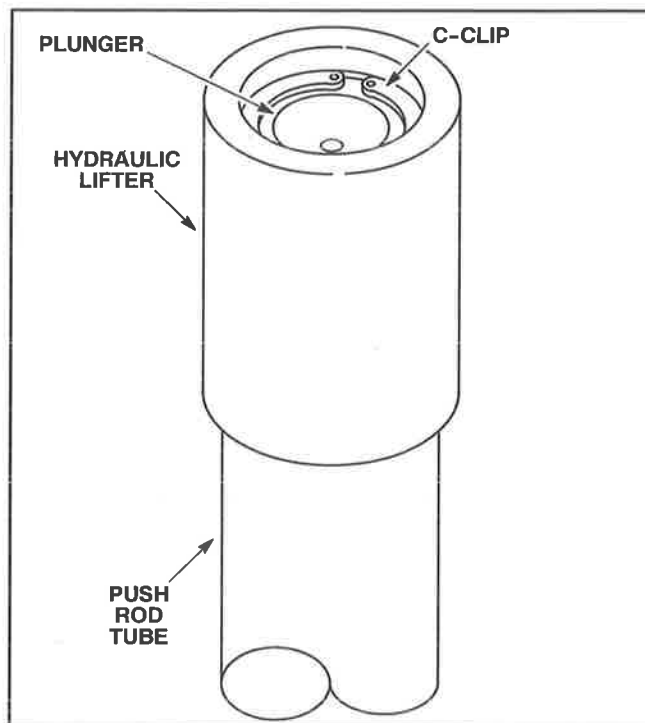


Figure 4.55-13. Hydraulic Lifter

8. Raise the intake rocker arm until it just contacts the intake actuator. Turn the intake rocker arm adjusting screw (closest to the actuator arm) down until the ball and tappet contacts the valve stem. Snugly center the tappet on the valve stem tip.

NOTE: Use finger pressure only when turning the rocker arm adjusting screws.

9. Verify that the fixed valve lifter screw just contacts, but does not depress, the hydraulic lifter plunger.

10. Using a valve adjusting wrench (P/N 494287) and screwdriver (see Figure 4.55-14), tighten the hex jam nut to lock the setting of the first intake rocker arm adjusting screw.

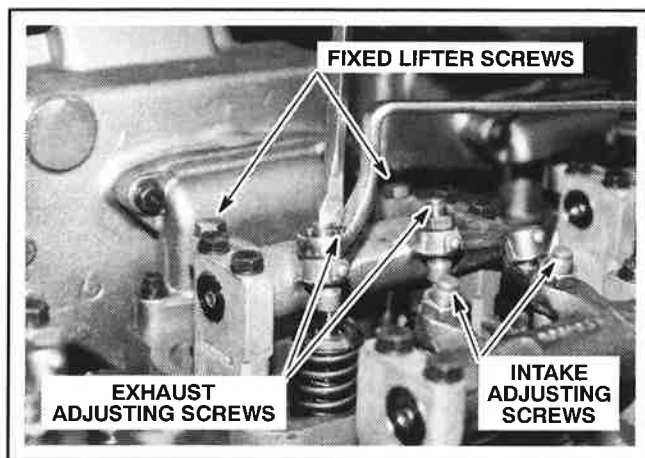


Figure 4.55-14. Valve Adjusting Wrench

NOTE: When tightening the hex jam nut, hold the rocker arm adjusting screw with a screwdriver. This method holds the adjusting screw while tightening the jam nut, without disturbing the setting of the adjusting screw.

11. Holding the tappet of the adjusting screw against the valve stem tip, turn the other intake rocker arm adjusting screw down until the tappet contacts the valve stem. Eliminate any play.

12. Tighten the hex jam nut, to lock the setting of the second intake rocker arm adjusting screw.

13. Rotate the tappets of the two intake rocker arm adjusting screws to feel for equal contact with the valve stem tips. If a tappet cannot be rotated, or if it rotates too freely, loosen the jam nut and readjust the screw.

14. Turn the exhaust rocker arm adjusting screw down until the tappet contacts the valve stem. Snugly center the tappet on the valve stem tip.

15. Verify that the fixed valve lifter screw just contacts, but does not depress, the hydraulic lifter plunger.

16. Tighten the hex jam nut to lock the setting of the first exhaust rocker arm adjusting screw.

17. Holding the tappet of the adjusting screw against the valve stem tip, turn the other exhaust rocker arm

adjusting screw down until the tappet contacts the valve stem. Eliminate any play.

18. Tighten the hex jam nut to lock the setting of the second exhaust rocker arm adjusting screw.

19. Rotate the tappets of the two exhaust rocker arm adjusting screws to feel for equal contact with the valve stem tips. Readjust, if necessary.

20. Turn the two fixed valve lifter screws clockwise 1/2 turn to their original setting. Preloading the hydraulic lifter backs the plunger off the C-clip and moves it into the upper range of lifter travel. Torque each valve lifter screw to 55 - 60 ft-lb (75 - 81 N-m).

21. Rotate the tappets of the two intake and two exhaust rocker arm adjusting screws to feel for equal contact with the valve stem tips.

22. Rotate the engine counter - clockwise to the next cylinder in the firing order, top dead center (compression stroke). Repeat the above procedures for each cylinder in the firing order (see Table 4.55-2 and Figure 4.55-7). Watch each mating cylinder for valve overlap.

23. After all valves are adjusted and before starting the engine. Use the engine barring device to manually rotate the engine in a counter-clockwise direction, to be certain that no oversights have occurred which might cause valve and piston interference.

24. Scrape the old gasket material from the valve covers.

25. Scrape the old gasket material from the cylinder heads.

26. Verify that the rocker arm cover and cylinder head gasket surfaces are clean and completely free of grease and oil.

27. Place new gaskets on the rocker arm covers.

CAUTION Carefully check the cylinder head for any old gasket debris before installing the rocker arm covers. Disregarding this information could result in product damage and/or personal injury.

28. Position the rocker arm covers on the cylinder heads. Install the washers, spark plug cable clips and rocker arm cover capscrews (2 capscrews per cover).

29. Torque the rocker arm cover capscrews to 30 - 35 ft-lb (41 - 47 N-m) oiled.

30. Install the spark plug extensions. Fit the rubber recess cover into the top of each spark plug carrier.

VALVE ADJUSTMENT

SECTION 4.60

MAINTENANCE SCHEDULE

MAINTENANCE SCHEDULE

Table 4.60-1. Routine Maintenance Chart

ITEM	SERVICE	DAILY OR AS REQUIRED	WEEKLY	MONTHLY	EVERY 3 MONTHS	EVERY 6 MONTHS	ANNUALLY	100 HRS.	250 HRS.	500 HRS.	720 HRS.	1,000 HRS.	1,500 HRS.	2,500 HRS.	4,000 HRS.	8,000 HRS.
Air Cleaner Filter Element	Check/Clean or Replace	•														
Air Starter Lubricator	Check/Fill	•														
Control Rod Ends and Linkage	Clean/Lubricate	•														
Cooling Systems Fluid Level (Jacket and Auxiliary)	Check/Fill	•														
Crankcase Oil Level	Check/Fill	•														
Governor Oil Level	Check/Fill	•														
Oil Filter	Release Trapped Air	•														
Precleaner Element	Check/Clean or Replace	•														
Prelube Motor Reservoir	Check/Fill	•														
Battery Electrolyte	Check/Fill		•													
Cooling Water Analysis	Check/Fill		•													
Belt Tension	Check		•													
Ignition Cables, Primary and Secondary Connect.	Inspect		•													
Water Temperature Gauge	Test				•											
Crankcase Pressure	Check				•											
Oil Pressure Safety	Test				•											
Safety Controls	Test				•											
Valve Clearance	Adjust				•											
Valve Cover Gasket	Replace				•											
Admission Valve Assembly	Clean or Replace					•										
Admission Valve O-Ring	Replace					•										
Electric Starter Bearings	Lubricate					•										

Continued

MAINTENANCE SCHEDULE

ITEM	SERVICE	DAILY OR AS REQUIRED	WEEKLY	MONTHLY	EVERY 3 MONTHS	EVERY 6 MONTHS	ANNUALLY	100 HRS.	250 HRS.	500 HRS.	720 HRS.	1,000 HRS.	1,500 HRS.	2,500 HRS.	4,000 HRS.	8,000 HRS.
Governor-Synchronizer Motor Bearings	Lubricate					•										
Turbocharger	Clean and Inspect					•										
Cooling System (Jacket and Auxiliary)	Clean and Flush						•									
Crankcase Oil Pickup Screen	Clean						•									
Exhaust Back Pressure	Check						•									
Full Flow Filter Relief Valve	Inspect						•									
High Tension Wires	Replace						•									
Ignition Primary Terminals, Harness Plug	Inspect						•									
Governor-Synchronizer Motor Reduction Gears	Lubricate						•									
Jacket Water Hoses	Replace						•									
Oil Pan	Clean						•									
Engine Oil (Excess of Continuous Duty, See Table 4.30-11, Table 4.30-12, and Table 4.30-13)*	Change								•							
Control Linkage	Clean and Lubricate										•					
Engine Oil	Analysis										•					
Fan Hub And idler Pulley Bearings	Lubricate										•					
Auxiliary Water Pump	Inspect/Lubricate										•					
Spark Plugs (or as required)	Clean and Regap											•				
Engine Protection Devices	Inspect											•				
Engine Oil & Filter (Standby Service, See Table 4.30-11, Table 4.30-12, and Table 4.30-13)*	Change												•			
Engine Oil (Continuous Duty, See Table 4.30-11, Table 4.30-12, and Table 4.30-13)*	Change												•			
Governor Rod Ends	Lubricate												•			
Ignition Timing	Check												•			
Lube Oil Strainer Element	Clean												•			
Magnetic Plugs	Clean												•			
Oil Cooler (Oil Side)	Drain												•			
Oil Filter Elements	Replace												•			
Crankcase Breather	Clean												•			
Oil Separators	Clean												•			
Water Pump Idler Pulley Bearings	Lubricate												•			
Spark Plugs (2500 - 4000 hours or as required)	Replace													•		

Continued

MAINTENANCE SCHEDULE

ITEM	SERVICE	DAILY OR AS REQUIRED	WEEKLY	MONTHLY	EVERY 3 MONTHS	EVERY 6 MONTHS	ANNUALLY	100 HRS.	250 HRS.	500 HRS.	720 HRS.	1,000 HRS.	1,500 HRS.	2,500 HRS.	4,000 HRS.	8,000 HRS.	
Oil Filter Seal	Replace													•			
Precleaner Element	Replace														•		
Cooling Water Analysis	Check																•
Hydraulic Governor Oil (or as required)	Change																•
Intercooler	Clean and Inspect																•
Belts	Replace																•
Ignition Coils	Inspect																•
Ignition Primary Terminals, Connections, Harness Plug, and Wires	Inspect																•
CEC Ignition	Inspect																•
Detonation Sensing Module	Inspect																•
Air/Fuel Module	Inspect																•

NOTE: * See Section 4.30, Lubrication System Maintenance, Table 4.30-11, Table 4.30-12 for ebullient cooled engines, or hot water system with engine water temperature 200° F (93° C) or above (5115GL rated at 220° C (104° C)). Table 4.30-12 details intervals for engines receiving normal maintenance and using gaseous fuel containing H₂S in excess of published limits.


WARNING

Failure to observe the above maintenance schedule could result in severe personal injury or death.

MAINTENANCE SCHEDULE

SECTION 4.65

ENGINE STORAGE

Consider the following factors before deciding how much preservation is required (see Table 4.65-1):

1. Whether the engine was used, the length of service since the last oil change.
2. The period of time the engine is likely to be idle or inoperative.
3. The atmospheric conditions at the time and place of storage. For example, the storage problems encountered in a tidewater warehouse will differ greatly from those that may be experienced in a dry and dusty location.
4. The hostility of the environment and the accessibility of the equipment for periodic inspection. An engine on a showroom floor that is turned over and oiled occasionally requires less treatment than an engine stored indefinitely abandoned in a warehouse.

PRESERVATION EQUIPMENT AND MATERIAL

Sprays And Atomizers

Often it is necessary to apply a protective compound under difficult field conditions. Several simple tools may be used to atomize preservative oil and force it into the manifolds and combustion chambers. One of these is a manually operated atomizing gun used ordinarily to lubricate inaccessible points on cars and truck chassis. Another is a hand-operated pump-type sprayer with a pointed discharge nozzle commonly used with insecticides. If desired, small oil pumps may be rigged with a motor drive to make a convenient spray unit of the mechanical pressure type. In almost all cases, the air available from shop compressor lines carries too much moisture to be safe for this purpose. Do not use high pressure air from this source.

Table 4.65-1. Waukesha Engine Preservative Oil Application

NUMBER OF CYLINDERS	UPPER CYLINDER		CRANKCASE		TOTAL QUANTITY OF ENGINE PRESERVATIVE OIL REQUIRED
	Ounces Of Preservative Oil Per Cylinder	Ounces Of Preservative Oil All Cylinders	Standard Oil Pan Capacity In Gallons	Quantity Of Preservative Oil	
Six	3 oz (90 cc)	18 oz (540 cc)	43 gal. (162.7 litres)	110 oz (3253 cc)	128 oz (3785 cc)
Twelve	3-1/2 oz (103.5 cc)	42 oz (1242 cc)	54 gal. (204 litres)	138 oz (4081 cc)	180 oz (5323 cc)
Sixteen	3-1/2 oz (103.5 cc)	56 oz (1680 cc)	110 gal. (416.3 litres)	282 oz (8339 cc)	338 oz (9995 cc)

ENGINE STORAGE

WAUKESHA ENGINE PRESERVATIVE OIL

During storage, protect internal metal surfaces from the effects of dampness, salt and other corrosive substances. Waukesha Engine Preservative Oil offers a practical and economical solution to these storage problems. It contains volatile corrosion-inhibiting chemicals that slowly vaporize and diffuse throughout any closed void. The chemicals form an invisible protective layer on all surfaces contacted and allow the engine to be safely stored for one year.

WARNING

Waukesha Preservative Oil contains a petroleum distillate which is harmful or fatal if swallowed. If taken internally, do not induce vomiting. Remove ingested material by gastric lavage with 2 to 4 quarts or litres of tap water or milk. Follow with fruit juice or vinegar to neutralize the alkali. Failure to follow these precautions could cause severe personal injury or death.

WARNING

Avoid prolonged or repeated breathing of vapor. Vapor is harmful and may cause irritation to eyes, nose and throat. Use only with adequate ventilation. If affected by exposure, move to fresh air immediately and get medical help. Failure to follow these precautions could cause severe personal injury or death.

WARNING

Avoid contact with eyes, skin and clothing. If skin contact occurs, immediately flush the affected area with plenty of water. If eye contact occurs, flush for at least 15 minutes and seek medical attention. If clothing is contaminated, remove and wash before using again. Failure to follow these precautions could cause severe personal injury or death.

WARNING

Keep container closed and away from heat. Always read and observe the CAUTION labels on the containers. Do not remove or deface the container labels. Failure to follow these precautions could cause severe personal injury or death.

WAUKESHA ENGINE PRESERVATIVE OIL USAGE

1. Verify that the engine temperature is below 100° F (38° C).
2. Verify that both the oil and oil filter elements are clean. The preservative oil will do an effective job only if added to the engine oil in a clean condition. If a high sulfur fuel was used or if improper control of oil condition left a highly corrosive oil in the bearings and other close contact surfaces, then the vapors cannot form a good protective layer. In these circumstances, change the oil and then run the engine long enough to ensure complete circulation of the clean oil.
3. Add Waukesha Engine Preservative Oil to the existing crankcase oil in an amount equivalent to 2% of the total oil capacity.
4. If possible, crank the engine for at least 20 seconds to ensure adequate circulation of the preservative oil.
5. Add the required amount of preservative oil to each cylinder through the spark plug hole or prechamber admission valve opening. Install the plugs or admission valves.
6. Apply the preservative oil to the rocker arm area through light brushing or pouring. Replace the rocker arm covers.
7. While it may not be practical to completely seal an engine in the field, try to block the paths through which the vaporized chemicals may escape.
8. The engine may be stored for one year. If storage is to exceed this period, inspect the engine annually and repeat the preservation routine.

USE OF OTHER PRESERVATIVE OILS AND MATERIALS

In addition to Waukesha Engine Preservative Oil, the following preservative oils have been found satisfactory for the internal protection of engines (see Table 4.65-2). Other equally good oils are also available. In general, the properties that make an oil suitable for preservative requirements are good aging stability; high resistance to gumming, oxidation and polymerization; low pour point and viscosity; freedom from acids, asphalts, resins, tars, water and other contaminants.

Table 4.65-2. Preservative Oils

SUPPLIER	BRAND NAME
American Oil Company	Amoco Anti-Rust Oil 4-V
Gulf Oil Corporation	No rust Engine Oil Grade 1
Mobil Oil Company	Mobil Arma 522
Shell Oil Company	Donax T-6
Atlantic Richfield Company	Dexron
Texaco, Inc.	#800 Regal Oil A (R O)

NOTE: *Waukesha Engine Preservative Oil is not formulated as a protective coating for external surfaces. Excellent products for polished and machined surfaces are available on the market and should be used when needed. Refer to Table 4.65-3.*

Table 4.65-3. Protective Materials

INTERNAL SURFACES	EXTERNAL SURFACES
U. S. Army Spec. 2-126 (Available as SAE 10 or SAE 30)	U.S. Army Spec. 2-121 (Waxy Coating)
WED Preservative Oil, Mil Spec. MIL-L46002 Grade 2	U. S. Army Ordinance Spec. AXS 673 (Harder Black Coating)

 WARNING

To avoid severe personal injury or death, do not heat preservative compounds to temperatures that exceed 200° F (93° C). This temperature may be inadvertently reached by placing the container in boiling water. Direct heating always presents a dangerous and unnecessary fire hazard.

ENGINE STORAGE - NEW

OPERATIONAL

Internal Component Protection

- Mix an inhibitive type preservative oil with the engine lubricating oil in the proportions recommended by the manufacturer. Operate the engine until the oil is hot. Treat the cooling water used in this run with the proper inhibitors based on the instructions of the manufacturer.
- Drain both the oil and cooling water while they are still hot. For extra protection, remove the rocker arm covers and pour a quantity of preservative oil over the rocker arm and valve mechanisms.
- Remove the spark plugs and add 100 cc (3-1/2 oz.) of preservative oil to each cylinder/combustion chamber (see Table 4.65-1).
- Refill the crankcase with proper grade lube oil to which an inhibitive type preservative oil has been added in the recommended proportion.

External Component Protection

- Wipe the engine clean and dry.
- Protect all engine openings against the entrance of dirt and other foreign matter. Apply a wax type masking tape or similar type of material over the intake openings of air cleaners, exhaust outlets, breathers, magneto vents, open line fittings, etc.
- Relieve the tension on all belts to avoid deterioration of the rubber.
- Use a brush to apply a coating of heavy preservative compound to all exposed machined surfaces, such as flywheels.
- Protect all accessory equipment (such as carburetors, gas regulators, starters, generators, etc.) against corrosion, dirt, moisture saturation and progressive deterioration.
- Protect the cooling system and intercoolers against freezing, rusting or seizure of water pump seals.
- Protect against rain, snow and temperature extremes.
- Disconnect the batteries and remove them to a slow charging station where they can be kept fully charged.

NOTE: *Engines stored according to these instructions using Waukesha Engine Preservative Oil will normally be protected for one year. If storage is to exceed this period, inspect the engine annually and repeat the preservation routine.*

NON-OPERATIONAL

- Open drains, as required, to remove oil, water and fuel.
- Remove the spark plugs and add 100 cc (3-1/2 oz.) of preservative oil to each cylinder/combustion chamber. Crank the engine in the normal direction about one-quarter turn, then spray each cylinder again. Repeat this procedure at least eight times or until the engine has been turned through two complete revolutions, so that each valve is exposed to a coating of preservative oil.
- Depending upon storage conditions, open the crankshaft and camshaft inspection doors, valve rocker covers, gear cover plates and as many points as possible to spray, squirt or pour oil over the interior engine parts. Replace all spark plugs and covers.
- Refer to *Engine Storage - New, Operational, External Component Protection*, in this chapter.

ENGINE STORAGE

ENGINE STORAGE - USED

OPERATIONAL

During normal engine operation, residues of various combustion products accumulate in the combustion area and in the lubricating oil. Portions of these residues combine with atmospheric moisture to form acids and other corrosive compounds. The following treatment will help reduce damage from this source:

1. Run the engine until the original oil is hot. Drain oil.
2. For best results, refill the engine with a good flushing oil. Run the engine until the flushing oil is hot. Drain both the oil and cooling water while still hot.
3. Refill the crankcase with proper grade lube oil to which an inhibitive type preservative oil has been added in the recommended proportion.
4. Remove the spark plugs and add 100 cc (3-1/2 oz.) of preservative oil to each cylinder/combustion chamber (see Table 4.65-1). Replace the spark plugs.
5. Refer to *Engine Storage - New, Operational, External Component Protection*, in this chapter.

NON-OPERATIONAL

1. Refer to *Engine Storage - New, Non-Operational*.
2. Protect the fuel system against the gumming effects of gas residues.
3. In those cases where fuels with high sulfur concentrations have been used or where extremely harsh climatic or environmental conditions prevail, the engine may need to be disassembled, thoroughly cleaned and then reassembled for treatment as a new engine.

ENGINES RETURNED TO SERVICE AFTER STORAGE

 **WARNING**

Never attempt to start an engine that has been stored without first cranking it over with the spark plugs removed. Any oil, water or preservative compound that might spurt from these openings must be removed to prevent a hydraulic lock. Continue to crank the engine with the starter until liquid is no longer being ejected from the openings. Inspect the intake passages and manifolds for thickened preservative oil. Accumulations of this type may thin out as the engine warms up and be burned as fuel, resulting in a runaway engine. Disregarding this information could result in severe personal injury or death.

1. Remove the old spark plugs and crank the engine over to remove any accumulation of oil, water or preservative compounds.
2. Crank the engine with the starter until liquid is no longer ejected from the openings.
3. Inspect the intake passages and manifolds for thickened preservative oil.
4. Install new spark plugs.

The steps needed to bring an engine into active service after storage in accordance with these instructions are about the same as those normally carried out on a new engine. Refer to *Prestart Inspection and Engine Startup Procedures* in Section 3.00.

CONTENTS

SECTION 5.00 - TROUBLESHOOTING

SECTION 5.00

TROUBLESHOOTING

TROUBLESHOOTING

The following table is provided to assist the user in determining the possible causes of unsatisfactory engine operation, as well as point out the corrective action that may be undertaken to remedy the problem.

Knowledge of how the engine operates along with the current readings from the engine instrument panel can be combined with this information to provide a framework for resolving actual or potential problems.

NOTE: This chart is only provided as a service to our customers. It should not be viewed as a reflection of Waukesha Engine's actual experience with this product. This chart is not "all inclusive", refer to respective sections in this manual for details.

Table 5.00-1. Troubleshooting Table

SYMPTOM	PROBABLE CAUSE	REMEDY
Engine crankshaft cannot be barred over.	Load not disengaged from engine.	Disengage load.
Engine will crank, but will not start. (50° F minimum ambient Temperature)	ON-OFF switch in OFF position or defective (if used).	Place switch in the ON position or replace if defective.
	Fuel throttle or manual shutoff control in OFF position.	Place fuel throttle or manual shutoff control in ON position.
	Safeties tripped.	Determine cause, correct, and reset.
	Insufficient cranking speed: a. Low starting air/gas pressure. b. Lube oil temperature too low or viscosity too high.	a. Build up air/gas pressure. 100 - 125 rpm required to start engine. b. Change lube oil or raise the oil temperature.
	Fuel system inoperative: a. Insufficient fuel supply or fuel pressure.	a. Check gas pressure.
	Faulty ignition system: a. No power to ignition module . b. Low or no output from ignition module . c. Hall-effect pickup disconnected, or damaged. d. Incorrect ignition timing. e. Broken or damaged wiring. f. Spark plug(s) not firing.	a. Reconnect. b. Replace ignition module as required. c. Reconnect. d. Reset the timing. e. Repair or replace. f. Check gap/replace as required.
	Insufficient or no air intake: a. Clogged intake air filters. b. Clogged/dirty intercooler (air side).	NOTE: Bar the engine over by hand to verify that cylinders are clear. Inspect the intake manifold for accumulations of lube oil. a. Remove and clean. b. Remove and clean.

(Continued)

TROUBLESHOOTING


SYMPTOM	PROBABLE CAUSE	REMEDY
Engine will crank, but will not start (cont'd).	Detonation Sensing Module Inoperative or in Shutdown Condition: <ol style="list-style-type: none"> a. DSM in shutdown mode. b. Wiring from sensors to DSM damaged. 	<ol style="list-style-type: none"> a. Check DSM diagnostic display codes, and perform appropriate procedures as outlined in Form 6268, <i>DSM Custom Engine Control[®] Detonation Sensing Module Installation, Operation, And Maintenance Manual</i>. Contact your Waukesha Engine Distributor for assistance. b. Repair or replace wiring as required. Refer to Form 6268, <i>DSM Custom Engine Control[®] Detonation Sensing Module Installation, Operation, And Maintenance Manual</i>, and rerun AutoCal program. Contact your Waukesha Engine Distributor for assistance.
	AFM Inoperative or in Alarm Condition: <ol style="list-style-type: none"> a. Wiring from sensors, Air Fuel Module or AFM actuator damaged. b. AFM in alarm mode. 	<ol style="list-style-type: none"> a. Repair or replace wiring as required. Refer to Form 6263, <i>AFM Custom Engine Control[®] Air/Fuel Module Second Edition</i>. Contact your Waukesha Engine Distributor for assistance. b. Check AFM diagnostic display codes, and perform appropriate procedures as outlined in Form 6263, <i>AFM Custom Engine Control[®] Air/Fuel Module Second Edition</i>. Contact your Waukesha Engine Distributor for assistance.
	Governor inoperative: <ol style="list-style-type: none"> a. Governor set incorrectly: b. Insufficient oil: <ol style="list-style-type: none"> 1. UG-8 low oil level. 2. Water/sludge in oil passages. c. Binding control linkage: <ol style="list-style-type: none"> 1. Linkage dirty. 	Contact your Waukesha Engine Distributor for assistance. <ol style="list-style-type: none"> 1. Add oil. 2. Clean or replace governor. 1. Clean.
Engine stops suddenly.	Safeties tripped.	Determine cause, correct, and reset.
	Insufficient fuel supply.	Check gas pressure.
	Low oil pressure causes engine protection control to shut down engine.	Inspect lubricating oil system and components; correct cause.
	High coolant temperature causes engine protection control to shut engine down.	Inspect cooling system and components; correct cause.
	High intake manifold temperature.	Correct cause.
	High lube oil temperature.	Correct cause.
	Engine overspeed causes engine protection control to shut down engine.	Determine and correct cause.
	Excessive load causes engine to stall.	Determine and correct cause of overload.
	Insufficient intake air: <ol style="list-style-type: none"> a. Clogged intake air filter(s). b. Clogged intercooler (air side). 	<ol style="list-style-type: none"> a. Remove and clean. b. Remove and clean.
	Obstructed exhaust manifold.	Locate and remove obstruction.
Seizure of bearings main, connecting rod, piston pin or camshaft. <ol style="list-style-type: none"> a. Lack of lubrication. b. Dirt in lube oil. 	Replace bearings – clean up or replace crankshaft, camshaft or piston pins, as required. <ol style="list-style-type: none"> a. Check lube oil system; correct cause. b. Check lube oil filters. 	

(Continued)

SYMPTOM	PROBABLE CAUSE	REMEDY
Engine stops suddenly (Cont'd).	Detonation Sensing Module Inoperative or in Shutdown Condition: <ul style="list-style-type: none"> a. Wiring from sensors to DSM damaged. b. DSM in shutdown mode. 	<ul style="list-style-type: none"> a. Repair or replace wiring as required. Refer to Form 6268, <i>DSM Custom Engine Control[®] Detonation Sensing Module Installation, Operation, And Maintenance Manual</i>, and rerun AutoCal program. Contact your Waukesha Engine Distributor for assistance. b. Check DSM diagnostic display codes, and perform appropriate procedures as outlined in Form 6268, <i>DSM Custom Engine Control[®] Detonation Sensing Module Installation, Operation, And Maintenance Manual</i>. Contact your Waukesha Engine Distributor for assistance.
	AFM Inoperative or in Alarm Condition: <ul style="list-style-type: none"> a. Wiring from sensors, Air Fuel Module or AFM actuator damaged. b. AFM in alarm mode. 	<ul style="list-style-type: none"> a. Repair or replace wiring as required. Refer to Form 6263, <i>AFM Custom Engine Control[®] Air/Fuel Module Second Edition</i>. Contact your Waukesha Engine Distributor for assistance. b. Check AFM diagnostic display codes, and perform appropriate procedures as outlined in Form 6263, <i>AFM Custom Engine Control[®] Air/Fuel Module Second Edition</i>. Contact your Waukesha Engine Distributor for assistance.
Engine loses power.	Insufficient fuel: <ul style="list-style-type: none"> a. Low gas pressure. 	<ul style="list-style-type: none"> a. Check gas fuel system.
	Air intake system malfunction: <ul style="list-style-type: none"> a. Dirty intake air filters. b. Clogged intercooler. 	<ul style="list-style-type: none"> a. Remove and clean. b. Remove and clean. <p>⚠ CAUTION Bar the engine over by hand to verify that the cylinders are clear. Inspect the intake manifold for accumulations of lube oil.</p>
	Detonation sensing module, sensing detonation condition in one or more cylinders: <ul style="list-style-type: none"> a. "Hot" or unprocessed gas has gone through engine that could cause detonation. 	<ul style="list-style-type: none"> a. Determine if "hot" or unprocessed gas has gone through engine that could cause detonation. Check DSM diagnostic display codes, and perform appropriate procedures as outlined in Form 6268, <i>DSM Custom Engine Control[®] Detonation Sensing Module Installation, Operation, And Maintenance Manual</i>.
	AFM Inoperative or in Alarm Condition: <ul style="list-style-type: none"> a. Wiring from sensors, Air Fuel Module or AFM actuator damaged. b. AFM in alarm mode. 	<ul style="list-style-type: none"> a. Repair or replace wiring as required. Refer to Form 6263, <i>AFM Custom Engine Control[®] Air/Fuel Module Second Edition</i>. Contact your Waukesha Engine Distributor for assistance. b. Check AFM diagnostic display codes, and perform appropriate procedures as outlined in Form 6263, <i>AFM Custom Engine Control[®] Air/Fuel Module Second Edition</i>. Contact your Waukesha Engine Distributor for assistance.
	Air leaks in intake system.	Find and correct as required.
	Turbocharger malfunction or failure: <ul style="list-style-type: none"> a. Lack of lubrication. 	<ul style="list-style-type: none"> a. Contact your Waukesha Engine Distributor for assistance.

(Continued)

TROUBLESHOOTING

SYMPTOM	PROBABLE CAUSE	REMEDY
Engine loses power (Cont'd).	Engine misfiring: a. Sticky gas admission valve.	a. Repair or replace gas admission valve.
	Ignition system timing incorrect.	Re-time.
	Low compression pressure: a. Misadjusted intake and exhaust valves (if recently overhauled).	a. Readjust.
	Excessive exhaust system backpressure.	Correct as required.
Engine will not shut down using normal stopping procedures.	Defective ON-OFF switch.	Shut off fuel supply.
<div style="border: 1px solid black; padding: 2px; display: inline-block;">  WARNING </div> Shut off the gas supply for positive shutdown of gas engines. Inspect the intake manifold for accumulations of lube oil.	Overheated combustion chamber deposits cause the engine to run on auto ignition.	Allow engine to cool down before attempting to stop.
	Engine will not reach rated speed.	Engine overloaded.
	Insufficient fuel supply.	Check fuel supply system.
	AFM Inoperative or in Alarm Condition: a. Wiring from sensors, Air Fuel Module or AFM actuator damaged. b. AFM in alarm mode.	a. Repair or replace wiring as required. Refer to Form 6263, <i>AFM Custom Engine Control[®] Air/Fuel Module Second Edition</i> . Contact your Waukesha Engine Distributor for assistance. b. Check AFM diagnostic display codes, and perform appropriate procedures as outlined in Form 6263, <i>AFM Custom Engine Control[®] Air/Fuel Module Second Edition</i> . Contact your Waukesha Engine Distributor for assistance.
	Restricted air intake.	Correct cause.
	Ignition not properly timed.	Re-time.
	Tachometer inaccurate.	Calibrate or replace tachometer.
	Engine cannot make rapid load changes.	Engine misfiring: a. Prechamber gas admission valves sticking. b. Admission valve plugged.
Individual cylinders misfire.	Prechamber gas admission valve stuck shut.	Clean or replace valve.
Engine will not run at maximum power.	Engine misfiring: a. Fuel system setting incorrect.	a. Contact your Waukesha Engine Distributor for assistance.
	AFM Inoperative or in Alarm Condition: a. Wiring from sensors, Air Fuel Module or AFM actuator damaged. b. AFM in alarm mode.	a. Repair or replace wiring as required. Refer to Form 6263, <i>AFM Custom Engine Control[®] Air/Fuel Module Second Edition</i> . Contact your Waukesha Engine Distributor for assistance. b. Check AFM diagnostic display codes, and perform appropriate procedures as outlined in Form 6263, <i>AFM Custom Engine Control[®] Air/Fuel Module Second Edition</i> . Contact your Waukesha Engine Distributor for assistance.

(Continued)

TROUBLESHOOTING

SYMPTOM	PROBABLE CAUSE	REMEDY
Engine detonates.	Engine overloaded.	Determine and correct cause of overload.
	Incorrect ignition timing.	Reset to specification.
	Engine misfiring: a. Spark plugs misfiring. b. Sticking gas admission valve.	a. Clean and regap, or replace spark plugs. b. Clean or replace valve.
Emission levels too high.	Advanced ignition timing.	Reset to specification.
	Air/fuel ratio incorrect.	Reset to specification.
	AFM Inoperative or in Alarm Condition: a. Wiring from sensors, Air Fuel Module or AFM actuator damaged. b. AFM in alarm mode.	a. Repair or replace wiring as required. Refer to Form 6263, <i>AFM Custom Engine Control[®] Air/Fuel Module Second Edition</i> . Contact your Waukesha Engine Distributor for assistance. b. Check AFM diagnostic display codes, and perform appropriate procedures as outlined in Form 6263, <i>AFM Custom Engine Control[®] Air/Fuel Module Second Edition</i> . Contact your Waukesha Engine Distributor for assistance.
	Engine misfiring: a. Faulty ignition system. b. Prechamber fuel system incorrectly set. c. Sticking gas admission valve.	a. Repair or replace components as required. b. Reset per fuel system specification. c. Clean or replace valve.
Low or fluctuating lube oil pressure. ⚠ CAUTION Shut down the engine immediately.	Insufficient oil.	Add oil as required.
	Lube oil pressure gauge inaccurate.	Compare to master gauge. Replace gauge if necessary.
	Oil gauge line plugged or valve shut.	Renew gauge line; open valve.
	Lube oil filters plugged.	Change elements; clean filter.
	Lube oil pressure regulating valve stuck in open position.	Clean and polish valve.
	Oil pressure regulating valve set too low.	Refer to Table 1.15-2 and readjust oil pressure regulating valve to proper pressure at governed speed.
	Lube oil dilution.	Change oil and filter elements. Determine and correct source of dilution.
	Lube oil of low viscosity.	Change to higher viscosity oil as recommended.
	Lube oil foaming.	Use oil grade recommended. Check for water leaks into oil.
	Clogged oil inlet screen(s).	Remove and clean screen(s).
	Engine is operated at angles that exceed the maximum safe tilt specification.	Operate within maximum safe tilt angles (see Specifications).
	Dirty oil cooler.	Clean.
Low gas/air pressure.	Insufficient line pressure.	Increase line pressure.

(Continued)

TROUBLESHOOTING

SYMPTOM	PROBABLE CAUSE	REMEDY
High gas/air pressure	Incorrectly adjusted gas regulator.	Readjust.
	Incorrect spring in gas regulator.	Replace spring.
	Excessive line pressure.	Reduce line pressure.
	AFM Inoperative or in Alarm Condition: <ul style="list-style-type: none"> a. Wiring from sensors, Air Fuel Module or AFM actuator damaged. b. AFM in alarm mode. 	<ul style="list-style-type: none"> a. Repair or replace wiring as required. Refer to Form 6263, <i>AFM Custom Engine Control[®] Air/Fuel Module Second Edition</i>. Contact your Waukesha Engine Distributor for assistance. b. Check AFM diagnostic display codes, and perform appropriate procedures as outlined in Form 6263, <i>AFM Custom Engine Control[®] Air/Fuel Module Second Edition</i>. Contact your Waukesha Engine Distributor for assistance.
High lube oil pressure.	Misadjusted oil pressure regulating valve.	Refer Section 4.30 <i>Lube Oil Pressure Adjustment</i> , and readjust oil pressure regulating valve to proper pressure.
	Lubricating oil of high viscosity.	Change to lower viscosity oil as recommended.
Low jacket water temperature.	Gauge inaccurate.	Compare to master gauge; replace gauge if necessary.
High jacket water temperature.	Gauge inaccurate.	<div style="border: 1px solid black; padding: 2px; display: inline-block;">CAUTION</div> Allow engine to cool. Compare to master gauge; replace gauge if necessary.
	Gauge line clogged or valve shut.	Replace line, open valve.
	Low coolant level.	Fill cooling system.
	Broken or loose water pump belts.	Replace or adjust belts.
	Air bound cooling system.	Purge air from cooling system.
	Engine overloaded.	Determine and correct cause.
	Leaking pump seals.	Repair pump.
	Frozen coolant.	Completely thaw cooling system before restarting engine.
High auxiliary water temperature.	Gauge inaccurate.	Compare to master gauge; replace gauge if necessary.
	Clogged gauge line or the gauge line valve is shut.	Replace line or open valve.
	Broken or loose auxiliary water pump belts.	Replace or adjust belts.
	Clogged heat exchanger or intercooler.	Clean heat exchanger/intercooler.
High lube oil consumption.	Oil leaks in lube oil system.	Locate and repair leaks.
	Improper viscosity.	Change to a viscosity recommended for operating temperatures.
	Worn piston rings or liners.	Contact your Waukesha Engine Distributor for assistance.
Lube oil contamination.	Lube oil contaminated with water:	NOTE: Change oil.
	Lube oil contaminated with dirt: <ul style="list-style-type: none"> a. Lube oil filter bypass valves opening because elements are plugged. b. Lube oil filter elements punctured. c. Air intake filters punctured. 	<ul style="list-style-type: none"> a. Replace elements. b. Replace elements. c. Replace air intake filters.

(Continued)

TROUBLESHOOTING

SYMPTOM	PROBABLE CAUSE	REMEDY
Excessive vibration.	Engine misfiring	Refer to <i>Engine Detonates</i> causes.
<div style="border: 1px solid black; padding: 2px; display: inline-block;">CAUTION</div> Stop engine at once; investigate cause.	Foundation bolts: a. Loose.	a. Contact your Waukesha Engine Distributor for assistance.
	Vibration damper: a. Loose.	a. Contact your Waukesha Engine Distributor for assistance.
	Crankshaft: a. Broken. b. Main bearing nuts loose. c. Crankshaft counterweight loose.	a. Contact your Waukesha Engine Distributor for assistance. b. Contact your Waukesha Engine Distributor for assistance. c. Contact your Waukesha Engine Distributor for assistance.
	Loose flywheel.	Contact your Waukesha Engine Distributor for assistance.
High lube oil temperature.	Gauge inaccurate.	Compare to master gauge; replace gauge if necessary.
	Engine overloaded.	Determine and correct cause.
	Insufficient cooling: a. High auxiliary water temperature. b. Dirty lube oil cooler. c. Broken or loose auxiliary water pump belts.	a. See <i>High Auxiliary Water Temperature</i> causes. b. Clean or replace. c. Replace or adjust belts.
	Dirty jacket water heat exchanger or radiator.	Clean or replace.
	Low lubricating oil pressure.	See <i>Low Lubricating Oil Pressure</i> causes.
Knocking or unusual noises.	Low octane fuel.	Adjust timing for the fuel used.
	Engine overloaded.	Determine and correct cause.
	Overly advanced ignition timing.	Retime.
	Detonation sensing module, sensing detonation condition in one or more cylinders: b. "Hot" or unprocessed gas has gone through engine that could cause detonation.	b. Determine if "hot" or unprocessed gas has gone through engine that could cause detonation. Check DSM diagnostic display codes, and perform appropriate procedures as outlined in Form 6268, <i>DSM Custom Engine Control[®] Detonation Sensing Module Installation, Operation, And Maintenance Manual</i> .
	Excessive valve clearance.	Adjust to specification.
	Loose bearings (failed).	Contact your Waukesha Engine Distributor for assistance.
	Loose piston pins (failed).	Contact your Waukesha Engine Distributor for assistance.
	Excessive crankshaft end play.	Contact your Waukesha Engine Distributor for assistance.
Misfitted or excessively worn timing gears.	Contact your Waukesha Engine Distributor for assistance.	

(Continued)

TROUBLESHOOTING

SYMPTOM	PROBABLE CAUSE	REMEDY
Excessive fuel consumption.	Leaks in fuel system.	Contact your Waukesha Engine Distributor for assistance.
	Retarded ignition timing.	Set timing to specifications.
	Engine overloaded.	Determine and correct cause.
TURBOCHARGER: Excessive noise or vibration.	Low lube oil pressure. Improper bearing lubrication. Load engine before warm oil is supplied to the turbocharger.	Contact your Waukesha Engine Distributor for assistance.
GOVERNOR: UG-8 Engine hunts or surges.	Dirty oil in governor.	Drain oil, clean governor and refill.
	Foamy oil in governor.	Drain oil and refill.
	Low oil level.	Add oil to correct level on gauge glass. Check for leaks, especially at drive shaft.
GOVERNOR: UG-8 Engine is slow to respond to speed or load changes	Engine overloaded.	Reduce load.
GOVERNOR: UG-8 Engine will not pick up rated load	Restricted fuel supply.	Clean fuel supply line and filters.
	Governor linkage binding or sticking.	Contact your Waukesha Engine Distributor for assistance.
	Governor linkage loose or sloppy.	Contact your Waukesha Engine Distributor for assistance.
	Governor rod length incorrect.	Contact your Waukesha Engine Distributor for assistance.
	Incorrect angle on governor terminal shaft.	Contact your Waukesha Engine Distributor for assistance.
	Governor compensation set too low.	Contact your Waukesha Engine Distributor for assistance.
	Fuel pressure unstable and "hunting".	Contact your Waukesha Engine Distributor for assistance.
	Governor drive gear dampers are worn out.	Contact your Waukesha Engine Distributor for assistance.

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WAUKESHA ENGINE DIVISION, DRESSER EQUIPMENT GROUP, INC.
EXPRESS LIMITED WARRANTY FOR PRODUCTS USED IN CONTINUOUS DUTY APPLICATIONS

INTRODUCTION

CONTINUOUS DUTY DEFINITION: The highest load and speed which can be applied, subject to Waukesha's approved ratings in effect at time of sale.

I. TERMS OF EXPRESS LIMITED WARRANTY

Waukesha Engine Division warrants that it will repair or replace, AT ITS ELECTION AND EXPENSE, any part of an engine, or Enginator®, or product (hereinafter referred to as "Products") manufactured by Waukesha, which proves to have had a defect in material or workmanship.

II. TERM LIMITATIONS OF EXPRESS LIMITED WARRANTY

- A. This coverage shall commence upon initial new Products start-up date and shall expire upon the earlier of the following:
1. 12 months after the initial new Products start-up date; or
 2. 24 months after the original shipment date of the covered products by Waukesha Engine Division.
- B. Notwithstanding the foregoing, Waukesha further warrants that the cylinder block casting, cylinder head castings, connecting rod forgings, and crankshaft forging will be free from defects in material or workmanship. This additional warranty only covers failures of the specific items noted within this subparagraph.
- This coverage shall expire upon the earlier of the following:
1. 60 months after the initial new Products start-up date; or
 2. 25,000 hours of operation of the covered Products; or
 3. 72 months after the original shipment date of the covered Products by Waukesha Engine Division.

NOTE: *No damage from other sources, such as damage from the loss of a crankshaft bearing, shall be considered as a forging defect.*

III. WAUKESHA'S RESPONSIBILITIES UNDER THE EXPRESS LIMITED WARRANTY

Waukesha shall be responsible for:

- A. The repair or replacement, at Waukesha's election, of covered defective parts and all reasonable labor required regarding a warranted failure during the express limited warranty term. All such labor shall be provided by Waukesha's authorized contractor or distributor.
- B. Reasonable and necessary travel and expenses incurred by Waukesha's authorized contractor or distributor.
- C. Replacement of lubricating oil, coolant, filter elements, or other normal maintenance items that are contaminated and/or damaged as a direct result of a warranted failure.

NOTWITHSTANDING THE FOREGOING, WAUKESHA SHALL NOT BE RESPONSIBLE FOR LABOR COSTS ASSOCIATED WITH WARRANTY CLAIMS BROUGHT PURSUANT TO SUBPARAGRAPH II(B).

IV. OWNER'S RESPONSIBILITIES UNDER THE EXPRESS LIMITED WARRANTY

Owner shall be responsible for:

- A. The operation and maintenance of the Products within the guidelines established by Waukesha.
- B. Making the Products available to Waukesha or Waukesha's authorized contractors or distributors for any warranty repair, during normal business hours.
- C. All additional costs incurred for premium or overtime labor, should owner request that repairs be made on a premium or overtime schedule.
- D. All costs incurred as the result of removal or reinstallation of the Products as may be required to effect any warranted repair.
- E. All administrative costs and expenses resulting from a warranted failure.
- F. Any costs of transportation, towing, repair facilities, or associated costs.
- G. All labor, travel, mileage, and other related costs and expenses associated with a claim made pursuant to subparagraph II(B) above.
- H. Loss of revenue and loss of/or damage to real and/or personal property.

V. LIMITATION OF WAUKESHA'S OBLIGATIONS

The obligations of Waukesha under this express limited warranty shall be waived and voided, and Waukesha shall not, thereafter, be responsible for:

- A. Any failure resulting from owner or operator abuse or neglect, including but not by way of limitation, any operation, installation, application, or maintenance practice not in accordance with guidelines or specifications established by Waukesha; or
- B. Any failure resulting from unauthorized modifications or repairs of the Products; or
- C. Any failure resulting from overload, overspeed, overheat, accident, improper storage; or
- D. Failure of owner to promptly provide notice of a claimed defect; or
- E. Failure of Products for which Waukesha did not receive properly completed start-up reports; or
- F. Repairs of a covered failure performed with non-genuine Waukesha parts; or
- G. Repairs of covered failure performed by non-authorized contractors or distributors; or
- H. Failure to make Products available to Waukesha or its authorized representatives; or
- I. Failure to supply documents such as drawings and specifications relating to the specific application of the Product.

VI. APPLICATION AND EXPIRATION

The warranties set out above are extended to all owners in the original chain of distribution. The warranties and obligations of Waukesha shall expire and be of no further effect upon the dates of expiration of the applicable warranty periods.

THE FOREGOING SETS FORTH WAUKESHA'S ONLY OBLIGATIONS AND OWNERS' EXCLUSIVE REMEDY FOR BREACH OF WARRANTY, WHETHER SUCH CLAIMS ARE BASED ON BREACH OF CONTRACT, TORT (INCLUDING NEGLIGENCE AND STRICT LIABILITY), OR OTHER THEORIES, AND THE FOREGOING IS EXPRESSLY IN LIEU OF OTHER WARRANTIES WHATSOEVER EXPRESSED, IMPLIED, AND STATUTORY, INCLUDING WITHOUT LIMITATION, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS.

Notwithstanding the preceding, in no event shall Waukesha be liable for any direct, special, incidental or consequential damages (whether denominated in contract, tort, strict liability, negligence or other theories) arising out of this Agreement or the use of any Products provided under this Agreement.

Any action arising hereunder or relating hereto, whether based on breach of contract, tort (including negligence and strict liability), or other theories must be commenced within two (2) years after the cause of action accrues or it shall be barred.

All disputes and claims between the parties which may arise out of or in connection with this Contract shall be settled by good faith negotiation between an executive level representative of each party. If the parties are nonetheless unable to reach agreement, such dispute shall be resolved by binding arbitration. The arbitration shall be administered by the American Arbitration Association according to its rules of Commercial Arbitration then in force. The arbitration shall take place in Milwaukee, Wisconsin, before one arbitrator. The language to be used in the arbitration shall be English. The law of Texas shall govern. Judgment upon the award of the arbitrators may be entered in any court of competent jurisdiction.

WAUKESHA ENGINE DIVISION, DRESSER EQUIPMENT GROUP, INC.
EXPRESS LIMITED WARRANTY FOR PRODUCTS OPERATED IN EXCESS OF CONTINUOUS DUTY RATINGS

INTRODUCTION

This warranty only applies to engines which Waukesha Engine Division has approved to operate in excess of the continuous duty rating.

APPLICATIONS COVERED BY THIS WARRANTY

Standby Service Applications: This rating applies to those systems used as a secondary or backup source of electrical power. This rating is the output the system will produce continuously (no overload), 24 hours per day for the duration of the prime power source outage.

Intermittent Service Applications: This rating is the highest load and speed that can be applied in variable speed mechanical system applications only (i.e., blowers, pumps, compressors, etc.). Operation at this rating is limited to a maximum of 3500 hours/year. For continuous operation for any length of time between the continuous and intermittent ratings see the Peak Shaving Application rating procedure.

Peak Shaving Applications for VHP Natural Gas Engines: The Rating for a Peak Shaving Application is based on the number of horsepower-hours available per year at site specific conditions. All applications using a Peak Shaving Rating require a signed Special Application Approval (SAA) from Waukesha's Application Engineering Department.

I. TERMS OF EXPRESS LIMITED WARRANTY

Waukesha Engine Division warrants that it will repair or replace, AT ITS ELECTION AND EXPENSE, any part of an engine, or engine powered Engineator® (hereinafter referred to as "Products") manufactured by Waukesha, which proves to have had a defect in material or workmanship.

II. TERM LIMITATIONS OF EXPRESS LIMITED WARRANTY

A. This coverage shall commence upon initial new Products start-up date and shall expire upon the earlier of the following:

1. 60 months or 3500 hours, whichever occurs first, after the initial new Products start-up date; or
2. 72 months after the original shipment date of the covered products by Waukesha Engine Division.

B. Notwithstanding the foregoing, Waukesha further warrants that the cylinder block casting, cylinder head castings, connecting rod forgings, and crankshaft forging will be free from defects in material or workmanship. This additional warranty only covers failure of the specific items noted within this subparagraph.

This coverage shall expire upon the earlier of the following:

1. 60 months after the initial new Products start-up date; or
2. 25,000 hours of operation of the covered Products; or
3. 72 months after the original shipment date of the covered Products by Waukesha Engine Division.

NOTE: No damage from other sources, such as damage from the loss of a crankshaft bearing, shall be considered as a forging defect.

III. WAUKESHA'S RESPONSIBILITIES UNDER THE EXPRESS LIMITED WARRANTY

Waukesha shall be responsible for:

- A. The repair or replacement, at Waukesha's election, of covered defective parts and all reasonable labor required regarding a warranted failure during the express limited warranty term. All such labor shall be provided by Waukesha's authorized contractor or distributor.
- B. Reasonable and necessary travel and expenses incurred by Waukesha's authorized contractors or distributor.
- C. Replacement of lubricating oil, coolant, filter elements, or other normal maintenance items that are contaminated and/or damaged as a direct result of a warranted failure.

NOTWITHSTANDING THE FOREGOING, WAUKESHA SHALL NOT BE RESPONSIBLE FOR LABOR COSTS ASSOCIATED WITH WARRANTY CLAIMS BROUGHT PURSUANT TO SUBPARAGRAPH II (B).

IV. OWNER'S RESPONSIBILITIES UNDER THE EXPRESS LIMITED WARRANTY

Owner shall be responsible for:

- A. The operation of the product within the allowable HP-HR/YR rating granted by the specific Special Application Approval for the Product.
- B. The operation and maintenance of the Products within the guidelines established by Waukesha.
- C. Making the Products available to Waukesha or Waukesha's authorized contractors or distributors for any warranty repair, during normal business hours.
- D. All additional costs incurred for premium or overtime labor, should owner request that repairs be made on a premium or overtime schedule.
- E. All costs incurred as the result of removal or reinstallation of the Products as may be required to effect any warranted repair.
- F. All administrative costs and expenses resulting from a warranted failure.
- G. Any costs of transportation, towing, repair facilities, or associated costs.
- H. All labor, travel, mileage, and other related costs and expenses associated with a claim made pursuant to subparagraph II (B) above.
- I. Loss of revenue and loss of/or damage to real and/or personal property.

V. LIMITATION OF WAUKESHA'S OBLIGATIONS

The obligations of Waukesha under this express limited warranty shall be waived and voided, and Waukesha shall not, thereafter, be responsible for:

- A. Any failure resulting from owner or operator abuse or neglect, including but not by way of limitation, any operation, installation, application, or maintenance practice not in accordance with guidelines or specifications established by Waukesha; or
- B. Any failure resulting from unauthorized modifications or repairs of the Products; or
- C. Any failure resulting from overload, overspeed, overheat, accident, improper storage; or
- D. Failure of owner to promptly provide notice of a claimed defect; or
- E. Failure of Products for which Waukesha did not receive properly completed start-up reports; or
- F. Repairs of a covered failure performed with non-genuine Waukesha parts; or
- G. Repairs of a covered failure performed by non-authorized contractors or distributors; or
- H. Failure to make Products available to Waukesha or its authorized representatives; or
- I. Failure to supply documents such as drawings and specifications relating to the specific application of the Products.

VI. APPLICABILITY AND EXPIRATION

The warranties set out above are extended to all owners in the original chain of distribution. The warranties and obligations of Waukesha shall expire and be of no further effect upon the dates of expiration of the applicable warranty periods.

THE FOREGOING SETS FORTH WAUKESHA'S ONLY OBLIGATIONS AND OWNERS' EXCLUSIVE REMEDY FOR BREACH OF WARRANTY, WHETHER SUCH CLAIMS ARE BASED ON BREACH OF CONTRACT, TORT (INCLUDING NEGLIGENCE AND STRICT LIABILITY), OR OTHER THEORIES, AND THE FOREGOING IS EXPRESSLY IN LIEU OF OTHER WARRANTIES WHATSOEVER EXPRESSED, IMPLIED, AND STATUTORY, INCLUDING WITHOUT LIMITATION, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS.

Notwithstanding the preceding, in no event shall Waukesha be liable for any direct, special, incidental or consequential damages (whether denominated in contract, tort, strict liability, negligence or other theories) arising out of this Agreement or the use of any Products provided under this Agreement.

Any action arising hereunder or relating hereto, whether based on breach of contract, tort (including negligence and strict liability), or other theories must be commenced within two (2) years after the cause of action accrues or it shall be barred.

All disputes and claims between the parties which may arise out of or in connection with this Contract shall be settled by good faith negotiation between an executive level representative of each party. If the parties are nonetheless unable to reach agreement, such dispute shall be resolved by binding arbitration. The arbitration shall be administered by the American Arbitration Association according to its rules of Commercial Arbitration then in force. The arbitration shall take place in Milwaukee, Wisconsin, before one arbitrator. The language to be used in the arbitration shall be English. The law of Texas shall govern. Judgment upon the award of the arbitrators may be entered in any court of competent jurisdiction.

M-761 Effective November 1, 1994

**WAUKESHA ENGINE DIVISION, DRESSER EQUIPMENT GROUP, INC.
EXPRESS LIMITED WARRANTY FOR GENUINE WAUKESHA SERVICE PARTS**

INTRODUCTION

This warranty only applies to Genuine Waukesha Service Parts (to include assemblies and short blocks) sold by Waukesha Engine Division and used for repair, maintenance, or overhaul of Waukesha Products.

I. TERMS OF EXPRESS LIMITED WARRANTY

Waukesha Engine Division warrants that it will repair or replace, AT ITS ELECTION AND EXPENSE, any Genuine Waukesha Service Part installed on an engine, or Engine[®], or product (hereinafter referred to as "Products") manufactured by Waukesha, which proves to have had a defect in material or workmanship.

II. TERM LIMITATIONS OF EXPRESS LIMITED WARRANTY

This coverage will begin on the purchase date from an authorized Waukesha Distributor and will expire twelve (12) months after the purchase date.

III. WAUKESHA'S RESPONSIBILITIES UNDER THE EXPRESS LIMITED WARRANTY

Waukesha shall be responsible for:

- A. The repair or replacement, at Waukesha's election, of covered defective Service Parts.
- B. Labor time to repair or replace the defective part as established by the Waukesha Labor Guide Manual. All reimbursable labor costs shall be provided by Waukesha's authorized distributor.
- C. The reimbursement of documented Distributor expenses covering Freight, Customs, Brokers Fees, and Import Duties to obtain the replacement Service Part from Waukesha.

IV. OWNER'S RESPONSIBILITIES UNDER THE EXPRESS LIMITED WARRANTY

Owner shall be responsible for:

- A. The operation and maintenance of the Products/Service Parts within the guidelines established by Waukesha.
- B. Making the Products/Service Parts available to Waukesha or Waukesha's authorized distributors for any warranty repair, during normal business hours.
- C. All additional costs incurred for premium or overtime labor, should owner request that repairs be made on a premium or overtime schedule.
- D. All costs incurred as the result of removal or reinstallation of the Products as may be required to effect any warranted repair.
- E. All administrative costs and expenses resulting from a warranted failure.
- F. Any costs of transportation, towing, repair facilities, or associated costs.
- G. All travel, mileage, and other related Distributor costs and expenses associated with repair under the terms of this Service Parts Warranty
- H. All additional labor time in excess of Waukesha's Labor Guide for the warrantable repair.
- I. Loss of revenue and loss of/or damage to real and/or personal property.

V. LIMITATION OF WAUKESHA'S OBLIGATIONS

The obligations of Waukesha under this express limited warranty shall be waived and voided, and Waukesha shall not, thereafter, be responsible for:

- A. Any failure resulting from owner or operator abuse or neglect, including but not by way of limitation, any operation, installation, application, maintenance, or assembly practice not in accordance with guidelines or specifications established by Waukesha; or
- B. Any failure resulting from unauthorized modifications or repairs of the Products or Service Parts; or
- C. Any failure resulting from overload, overspeed, overheat, accident; or
- D. Failure of owner to promptly provide notice of a claimed defect; or
- E. Failure of Service Parts for which Waukesha did not receive proper documentation concerning the Service Parts purchase date from an Authorized Waukesha Engine Division Distributor; or
- F. Repairs of a covered failure performed with non-genuine Waukesha parts; or
- G. Repairs of a covered failure performed by non-authorized Contractors or Distributors; or
- H. Failure to make Products and Service Parts available to Waukesha or its authorized representatives; or
- I. Failure to supply documents such as drawings and specifications relating to the specific application of the Products; or
- J. Any failure of Service Parts resulting from misapplication or improper repair procedures; or
- K. Any failure or damage resulting from the improper or extended storage of a Service Part; or
- L. Freight, Customs, Brokers Fees, and Import Duties if appropriate documentation is not provided.

VI. APPLICABILITY AND EXPIRATION

The warranty set out above is extended to the original purchaser of the Genuine Waukesha Service Parts. The warranty and obligations of Waukesha shall expire and be of no further effect upon the dates of expiration of the applicable warranty period.

VII. WARRANTY ADMINISTRATION

This warranty is administered exclusively by an Authorized Waukesha Distributor. The invoice for the failed Service Parts must be provided to the Distributor to determine whether the warranty is applicable.

Contact the nearest Authorized Waukesha Distributor for assistance with warranty matters or questions. The location of the nearest Authorized Distributor is available by contacting Waukesha Engine Division at (414) 547-3311.

THE FOREGOING SETS FORTH WAUKESHA'S ONLY OBLIGATIONS AND OWNERS' EXCLUSIVE REMEDY FOR BREACH OF WARRANTY, WHETHER SUCH CLAIMS ARE BASED ON BREACH OF CONTRACT, TORT (INCLUDING NEGLIGENCE AND STRICT LIABILITY), OR OTHER THEORIES, AND THE FOREGOING IS EXPRESSLY IN LIEU OF OTHER WARRANTIES WHATSOEVER EXPRESSED, IMPLIED, AND STATUTORY, INCLUDING WITHOUT LIMITATION, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS.

Notwithstanding the preceding, in no event shall Waukesha be liable for any direct, special, incidental, or consequential damages (whether denominated in contract, tort strict liability, negligence, or other theories) arising out of this Agreement or the use of any Products provided under this Agreement.

Any action arising hereunder or relating hereto, whether based on breach of contract, tort (including negligence and strict liability), or other theories must be commenced within two (2) years after the cause of action accrues or it shall be barred.

All disputes and claims between the parties which may arise out of or in connection with this Contract shall be settled by good faith negotiation between an executive level representative of each party. If the parties are nonetheless unable to reach agreement, such dispute shall be resolved by binding arbitration. The arbitration shall be administered by the American Arbitration Association according to its rules of Commercial Arbitration then in force. The arbitration shall take place in Milwaukee, Wisconsin, before one arbitrator. The language to be used in the arbitration shall be English. The law of Texas shall govern. Judgment upon the award of the arbitrators may be entered in any court of competent jurisdiction.

WAUKESHA ENGINE DIVISION, DRESSER EQUIPMENT GROUP, INC.
EXPRESS LIMITED WARRANTY FOR CUSTOM ENGINE CONTROL®

INTRODUCTION

Custom Engine Control® (CEC) are sold as standard, or as options on new Engines or as Genuine Waukesha Service Parts, and include the Detonation Sensing Module (DSM), Air Fuel Module (AFM), Turbocharger Control Management System (TCMS), and Ignition Module (IM), or any other control device identified as a CEC product.

I. TERMS OF EXPRESS LIMITED WARRANTY

Waukesha Engine Division warrants that it will repair or replace, AT ITS ELECTION AND EXPENSE, any CEC installed on an engine, or Enginor® or product (hereinafter referred to as "Products") manufactured by Waukesha, or purchased as a Genuine Service Part, which proves to have had a defect in material or workmanship.

II. TERM LIMITATIONS OF EXPRESS LIMITED WARRANTY

- A. This coverage shall commence upon initial new Products start-up date or the purchase date, in the case of service parts sales, and shall expire upon the earlier of the following:
1. New Products
 - A. 12 months after the initial new Products start-up date; or
 - B. 24 months after the original shipment date of the covered Products by Waukesha Engine Division.
 2. Genuine Service Parts
 - A. 12 months from the date the CEC is put into service; or
 - B. 18 months from the purchase date.
- B. Notwithstanding the foregoing, Waukesha further warrants that it will repair or replace, AT ITS ELECTION AND EXPENSE, any component of the Waukesha Product damaged as the direct result of a warrantable defect in a CEC product.

III. WAUKESHA'S RESPONSIBILITIES UNDER THE EXPRESS LIMITED WARRANTY

Waukesha shall be responsible for:

- A. The repair or replacement, at Waukesha's election, of covered defective parts and all reasonable labor required regarding a warranted failure during the express limited warranty term. All such labor shall be provided by Waukesha's authorized contractor or distributor.
- B. For the repair of CEC's installed on Products shipped from Waukesha, reasonable and necessary travel and expenses incurred by Waukesha's authorized contractor or distributor.
- C. Replacement of lubricating oil, coolant, filter elements, Waukesha supplied engine components, or other normal maintenance items that are contaminated and/or damaged as a direct result of a warranted failure.

IV. OWNER'S RESPONSIBILITIES UNDER THE EXPRESS LIMITED WARRANTY

Owner shall be responsible for:

- A. The operation and maintenance of the Products within the guidelines established by Waukesha.
- B. Making the Products available to Waukesha or Waukesha's authorized contractors or distributors for any warranty repair, during normal business hours.
- C. All additional costs incurred for premium or overtime labor, should owner request that repairs be made on a premium or overtime schedule.
- D. All costs incurred as the result of removal or reinstallation of the Products as may be required to effect any warranted repair.
- E. All administrative costs and expenses resulting from a warranted failure.
- F. Any costs of transportation, towing, repair facilities, or associated costs.
- G. All travel, mileage, and other related Distributor costs and expenses associated with repair under the terms of the Service Parts Warranty.
- H. All additional labor time in excess of Waukesha's Labor Guide for the warrantable repair.
- I. Loss of revenue and loss of or damage to real and/or personal property.

V. LIMITATION OF WAUKESHA'S OBLIGATIONS

The obligations of Waukesha under this express limited warranty shall be waived and voided, and Waukesha shall not, thereafter, be responsible for:

- A. Any failure resulting from owner or operator abuse or neglect, including but not by way of limitation, any operation, installation, application, or maintenance practice not in accordance with guidelines or specifications established by Waukesha; or
- B. Any failure resulting from unauthorized modifications or repairs of the Products; or
- C. Any failure resulting from overload, overspeed, overheat, accident, improper storage; or
- D. Failure of owner to promptly provide notice of a claimed defect; or
- E. Failure of Products for which Waukesha did not receive properly completed start-up reports; or
- F. Repairs of a covered failure performed with non-genuine Waukesha parts; or
- G. Repairs of a covered failure performed by non-authorized contractors or distributors; or
- H. Failure to make Products available to Waukesha or its authorized representatives; or
- I. Failure to supply documents such as drawings and specifications relating to the specific application of the Products; or
- J. Improper diagnosis of a Product problem for which a CEC product is replaces.
- K. Failure of Service Parts for which Waukesha did not receive proper documentation concerning the Service Parts purchase date from an Authorized Waukesha Engine Division Distributor; or
- L. Any failure of a Service Part resulting from misapplication or improper repair procedures; or
- M. Any failure or damage resulting from the improper or extended storage of a Service Part; or
- N. Freight, Customs, Brokers Fees, and Import Duties if appropriate documentation is not provided.

VI. APPLICABILITY AND EXPIRATION

The warranties set out above are extended to all owners in the original chain of distribution. The warranties and obligations of Waukesha shall expire and be of no further effect upon the dates of expiration of the applicable warranty periods.

VII. WARRANTY ADMINISTRATION

This warranty is administered exclusively by an Authorized Waukesha Distributor. The invoice for the failed Service Part must be provided to the Distributor to determine whether the warranty is applicable. Contact the nearest Authorized Waukesha Distributor for assistance with warranty matters or questions. The location of the nearest Authorized Distributor is available by contacting Waukesha Engine Division at (414) 547-3311.

THE FOREGOING SETS FORTH WAUKESHA'S ONLY OBLIGATIONS AND OWNERS' EXCLUSIVE REMEDY FOR BREACH OF WARRANTY, WHETHER SUCH CLAIMS ARE BASED ON BREACH OF CONTRACT, TORT (INCLUDING NEGLIGENCE AND STRICT LIABILITY), OR OTHER THEORIES, AND THE FOREGOING IS EXPRESSLY IN LIEU OF OTHER WARRANTIES WHATSOEVER EXPRESSED, IMPLIED, AND STATUTORY, INCLUDING WITHOUT LIMITATION, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS.

Notwithstanding the preceding, in no event shall Waukesha be liable for any direct, special, incidental, or consequential damages (whether denominated in contract, tort strict liability, negligence, or other theories) arising out of this Agreement or the use of any Products provided under this Agreement.

Any action arising hereunder or relating hereto, whether based on breach of contract, tort (including negligence and strict liability), or other theories must be commenced within two (2) years after the cause of action accrues or it shall be barred.

All disputes and claims between the parties which may arise out of or in connection with this Contract shall be settled by good faith negotiation between an executive level representative of each party. If the parties are nonetheless unable to reach agreement, such dispute shall be resolved by binding arbitration. The arbitration shall be administered by the American Arbitration Association according to its rules of Commercial Arbitration then in force. The arbitration shall take place in Milwaukee, Wisconsin, before one arbitrator. The language to be used in the arbitration shall be English. The law of Texas shall govern. Judgment upon the award of the arbitrators may be entered in any court of competent jurisdiction.



Waukesha Engine Division Welcomes Your Comments

In order to continue bringing you the BEST in Waukesha product information, we ask that you take a moment to let us know about any errors or omissions in this publication. Comments and suggestions are also welcome. Please use one of the self-addressed, postage paid cards attached below.

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KD-200

Waukesha

DSM

Custom Engine Control[®]
Detonation Sensing Module
Installation, Operation &
Maintenance

First Edition

Software Version 6 Series



Form 6278

Serial No.

Specification No.

Waukesha **DSM** Custom Engine Control[®] Detonation Sensing Module Installation, Operation & Maintenance First Edition

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Dresser Equipment Group, Inc.
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HOW TO USE THIS MANUAL

Your purchase of a Custom Engine Control® (CEC) Detonation Sensing Module (DSM) system was a wise investment. In the industrial engine field the name, Waukesha Engine, stands for quality and durability. With normal care and maintenance this equipment will provide many years of reliable service.

Before placing the Detonation Sensing Module system in service read Chapter 1 very carefully. This chapter covers Safety and General Information.

Section 1.00 - Safety Section - Provides a list of warnings and cautions to make you aware of the dangers present during operation and maintenance of the engine. - READ THEM CAREFULLY AND FOLLOW THEM COMPLETELY -

Section 1.05 - General Information - Provides conversion data, intake manifold calculations, wiring information, and grounding information.

Section 1.10 - Description of Operation - Provides basic data on the Detonation Sensing Module system such as: system description, theory of operation, and definitions.

ALWAYS BE ALERT FOR THE SPECIAL WARNINGS WITHIN THE MANUAL TEXT. THESE WARNINGS PRECEDE INFORMATION THAT IS CRUCIAL TO YOUR SAFETY AS WELL AS OTHER PERSONNEL WORKING ON OR NEAR THE ENGINE. CAUTIONS OR NOTES IN THE MANUAL CONTAIN INFORMATION THAT RELATES TO POSSIBLE DAMAGE TO THE ENGINE OR ITS COMPONENTS DURING ENGINE OPERATION OR MAINTENANCE PROCEDURES.

This manual contains installation, operation, and maintenance instructions for the Detonation Sensing Module system. There are four chapters within the manual and each chapter contains one or more sections. The title of each chapter or section appears at the top of each page. To locate information on a specific topic, refer to the Table of Contents at the front of the manual or the Index at the back of the manual.

Recommendations and data contained in the manual are the latest information available at the time of this printing and are subject to change without notice. Since engine accessories may vary due to customer specifications consult your local distributor or Waukesha Engine Division Service Operations Department for any information on subjects beyond the scope of this manual.

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WARRANTY

Waukesha Engine Division -
Dresser Industries, Inc.

Express Limited Warranty For Custom Engine Control®

W-1

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SECTION 1.00

SAFETY

SAFETY INTRODUCTION

The following safety precautions are published for your information. Waukesha Engine Division, A Dresser Company, does not, by the publication of these precautions, imply or in any way represent that they are the sum of all dangers present near industrial engines or fuel rating test units. If you are installing, operating, or servicing a Waukesha product, it is your responsibility to ensure full compliance with all applicable safety codes and requirements. All requirements of the Federal Occupational Safety and Health Act must be met when Waukesha products are operated in areas that are under the jurisdiction of the United States of America. Waukesha products operated in other countries must be installed, operated, and serviced in compliance with any and all applicable safety requirements of that country.

For details on safety rules and regulations in the United States, contact your local office of the Occupational Safety and Health Administration (OSHA).

The words "danger," "warning," "caution," and "note" are used throughout this manual to highlight important information. Be certain that the meanings of these alerts are known to all who work on or near the equipment.

NOTE: This symbol identifies information which is **NECESSARY TO THE PROPER OPERATION, MAINTENANCE OR REPAIR OF THE EQUIPMENT.**

 **CAUTION** This symbol identifies information about hazards or unsafe practices. Disregarding this information could result in **PRODUCT DAMAGE AND/OR PERSONAL INJURY.**

 **WARNING**
This symbol identifies information about hazards or unsafe practices. Disregarding this information could result in **SEVERE PERSONAL INJURY OR DEATH.**

 **DANGER**

This symbol identifies information about immediate hazards. Disregarding this information will result in **SEVERE PERSONAL INJURY OR DEATH.**

SAFETY TAGS AND DECALS

 **WARNING**

To avoid severe personal injury or death, all warning tags and decals must be visible and legible to the operator while the equipment is operating.

EQUIPMENT REPAIR AND SERVICE

Proper maintenance, service, and repair are important to the safe, reliable operation of the unit and related equipment. Do not use any procedure not recommended in the Waukesha Engine manuals for this equipment.

 **WARNING**

To prevent severe personal injury or death, always stop the unit before cleaning, servicing, or repairing the unit or any driven equipment.

Place all controls in the OFF position and disconnect or lock out starters to prevent accidental restarting. If possible, lock all controls in the OFF position and take the key. Put a sign on the control panel warning that the unit is being serviced.

Close all manual control valves, disconnect and lock out all energy sources to the unit, including all fuel, electric, hydraulic, and pneumatic connections.

Disconnect or lock out driven equipment to prevent the possibility of the driven equipment rotating the disabled engine.

SAFETY

WARNING

To avoid severe personal injury or death, ensure that all tools and other objects are removed from the unit and any driven equipment before restarting the unit.

WARNING

Allow the engine to cool to room temperature before cleaning, servicing, or repairing the unit. Hot components or fluids can cause severe personal injury or death.

Some engine components and fluids are extremely hot even after the engine has been shut down. Allow sufficient time for all engine components and fluids to cool to room temperature before attempting any service procedure.

ACIDS

WARNING

Comply with the acid manufacturer's recommendations for proper use and handling of acids. Improper handling or misuse could result in severe personal injury or death.

BATTERIES

WARNING

Comply with the battery manufacturer's recommendations for procedures concerning proper battery use and maintenance. Improper maintenance or misuse could result in severe personal injury or death.

BODY PROTECTION

WARNING

Always wear OSHA approved body, sight, hearing and respiratory system protection. Never wear loose clothing, jewelry, or long hair around an engine. The use of improper attire or failure to use protective equipment may result in severe personal injury or death.

CHEMICALS

GENERAL

WARNING

Always read and comply with safety labels on all containers. Do not remove or deface the container labels. Improper handling or misuse could result in severe personal injury or death.

CLEANING SOLVENTS

WARNING

Comply with the solvent manufacturer's recommendations for proper use and handling of solvents. Improper handling or misuse could result in severe personal injury or death. Do not use gasoline, paint thinners, or other highly volatile fluids for cleaning.

LIQUID NITROGEN/DRY ICE

WARNING

Comply with the liquid nitrogen/dry ice manufacturer's recommendations for proper use and handling of liquid nitrogen/dry ice. Improper handling or use could result in severe personal injury or death.

COMPONENTS

HEATED OR FROZEN

WARNING

Always wear protective equipment when installing or removing heated or frozen components. Some components are heated or cooled to extreme temperatures for proper installation or removal. Direct contact with these parts could cause severe personal injury or death.

INTERFERENCE FIT

WARNING

Always wear protective equipment when installing or removing components with an interference fit. Installation or removal of interference components may cause flying debris. Failure to use protective equipment may result in severe personal injury or death.

COOLING SYSTEM

⚠ WARNING

Always wear protective clothing when venting, flushing or blowing down the cooling system. Operational coolant temperatures can range from 180° - 250° F (82° - 121° C). Contact with hot coolant or coolant vapor can cause severe personal injury or death.

⚠ WARNING

Do not service the cooling system while the engine is operating or when the coolant is hot. Operational coolant temperatures can range from 180° - 250° F (82° - 121° C). Contact with hot coolant or vapor can cause severe personal injury or death.

ELECTRICAL

GENERAL

⚠ WARNING

Do not install, set up, maintain, or operate any electrical components unless you are a technically qualified individual who is familiar with the electrical elements involved. Electrical shock can cause severe personal injury or death.

⚠ WARNING

Disconnect all electrical power supplies before making any connections or servicing any part of the electrical system. Electrical shock can cause severe personal injury or death.

IGNITION

⚠ WARNING

Avoid contact with ignition units and wiring. Ignition system components can store electrical energy and if contacted can cause electrical shocks. Electrical shock can cause severe personal injury or death.

⚠ WARNING

Properly discharge any electrical component that has the capability to store electrical energy before connecting or servicing that component. Electrical shock can cause severe personal injury or death.

EXHAUST

⚠ WARNING

Do not inhale engine exhaust gases. Exhaust gases are highly toxic and could cause severe personal injury or death.

Ensure exhaust systems are leak free and that all exhaust gases are properly vented.

⚠ WARNING

Do not touch or service any heated exhaust components. Allow sufficient time for exhaust components to cool to room temperature before attempting any service procedure. Contact with hot exhaust system components can cause severe personal injury or death.

FIRE PROTECTION

⚠ WARNING

Refer to local and federal fire regulations for guidelines for proper site fire protection. Fires can cause severe personal injury or death.

SAFETY

FUELS

GENERAL

WARNING

Ensure that there are no leaks in the fuel supply. Engine fuels are highly combustible and can ignite or explode causing severe personal injury or death.

GASEOUS

WARNING

Do not inhale gaseous fuels. Some components of fuel gas are odorless, tasteless, and highly toxic. Inhalation of gaseous fuels can cause severe personal injury or death.

WARNING

Shut off the fuel supply if a gaseous engine has been cranked excessively without starting. Crank the engine to purge the cylinders and exhaust system of accumulated unburned fuel. Failure to purge accumulated unburned fuel in the engine and exhaust system can result in an explosion resulting in severe personal injury or death.

LIQUID

WARNING

Do not ingest liquid fuels or breathe in their vapors. Liquid fuels may be highly toxic and can result in severe personal injury or death.

WARNING

Use protective equipment when working with liquid fuels and related components. Liquid fuel can be absorbed into the body resulting in severe personal injury or death.

INTOXICANTS AND NARCOTICS

WARNING

Do not allow anyone under the influence of intoxicants and/or narcotics to work on or around industrial engines. Workers under the influence of intoxicants and/or narcotics are a hazard both to themselves and other employees and can cause severe personal injury or death to themselves or others.

PRESSURIZED FLUIDS/GAS/AIR

WARNING

Never use pressurized fluids/gas/air to clean clothing or body parts. Never use body parts to check for leaks or flow rates. Pressurized fluids/gas/air injected into the body can cause severe personal injury or death.

Observe all applicable local and federal regulations relating to pressurized fluid/gas/air.

PROTECTIVE GUARDS

WARNING

Provide guarding to protect persons or structures from rotating or heated parts. Contact with rotating or heated parts can result in severe personal injury or death.

It is the responsibility of the engine owner to specify and provide guarding.

SPRINGS

WARNING

Use appropriate equipment and protective gear when servicing or using products that contains springs. Springs, under tension or compression, can eject if improper equipment or procedures are used. Failure to take adequate precautions can result in serious personal injury or death.

TOOLS

ELECTRICAL

⚠ WARNING

Do not install, set up, maintain, or operate any electrical tools unless you are a technically qualified individual who is familiar with them. Electrical tools use electricity and if used improperly could cause severe personal injury or death.

HYDRAULIC

⚠ WARNING

Do not install, set up, maintain, or operate any hydraulic tools unless you are a technically qualified individual who is familiar with them. Hydraulic tools use extremely high hydraulic pressure and if used improperly could cause severe personal injury or death.

⚠ CAUTION Always follow recommended procedures when using hydraulic tensioning devices. Improper use of hydraulic tensioning tools can cause severe engine damage.

PNEUMATIC

⚠ WARNING

Do not install, set up, maintain, or operate any pneumatic tools unless you are a technically qualified individual who is familiar with them. Pneumatic tools use pressurized air and if used improperly could cause severe personal injury or death.

WEIGHT

⚠ WARNING

Always consider the weight of the item being lifted and use only properly rated lifting equipment and approved lifting methods. Failure to take adequate precautions can result in serious personal injury or death.

⚠ WARNING

Never walk or stand under an engine or component while it is suspended. Failure to adhere to this could result in severe personal injury or death.

WELDING

GENERAL

⚠ WARNING

Comply with the welder manufacturer's recommendations for procedures concerning proper use of the welder. Improper welder use can result in severe personal injury or death.

ON ENGINE

⚠ CAUTION Ensure that the welder is properly grounded before attempting to weld on or near an engine. Failure to properly ground the welder could result in severe engine damage.

⚠ CAUTION Disconnect the ignition harness before welding on or near an engine to eliminate charging of an ignition system capacitor. Failure to disconnect the ignition harness could result in severe engine damage.

SAFETY

WIRING REQUIREMENTS

All electrical equipment and wiring shall comply with applicable local codes. This Waukesha standard defines additional requirements for Waukesha engines.

⚠ WARNING

Do not install, set up, maintain, or operate any electrical components unless you are a technically qualified individual who is familiar with the electrical elements involved. Electrical shock can cause severe personal injury or death.

⚠ WARNING

Disconnect all electrical power supplies before making any connections or servicing any part of the electrical system. Electrical shock can cause severe personal injury or death.

1. Whenever two or more wires run together, they should be fastened together at no more than four (4) to six (6) inch intervals, closer where necessary, with tie wraps. Power wires (24 volts or greater) should never be run together with any other instrument or control wires. Spacing for these types of wires should be six (6) inches minimum to eliminate electrical "noise" problems in the instrument or control wires.

2. All wires should be mounted off hot areas of the engine with insulated clips, at intervals of no more than twelve (12) inches, closer where necessary. Wires must never be run closer than six (6) inches to exhaust manifolds, turbochargers, or exhaust pipes.

3. In cases where wires do not run over the engine, they should be fastened to rigid, non-moving bodies with insulated clips when possible or tie wraps. Fasteners should be spaced at no more than twelve (12) inch intervals.

4. When wires run through holes, rubber grommets should be installed in holes to protect the wires. Wires should never be run over rough surfaces or sharp edges without protection (see Item 11).

⚠ CAUTION Do not use non-electrical grade RTVs. Non-electrical RTVs can emit corrosive gases that can damage electrical connectors.

5. An electrical grade RTV should be applied around the wires entering all electrical devices such as Murphy Junction Boxes and gas valves, Syncro Start speed switches, microswitch boxes used in conjunction with safety equipment, solenoids, etc. An electrical grade RTV is to be applied immediately after wire installation and prior to the engine entering the test room.

6. A small "drip loop" should be formed in all wires before entering the electrical devices. This drip loop will reduce the amount of moisture entering electrical device via the wires if an electrical grade RTV does not seal completely.

7. The following procedures should be followed for wires entering engine junction boxes:

- Bottom entrance best and side entrance second best.
- Insert grommet in opening to protect wires.
- Wires to contain "drip loop" before entering box, except where using bottom entrance.
- When installing flexible conduit, use straight connector for side entrance. If top entrance is required, use elbow connector.

8. If wire harness has a covering, clamp harness so openings of covering are downward.

9. The routing of wires should be determined for reliability and appearance and not by shortest distance.

10. Installation connection wire must be coiled and secured to provide protection during shipment.

11. Each end of flexible metal conduit *must* have an insulating sleeve to protect wires from chafing.

⚠ WARNING

Always label "HIGH VOLTAGE" on engine mounted equipment over 24 volts. Failure to adhere to this warning could result in personal injury or death.

12. All engine mounted electrical equipment over 24 volts shall have "HIGH VOLTAGE" warning decal. Decal to be attached to all the equipment and junction boxes on visible surface (vertical surface whenever possible).

13. Wiring that is routed in rigid or flexible conduit shall have all wire splices made only in junction boxes, outlet boxes, or equipment boxes. Wire splices shall not be located in the run of any conduit.

GENERAL INFORMATION

POWER REQUIREMENTS FOR CUSTOM ENGINE CONTROL® PRODUCTS

Table 1.05-4 provides you with the power requirements for Waukesha's Custom Engine Control® (CEC) products. An oscilloscope must be used to verify ripple limitations. All power connections must be in accordance with the applicable electrical codes.

NOTE: To power the CEC Ignition Module, a nominal supply of 24 VDC with less than a 2 volt peak-to-peak ripple is recommended for compatibility with other CEC products.

CAPACITIVE DISCHARGE AND GROUNDING

A Capacitive Discharge (CD) ignition system, such as the CEC Ignition Module, requires an external power source and special wiring requirements.

This ignition system contains several large energy storage capacitors. When firing a spark plug, the energy stored in one of these capacitors is rapidly discharged into an ignition coil which converts it to the high tension ignition voltage. Having been discharged, the energy storage capacitor must then be recharged to be ready to fire again. The storage capacitor is typically recharged

by drawing energy from the power supply as quickly as possible, resulting in a high current flow (typically 30 amps or more) in the power supply wiring for a short period of time.

The average ignition system current remains low (1 or 2 amps depending on the number of cylinders, engine speed, and supply voltage) since the high current only flows for the short period of time and virtually no current flows the rest of the time. However, the wiring must be sized for the high instantaneous currents. In addition, the grounding, particularly where the ground is "referenced," becomes more critical when electronic controls are used on engines having this type of CD ignition system.

With ignition power supply currents of approximately 30 amps, the resistive voltage drop of the wiring can easily reach a volt or two. As a result, it is necessary to reference all of the grounds to the same point. Since many electronic sensors are internally grounded, the engine crankcase has been chosen as THE GROUND reference to minimize problems with sensor signals. By following the recommended wiring and grounding procedures, the concerns associated with the ignition power supply wiring voltage drops can be greatly reduced or eliminated.

Table 1.05-4. Power Requirements For Waukesha Custom Engine Control® Products

CEC PRODUCT	NOMINAL VOLTAGE (volts DC)	TOLERANCE	OPERATING RANGE (volts DC)	PEAK-TO-PEAK RIPPLE (volts AC)	OPERATING CURRENT (amps)
Ignition Module (IM)	24	+33%, -58%	10.0 - 32.0**	less than 2**	2 (typical)
Detonation Sensing Module (DSM) System	24	+25%, -10%	21.6 - 30.0	less than 2	1.5
Air/Fuel Module (AFM) System	24	+25%, -10%	21.6 - 30.0	less than 2	2.5 (all rich burn applications) 18.0 (lean burn applications on VHP 6 cylinder and all VGF engines) 32.0 (lean burn applications on all AT and VHP 12 & 16 cylinder engines)
Turbocharger Control Module (TCM) System	24	+25%, -10%	21.6 - 30.0	less than 2	1.5

NOTE: *The voltage specifications provided in this table apply to the power that is to be supplied to the the CEC modules. The CEC modules will supply the correct voltage specification (s) to other system components if required, such as oxygen sensors used in the AFM system.
**For compatibility with other CEC products, a nominal supply of 24 VDC with less than a 2 volt peak-to-peak ripple is recommended to power the IM.

SECTION 1.10

DESCRIPTION OF OPERATION

CUSTOM ENGINE CONTROL® DETONATION SENSING MODULE SYSTEM

SYSTEM DESCRIPTION

Detonation is the autoignition of end gas after the spark plug has fired that is not being consumed in normal flame-front reaction in an engine's combustion chamber. When this happens, two pressure waves, created by the two flame-fronts, slam together creating a high pressure pulse which causes an audible "ping" or "knock" known as detonation. Avoiding detonation conditions is critical since detonation is typically destructive to engine components.

Detonation is caused by site conditions and/or engine misadjustment, not the engine. The conditions that promote detonation are extremely complex. See "Detonation Theory" in this section for a definition of detonation and examples of detonation promoters and reducers.

To prevent detonation from occurring, Waukesha Engine has developed an electronic Custom Engine Control® Detonation Sensing Module (DSM) system that is designed to function with spark ignited Waukesha AT, VGF (12 and 16 cylinders), and VHP engines (see Figure 1.10-1). The DSM system protects Waukesha spark ignited gas engines from damage due to detonation.

NOTE: For maximum engine protection, the DSM system must be connected to a safety shutdown.

COMPONENTS

The DSM, and its related system, are designed to function with the CEC Ignition Module through a 14 pin DSM expansion port (see Figure 1.10-2). The DSM system also includes a Waukesha designed electronic filter, knock sensors, and a number of interconnecting cables and harnesses that may vary depending on the application (see Figure 1.10-1).

The DSM system is customized for each application with a personal computer. Minimum requirements include an 80286-12 Mhz microprocessor, a 3.5 inch high density (1.44 MB) floppy disk drive, an RS-232 serial port, and MS-DOS 3.3 or higher. However, a 386 or 486 based computer with both hard and floppy drives and a printer port is strongly recommended.

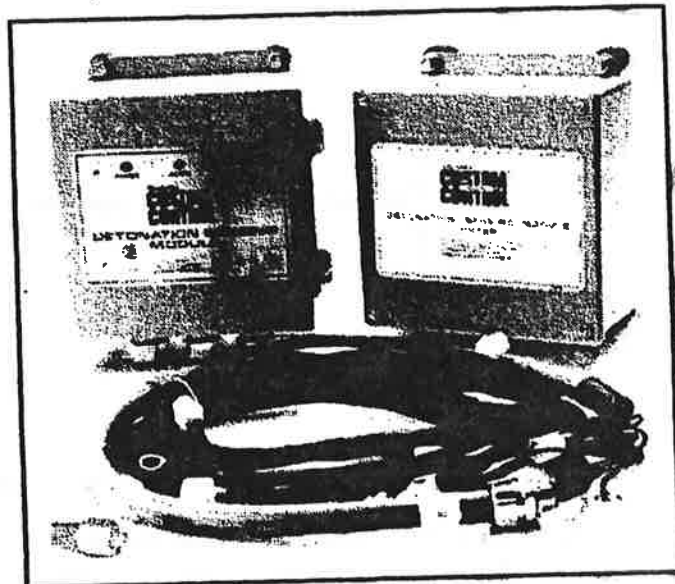


Figure 1.10-1. CEC Detonation Sensing Module System

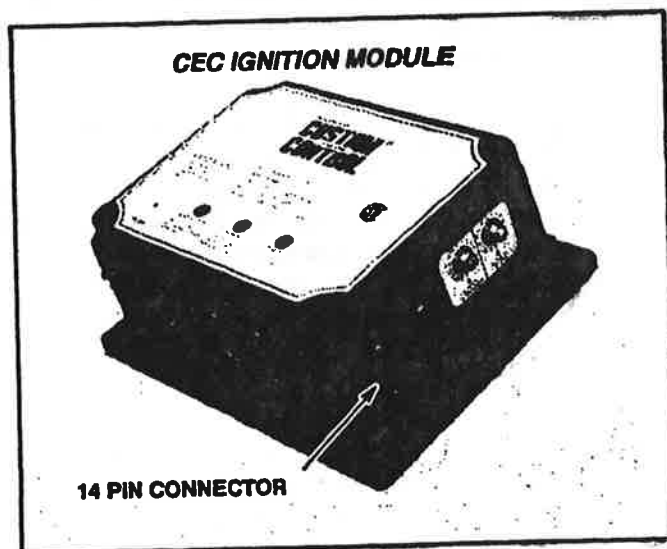


Figure 1.10-2. CEC Ignition Module With 14 Pin DSM Expansion Port

The schematic in Figure 1.10-3 illustrates the electronic route of the DSM system.

DESCRIPTION OF OPERATION

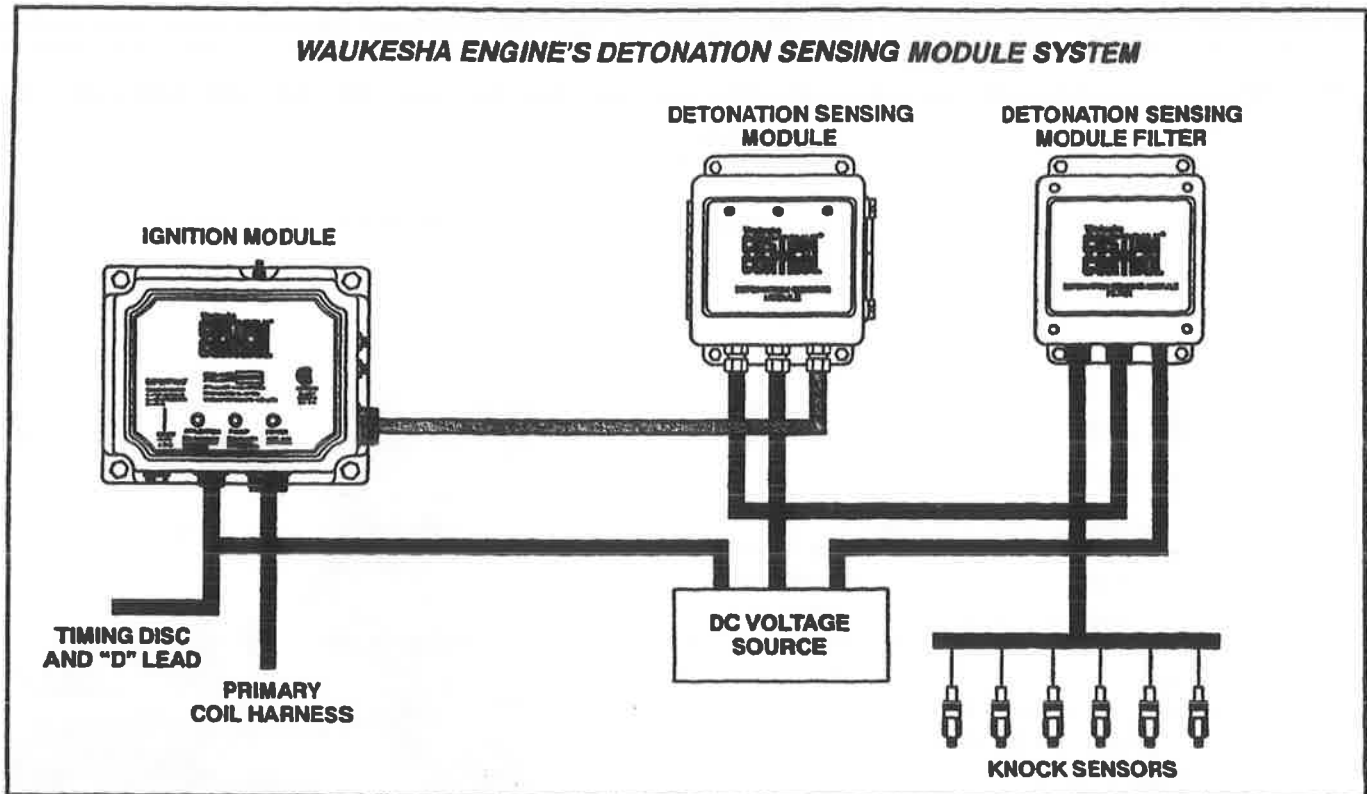


Figure 1.10-3. Detonation Sensing Module System Layout

CANADIAN STANDARDS ASSOCIATION (CSA)

The DSM system meets North American Canadian Standards Association (CSA) Class 1, Division 2, Group D Hazardous Location requirements. Under this classification, the DSM system can operate safely in locations where there is danger of explosion due to the presence of flammable gases.

CAUTION Never substitute any components of the CSA certified DSM system. Substitution of components may impair suitability for Class 1, Division 2 Group D Hazardous Location requirements. Disregarding this information could result in product damage and/or personal injury.

ENGINES SERVED

Currently, the DSM system is designed to function with spark ignited Waukesha AT, VGF (12 and 16 cylinders), and VHP engines. All information about the engine model and application is programmed to the DSM module using a personal computer.

IGNITION TIMING ADJUSTMENTS

The DSM system functions by monitoring vibrations at each cylinder with knock sensors. When a signal exceeds a detonation threshold, the DSM system, through the CEC Ignition Module, retards ignition timing incrementally. Ignition timing is adjusted on an individual cylinder basis or in "cylinder pairs." The descriptions that follow describe the adjustment made on the different engines.

- On 6 and 12 cylinder VHP engines, one knock sensor is mounted below each cylinder head. When detonation is detected with the DSM system, ignition timing is adjusted on an individual cylinder basis.
- On 8 and 12 cylinder AT engines, one knock sensor is mounted on each cylinder head. When detonation is detected with the DSM system, ignition timing is adjusted on an individual cylinder basis.
- On 12 cylinder VGF engines, one sensor is mounted for two adjacent cylinders (6 sensors total); however, when detonation is detected ignition timing is still adjusted on an individual cylinder basis. Individual timing is possible because the engine alternately fires a cylinder on each engine bank but the knock sensor works for adjacent cylinders on the same engine bank.

- On 16 cylinder VHP engines, one sensor is mounted below each cylinder head but ignition timing is adjusted in "cylinder pairs." Timing adjusts for two cylinders (one on each bank) at once when detonation is detected by either sensor of the paired cylinders.
- On 16 cylinder AT engines, one sensor is mounted on each cylinder head but ignition timing is adjusted in "cylinder pairs." Timing adjusts for two cylinders (one on each bank) at once when detonation is detected by either sensor of the paired cylinders.
- On 16 cylinder VGF engines, one sensor is mounted for two adjacent cylinders (8 sensors total). Ignition timing is adjusted in "cylinder pairs." Timing adjusts for two cylinders (one on each bank) at once when detonation is detected by either sensor of the paired cylinders.

OPERATOR INTERFACE

The DSM module is equipped with several features to inform site personnel of system status. These features include:

- "Power," "Alarm," and "Shutdown" lights (LEDs) on the front panel of the DSM module (see Figure 1.10-4)
- a liquid crystal display (LCD) located inside the DSM module which continually shows the current status of the system through diagnostic codes (see Figure 1.10-5)
- the capability to drive remote alarms or lights

Example: For 6, 8, and 12 cylinder engines the DSM module can detect if a sensor has been damaged or disconnected. In either event, a default timing value is imposed for the cylinder associated with the lost signal. In addition to imposing the default timing, the DSM module will also illuminate the yellow alarm LED on the front cover, provide a signal for a remote alarm, and will display the error code on the LCD within the DSM module.

NOTE: For 16 cylinder engines a sensor test must be performed to detect a lost sensor. The lost sensor check procedure is explained in Section 4.10, Lost Sensor Check Test On 16 Cylinder Engines. A test for lost sensors should be performed whenever the safety controls and alarms are tested on the engine.

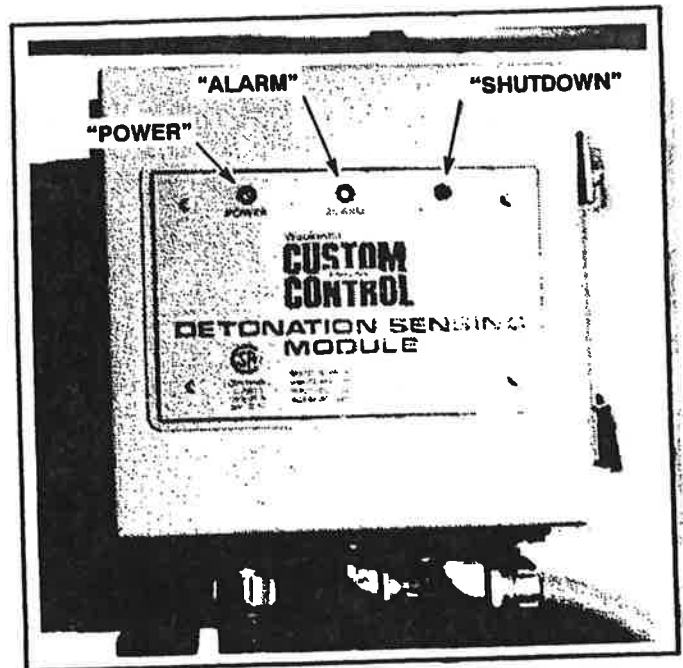


Figure 1.10-4. Detonation Sensing Module Front Panel

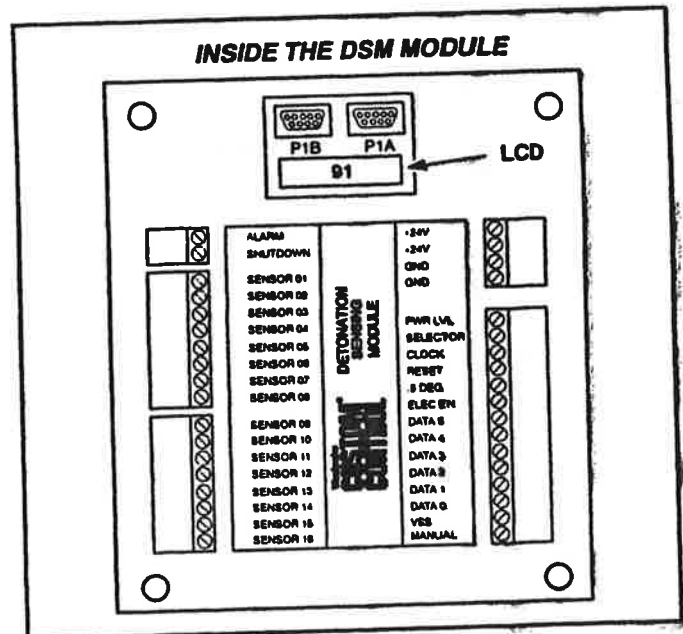


Figure 1.10-5. Detonation Sensing Module LCD

⚠ WARNING

For maximum engine protection, the DSM system must be connected to a safety shutdown. The DSM system is considered a safety system and, as such, must be connected to shut down the engine if the engine cannot be brought out of detonation. Disregarding this information could result in severe personal injury or death.

NOTE: Refer to Section 2.10 DSM System Power And Alarm Connections for installation.

DESCRIPTION OF OPERATION

THEORY OF OPERATION

The DSM system senses detonation with a technique called "windowing." This technique allows the DSM system to look for detonation only during the combustion time when detonation could be present.

The "window" opens shortly after the spark plug fires to eliminate the effects of ignition noise. This noise is caused from the firing of the spark plug and subsequent "ring-out" of coils. The "end of sample window" is closed near the end of the combustion event. This is a predetermined angle after top dead center (ATDC) in crankshaft degrees at which the "window" is closed (programmable) (see Figure 1.10-6).

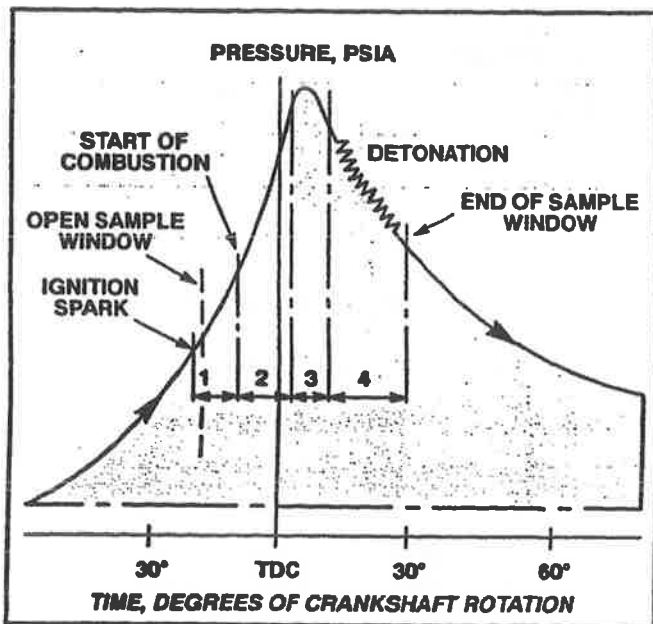


Figure 1.10-6. Windowing Chart

For 16 cylinder engines, the window opens after a short delay following the firing of the first cylinder in the cylinder pair just as it does in the other applications, but the window closes temporarily during the firing of the second cylinder in the pair. The window is opened again to look at the second cylinder during its combustion process. The DSM then closes the "window" after the programmed delay relative to the second cylinder in the "pair."

The DSM module monitors for detonation using the frequency output of each cylinder with engine mounted knock sensors.

During detonation a unique vibration called "knock" frequency is produced. Knock frequency is just one of many frequencies created in a cylinder during engine operation. The knock sensors mounted at each cylinder convert engine vibrations to electrical signals which are routed through a Waukesha designed electronic filter (electronic filters are engine model specific) (see Figure 1.10-7). This filter removes the electrical signals that are not associated with detonation and routes the knock signal to the DSM module. When the filtered signal exceeds a predetermined limit (detonation threshold), the DSM module, in conjunction with the Ignition Module, retards the ignition timing for the cylinder (or cylinder pair in 16 cylinder applications) associated with that sensor. The predetermined limit or detonation threshold can be reprogrammed using the DSM system software and a personal computer.

The DSM system controls timing between two predetermined limits. The maximum advanced timing (nameplate timing) at which the system will allow the engine to operate is the Most Advanced Timing (programmable). The minimum advanced timing at which the system will allow the engine to operate is the Most Retarded Timing (programmable). Several factors go into the selection of the retard limit, including exhaust temperature and emission considerations.

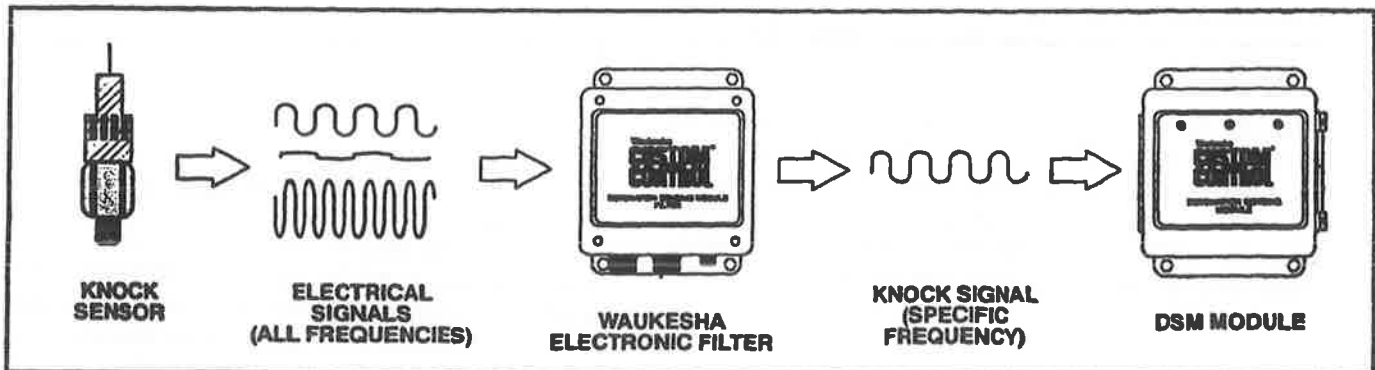


Figure 1.10-7. DSM Electronic Filter Operation

In the event that the DSM system senses detonation, the ignition timing will be retarded at a predetermined rate (programmable) until either the signal from the sensor falls below the "detonation threshold" or the Most Retarded Timing position is reached. Should detonation continue once the Most Retarded Timing is reached, the DSM module will illuminate the "Shutdown" light on the module's cover after a predetermined period of time (programmable), and provide an output that can be used to shut the engine off or activate other warning devices. As soon as conditions permit, the DSM system will advance spark timing to the original set-point at a predetermined rate (programmable).

For 6, 8, and 12 cylinder applications, the DSM system, in conjunction with the Ignition Module, is capable of varying engine timing a total of 35 crankshaft degrees. Twenty-five degrees of authority are available when the "D" lead of the Ignition Module is grounded, and 31 degrees of authority are available when the "D" lead is ungrounded. However, these two separate ranges of adjustment overlap by 21 degrees so a total span of 35 degrees is available.

On 16 cylinder VGF and VHP applications, 20 degrees of authority are available when the "D" lead of the Ignition Module is grounded, and 25 degrees of authority are available when the "D" lead is ungrounded. However, these two separate ranges of adjustment overlap by 16 degrees so a total span of 29 degrees is available.

On 16 cylinder AT applications, 20 degrees of authority are available when the "D" lead of the Ignition Module is grounded, and 19 degrees of authority are available when the "D" lead is ungrounded. However, these two separate ranges of adjustment overlap by 16 degrees so a total span of 23 degrees is available.

NOTE: Ignition timing varies for each engine application. Refer to the engine nameplate for engine timing (BTDC) or the Custom Engine Control[®] Ignition Module Installation, Operation, And Maintenance Manual Form 6253 or Form 6272 (for Models 811, 1211, and 1611) for more information.

The system also has a predetermined default timing value (programmable) that is used during a predetermined warm-up time period (programmable) and when a low sensor output is detected. During engine warm-up, the DSM system is disabled and is not protecting the engine so the default timing value is active. The purpose of this delay is to prevent misleading vibration signals, that may exist during the time that the engine is warming up, from being incorrectly detected as detonation signals. With careful selection of the default timing value and the warm-up time period, it may be possible to improve synchronization characteristics because the engine should have better speed stability at the retarded (from nameplate) default timing.

DETONATION THEORY

Detonation has been a known adversary of engine operation for many years. Avoiding detonation conditions is critical since detonation is typically destructive to engine components. Severe detonation often damages pistons, cylinder heads, valves, and piston rings. Damage from detonation will eventually lead to complete failure of the affected part. Detonation is preventable; however, the conditions which promote detonation are extremely complex and many variables can promote detonation at any one time. This section defines detonation and gives examples of detonation promoters and reducers.

In normal combustion, the forward boundary of the burning fuel is called the "flame-front." Research has shown that combustion in a gaseous air/fuel homogeneous mixture ignited by a spark is characterized by the more or less rapid development of a flame that starts from the ignition point and spreads continually outward in the manner of a grass fire. When this spread continues to the end of the chamber without abrupt change in its speed or shape, combustion is called "normal." When analyzing detonation, however, combustion is never normal.

Detonation is due to the autoignition of the end gas after spark ignition has occurred which is that part of the air/fuel charge which has not yet been consumed in the normal flame-front reaction. When detonation occurs, it is because compression of the end gas by expansion of the burned part of the charge raises its temperature and pressure to the point where the end gas autoignites. If the reaction of autoignition is sufficiently rapid and a sufficient amount of end gas is involved, the two flame-fronts will collide with sufficient force to be heard. This is referred to as audible "ping" or "knock."

The tendency to detonate will depend chiefly on the temperature and pressure of the end gas in the combustion chamber. Any change in engine operating characteristics which affects end gas temperature will determine whether combustion will result with or without detonation. The greater the end gas pressure and temperature and the time to which the end gas is exposed to this severe stress, the greater will be the tendency for the fuel to detonate.

DESCRIPTION OF OPERATION

Detonation is an extremely complex subject when dealing with internal combustion engines. The number of unpredictable variables in actual field running engines can be enormous. Table 1.10-1 lists the promoters and reducers of detonation.

Table 1.10-1. Detonation Promoters And Reducers

PROMOTERS	REDUCERS
Higher Cylinder Temperature	Lower Cylinder Temperatures
Lower Octane Fuels	Higher Octane Fuels
More Advanced Spark Timing	Less Advanced Spark Timing
Higher Compression Ratios	Lower Compression Ratios
Higher Inlet Pressure	Lower Inlet Pressure
Higher Coolant Temperatures	Lower Coolant Temperatures
Lower Engine Speeds	Higher Engine Speeds
Lower Atmospheric Humidity	Higher Atmospheric Humidity
Higher Engine Load	Lighter Engine Load
Stoichiometric Air/Fuel Ratio (Rich Burn Engine)	Lean or Rich Air/Fuel Ratios (Without Engine Overload)
Rich Air/Fuel Ratio (Lean Burn Engine)	Lean Air/Fuel Ratios

DEFINITIONS

AutoCal: Automatic calibration of the detonation threshold by the DSM Terminal Program.

NOTE: After doing any removal, repair, or replacement of engine cylinder heads, cylinder liners, cylinder gaskets, pistons, or knock sensors, the DSM system must be re-AutoCaled using the DSM Terminal Program and a personal computer.

Data-Set: A data-set is a group of site specific data points that are created and then stored within the DSM module. The DSM data-set includes values for: Most Advanced Timing, Most Retarded Timing, End of Sample Window angle, retard and advanced timing values, warm-up delay time, and shutdown delay time.

Default Timing: The default timing is the retarded ignition timing imposed by the DSM system when it is not protecting against detonation. The DSM system activates default timing for a cylinder when the cylinder's sensor is disabled, when the sensor fails, and during engine warm-up delay. (PC programmable)

Detonation: Detonation occurs when part of the air/fuel charge cannot wait for the normal flame-front, which was started by the spark plug, to pass completely through the combustion chamber. The advancing flame-front heats and squeezes the unburned mixture until it explodes or autoignites. A good comparison is a grass fire. Normal combustion is similar to a grass fire. It begins at one end of a field, and the flame-front progresses in an orderly manner through the field. When all of the grass is burned, the combustion stops. During "grass-detonation," the grass would begin burning normally, but before the flames could sweep through the length of the field, some portion of the unburned grass would burst into flames. When this happens in the combustion chamber of an engine, two pressure waves, associated with the two flame-fronts, slam together and cause the audible "ping" or "knock."

Detonation Level: Voltage that a detonation signal must exceed before the engine is considered to be in detonation and individual cylinder timing is retarded.

End of Sample Window: This is a predetermined angle after top dead center (ATDC) in crankshaft degrees at which the window is closed. The window is used so that detonation is only looked for during the combustion event. (PC programmable)

EPROM: Erasable Programmable Read Only Memory. This is the same as ROM (permanent memory) when speaking about programming the DSM module. The term EPROM is used to describe the electrical chip that resides in the DSM module.

Filter: The filter isolates the "knock" frequency from background engine noise and other frequencies.

Interface Program: The personal computer program that is used to create data-sets and communicate with the DSM system.

Knock Frequency: The unique vibration or frequency that an engine exhibits while in detonation.

Knock: Engine detonation.

Knock Sensor: Converts engine vibration to an electrical signal to be used by the DSM filter to isolate the "knock" frequency.

LCD: Liquid Crystal Display. Numerical display located inside the DSM module, that informs the system operator of current DSM system status via coded messages.

LED: Light Emitting Diode. A semiconductor that emits light (not a light bulb) and is used as power, alarm, and shutdown indicators, located on the front of the DSM module.

Most Advanced Timing: The maximum advanced timing at which the DSM system will allow the engine to operate (nameplate timing). (PC programmable)

Most Retarded Timing: The minimum timing at which the DSM system will allow a cylinder to retard in order to control detonation (PC programmable)

Pre-ignition: Pre-ignition is autoignition that occurs prior to the timed spark ignition. It is caused by an overheated surface in the combustion chamber. Pre-ignition may lead to detonation because during pre-ignition the combustion event is not initiated by the Ignition System's spark. Therefore, it is not possible to control pre-ignition with the DSM system.

RAM: Random Access Memory. RAM, temporary DSM system memory, is used to evaluate "test" data-sets before storing to ROM. The contents of RAM are lost whenever power to the DSM module is removed.

ROM: Read Only Memory. When the DSM module configures data-sets to ROM, or permanent memory, the data-set information is not lost when power to the DSM module is removed. The DSM module allows a limited number of saves to ROM (25 saves to ROM are possible). Once ROM has been fully configured, the EPROM chip in the DSM module must be replaced to permit further saves to permanent memory.

Shutdown Delay: Amount of delay between the moment when the cylinder reaches the Most Retarded Timing during detonation and the time the shutdown warning becomes active while still in detonation. (PC programmable)

Sinking Circuit: An electronic switching circuit with a single output terminal used to provide a path to ground. This mechanism can be used as a trigger to drive remote devices such as alarms, lights, and relays. When the DSM system is operating correctly it is an OPEN device. Any system fault will CLOSE the circuit. The circuit is designed to handle a maximum current rating of 1 amp and a maximum voltage rating of 50 VDC (no AC voltages are allowed).

Timing Disk Reference: The angular relationship between the magnet for the first cylinder to fire and top dead center (TDC). Example: 25° BTDC

Warm-Up Delay: Amount of delay between the time the engine begins rotating and when the DSM system takes control of ignition timing. While this delay is active, the cylinders are operating at the default timing. The purpose of this delay is to prevent misleading vibration signals, that may exist during the time the engine is warming up, from being incorrectly construed as "knock" signals. During the Warm-Up Delay time, the DSM system is not protecting against detonation. (PC programmable)

Windowing: This technique allows the DSM system to look for detonation only during the combustion time when detonation could be present.

DESCRIPTION OF OPERATION

CONTENTS

SECTION 2.00 - MOUNTING DSM SYSTEM COMPONENTS

SECTION 2.05 - DSM SYSTEM COMPONENT CONNECTIONS

**SECTION 2.10 - DSM SYSTEM POWER, ALARM, AND
GROUND CONNECTIONS**

SECTION 2.15 - DSM SYSTEM WIRING DIAGRAMS

1

2

3

SECTION 2.00

MOUNTING DSM SYSTEM COMPONENTS

SYSTEM COMPONENTS

The DSM system includes a DSM module, a Waukesha designed electronic filter, detonation knock sensors, and harnesses that vary depending on the application (see Figure 2.00-1). Table 2.00-1 lists the part numbers for the components of the DSM system.

NOTE: Unless otherwise shown in Table 2.00-1, DSM retrofit kit part numbers are same as production part numbers.

NOTE: The filters used with the DSM system are engine specific. If an incorrect filter is installed, the DSM system will appear to work but will not protect against detonation. Detonation can cause severe engine damage.

This chapter, Chapter 2 *Detonation Sensing Module System Installation*, explains how to mount the components of the DSM system (Section 2.00), make wire harness connections (Section 2.05), make power connections to the DSM module and filter (Section 2.10), make shutdown/alarm connections (Section 2.10), and make ground connections (Section 2.10). DSM system wiring diagrams for AT, VHP, and VGF engines are provided in Section 2.15.

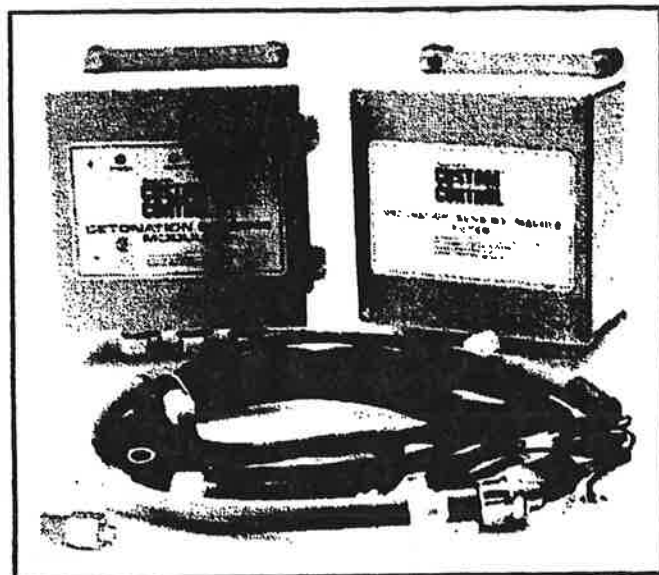


Figure 2.00-1. Detonation Sensing Module System

NOTE: The wiring diagrams included in this manual are to be used as a reference only. For additional reference, use the wiring diagrams received with the DSM system when making connections.

Table 2.00-1. Current DSM System Components

DESCRIPTION ¹		PART NUMBER	
CEC Detonation Sensing Module		D740401 (EPROM Ver. 6.0)	—
DSM Interface Program and Installation, Operation, & Maintenance Manual		A740014A (Ver. 6.0)	—
Knock Sensor		A740110A A740110B ²	— —
Filter	AT-25	A740412B	—
	AT-27	A740412A	—
	AT-27 16 Cylinder	D740412H	—
	VHP 9-3/8	A740412C	—
	VHP 8-1/2	A740412G	—
	VHP 16 Cylinder	C740412H	—
	VGF GL 12 Cylinder	A740412J	—
	VGF GL 16 Cylinder	A740412K	—

(Continued)

MOUNTING DSM SYSTEM COMPONENTS

DESCRIPTION ¹		PART NUMBER		
Harnesses	ATGL 8 Cylinder	"Sensor to Filter" Harness	AD740222	AJ740222 (Retrofit) ³
		"Filter to DSM" Harness	C740225A	F740225 (Retrofit) ³
		"Filter Power" Harness	C740230A	740230B (Retrofit) ³
		"DSM to Ignition" Harness	740221B	7402221 (Retrofit) ³
	ATGL 12 Cylinder	"Sensor to Filter" Harness	AE740222 (OEM)	AH740222 (Retrofit) ³
		"Filter to DSM" Harness	C740225 (OEM)	D740225 (Retrofit) ³
		"Filter Power" Harness	740230 (OEM)	740230B (Retrofit) ³
		"DSM to Ignition" Harness	740221A	7402221 (Retrofit) ³
	ATGL 16 Cylinder	"Sensor to Filter" Harness	AA740222H	—
		"Filter to DSM" Harness	A740225E	—
		"Filter Power" Harness	G740230A	—
		"DSM to Ignition" Harness	740221A	—
	VHP 6 Cylinder	"Sensor to J-Box" Harness	AG740222	G740222 (Retrofit) ³
		"J-Box to Filter" Harness	740232	740232 (Retrofit) ³
		"Filter to DSM" Harness	E740225	E740225 (Retrofit) ³
		"Filter Power" Harness	740230B	740230B (Retrofit) ³
	VHP 12 Cylinder	"DSM to Ignition" Harness	740221	740221 (Retrofit) ³
		"Sensor to J-Box" Harness	AA740222	A740222 (Retrofit) ³
		"J-Box to Filter" Harness	740231	740231 (Retrofit) ³
		"Filter to DSM" Harness	D740225	D740225 (Retrofit) ³
	VHP 16 Cylinder	"Filter Power" Harness	740230B	740230B (Retrofit) ³
		"DSM to Ignition" Harness	740221	740221 (Retrofit) ³
		"Sensor to J-Box" Harness	AA740222C	A740222C (Retrofit) ³
		"J-Box to Filter" Harness	740231A	740231A (Retrofit) ³
	VGF 12 Cylinder	"Filter to DSM" Harness	G740225	G740225 (Retrofit) ³
		"Filter Power" Harness	740230B	740230B (Retrofit) ³
		"DSM to Ignition" Harness	740221	740221 (Retrofit) ³
		"Sensor to Filter" Harness	AM740222	T740222 (Retrofit) ³
VGF 16 Cylinder	"Filter to DSM" Harness	A740225C	740225C (Retrofit) ³	
	"Filter Power" Harness	F740230A	740230B (Retrofit) ³	
	"DSM to Ignition" Harness	A740221D	740221 (Retrofit) ³	
	"Sensor to Filter" Harness	AK740222	N740222 (Retrofit) ³	
	"Filter to DSM" Harness	A740225B	740225B (Retrofit) ³	
	"Filter Power" Harness	E740230A	740230B (Retrofit) ³	
	"DSM to Ignition" Harness	A740221E	740221 (Retrofit) ³	

NOTE: ¹ These are not all of the components required for installation of the DSM system. The customer must supply junction boxes, terminal blocks, brackets, conduit assemblies, and other components depending on engine configuration. DSM system retrofit kits are available (see Table 2.00-2). Please contact your Waukesha Engine Distributor for more information.

² The knock sensor (P/N A740110B) will become standard as remaining stock of the other knock sensor (P/N A740110A) is used. If you have a knock sensor (P/N A740110A) that needs to be replaced, it is possible to replace it with the new knock sensor using a pigtail adaptor (P/N 740225D). The pigtail allows you to install the new sensor to the existing wire harness. Please contact your Waukesha Engine Distributor for more information.

³ The P/N given is for the harness included in a retrofit kit. Harnesses for retrofit kits are different lengths than the harnesses that come with an engine in a non-retrofit installation.

⚠ WARNING

For maximum engine protection, the DSM system must be connected to a safety shutdown. The DSM system is considered a safety system and, as such, must be connected to shut down the engine if the engine cannot be brought out of detonation. Disregarding this information could result in SEVERE PERSONAL INJURY OR DEATH.

NOTE: Refer to Section 2.10, DSM System Power, Alarm, And Ground Connections, for installation.

Table 2.00-2 lists the DSM retrofit kit part numbers for AT, VHP, and VGF engines.

NOTE: DSM system retrofit kits are available. Please contact your Waukesha Engine Distributor for more information.

Table 2.00-2. DSM System Retrofit Kit P/Ns

DESCRIPTION	RETROFIT KIT P/N
ATGL 8 Cylinder	G-962-1557
ATGL 12 Cylinder	G-962-1551
VHP 6 Cylinder	G-962-1552
VHP 12 Cylinder	G-962-1553
VHP 16 Cylinder	G-962-1558
VGF 12 Cylinder	G-962-1559
VGF 16 Cylinder	G-962-1560

MOUNTING THE DSM FILTER

Mount the DSM filter upright in an on or off engine location using the vibration isolators supplied with the filter (see Figure 2.00-2). Note the following concerning filter installation:

- The filter must be mounted within approximately 15 feet (4.5 meters) of the engine (or knock sensor junction box on VHP engines) due to wire length.
- The filter must also be mounted within approximately 15 feet (4.5 meters) of the DSM module due to wire length.
- Ambient temperature may vary from -40° F (-40° C) to 150° F (65° C).
- Although the filter is "splash-proof," exposure to direct sprays of water should be avoided.

⚠ CAUTION The DSM filter must be mounted with the entry ports down. Improper mounting of the DSM filter could result in water entering the DSM filter enclosure resulting in product damage.

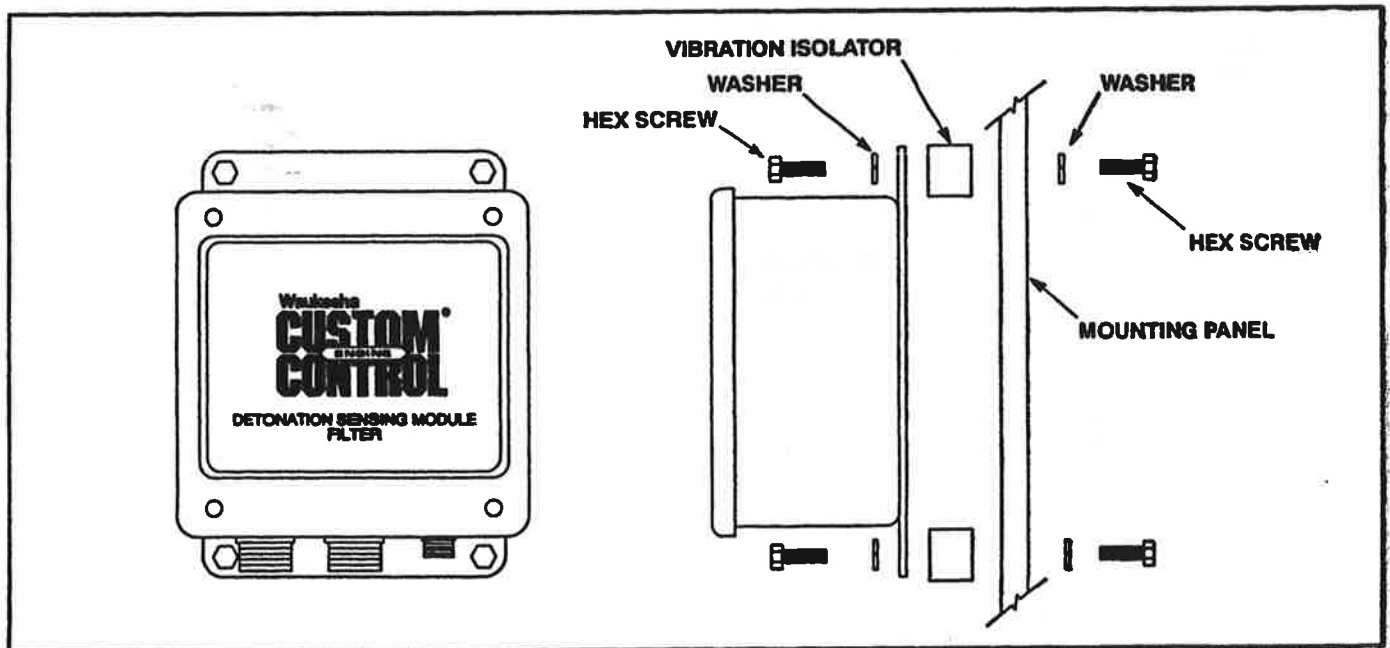


Figure 2.00-2. Mounting The DSM Filter

MOUNTING DSM SYSTEM COMPONENTS

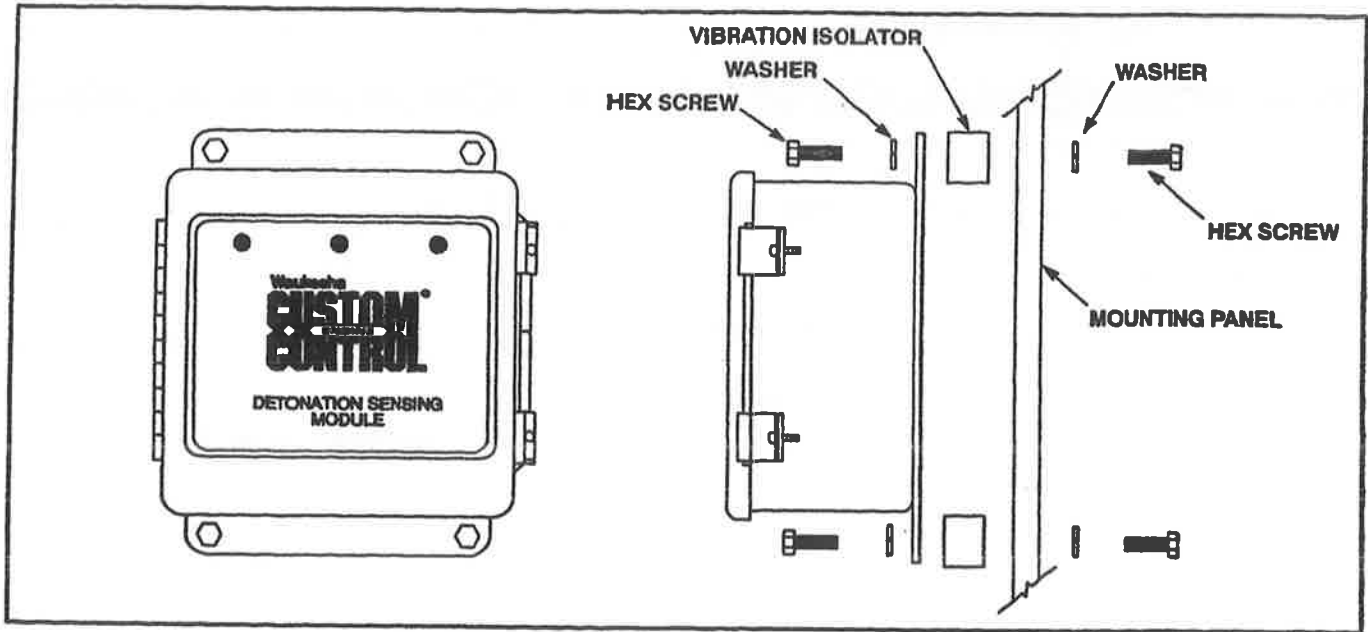


Figure 2.00-3. Mounting The DSM Module

MOUNTING THE DSM MODULE

Mount the DSM module upright in an on or off engine location using the vibration isolators supplied with the DSM module (see Figure 2.00-3). Note the following concerning DSM module mounting:

- The DSM module must be mounted within approximately 15 feet (4.5 meters) of the CEC Ignition Module due to wire length (a wire harness connects the DSM module directly to the Ignition Module).
- Ambient temperature may vary from -40°F (-40°C) to 150°F (65°C).
- Although the DSM module is "splash-proof," exposure to direct sprays of water should be avoided.
- Do not cut any new holes in the DSM module. Wire routing is important. The wires must be directed through the holes provided in the bottom of the DSM module as shown in Figure 2.00-4.

CAUTION Route the DSM system wires through the correct port on the DSM module. The wires must be directed through the holes provided in the bottom of the DSM module. If the wires are routed through the wrong port, electrical interference may result, affecting the performance of the DSM system.

CAUTION The DSM module must be mounted with the entry ports down. Improper mounting of the DSM module could result in water entering the DSM module enclosure resulting in product damage.

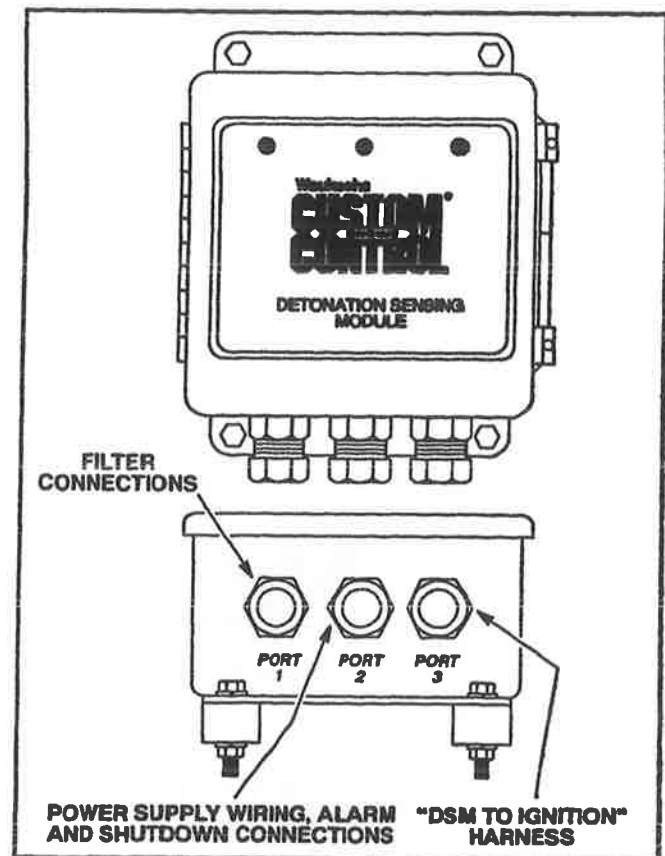


Figure 2.00-4. DSM Module Conduit Ports

MOUNTING THE KNOCK SENSORS

Knock sensors convert engine vibration to an electrical signal that is sent to the DSM filter. The number, location, and mounting procedure of the knock sensors are dependant on the series and age of your engine. On AT engines, knock sensors are installed on the horizontal or top cylinder head location. On VHP and VGF engines, knock sensors are installed just below the intake port on the side of the engine crankcase. Continue with the section "AT Series Engines," "VHP Series Engines," or "VGF Series Engines" to mount the DSM knock sensors on your engine.

AT SERIES ENGINES

The following items are needed for field installation of the knock sensors on AT cylinder heads without predrilled knock sensor mounting holes:

- Drill/Tap Fixture (Tool P/N 473011)
- 1/4" Drill bit
- 7/16" Drill bit
- 5/8" Drill bit
- Tap and Bottoming Tap, 12 mm x 1.25

AT Knock Sensor Mounting Steps

The knock sensors are installed on the left horizontal or top cylinder head locations (see Figure 2.00-5). As of May 1994, all AT cylinder heads are drilled at the factory to accommodate the installation of the knock sensors. If the cylinder heads are predrilled, continue with Step 16. If the cylinder heads are not predrilled, continue with Step 1.

NOTE: A knock sensor with its connector will extend about two inches away from the surface of the cylinder head. There should be at least three inches of clearance perpendicular to the knock sensor surface.

CAUTION All harnesses must be routed at least four inches away from ignition or other high voltage wiring (including ignition coil primary wiring). If knock sensor wires are bundled with other wires, electrical interference may result, affecting the performance of the DSM system.

1. Examine the cylinder head surface to the left of the valve cover. This area must be free of obstruction and paint. Secure any loose wires or tubes that may be in the area.

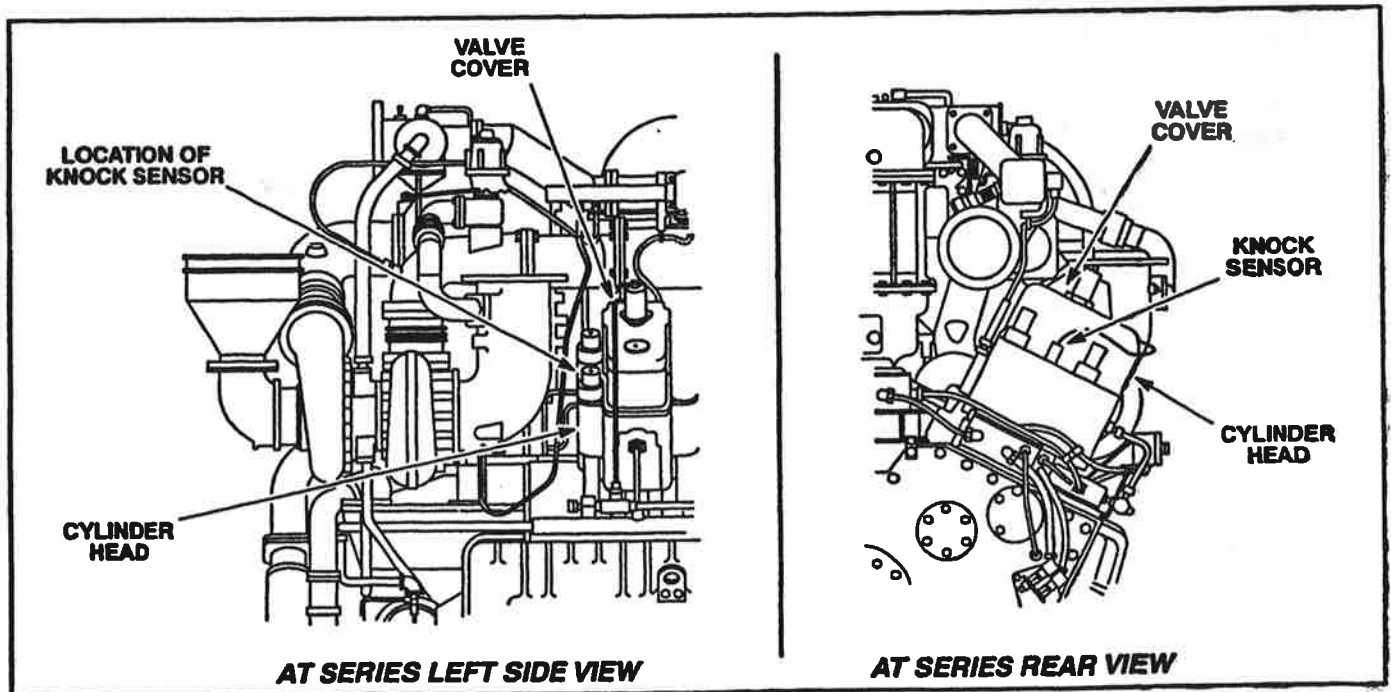


Figure 2.00-5. Knock Sensor Location On AT Series Engines

MOUNTING DSM SYSTEM COMPONENTS

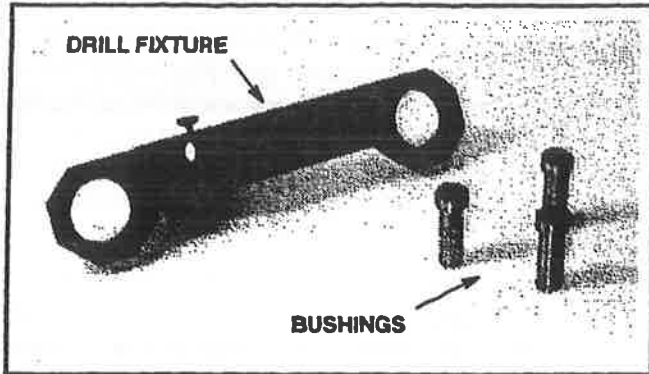


Figure 2.00-6. Drill/Tap Fixtures For Mounting Knock Sensors - AT Series (Tool P/N 473011)

2. Clean the top surface area on the left side of the cylinder head.
3. Place the drill fixture over the two left studs of the cylinder head (as viewed from the pre-chamber hole side) (see Figure 2.00-6 and Figure 2.00-7).
4. Place the 1/4" bushing into the drill fixture.

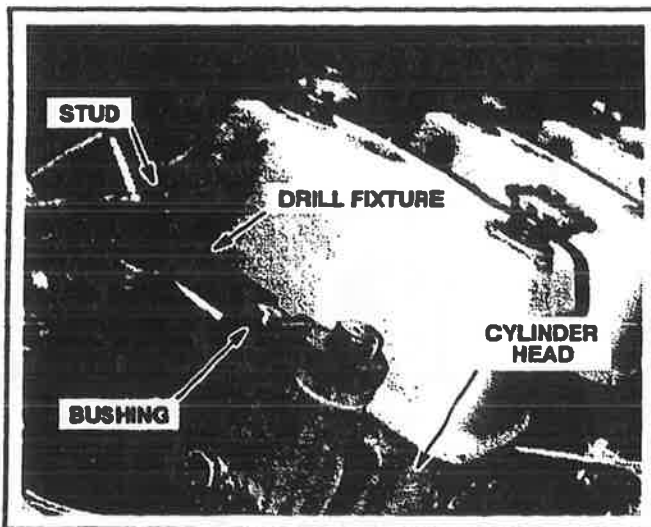


Figure 2.00-7. Drill Fixture Mounting - AT Series

5. Secure the drill fixture to the cylinder head studs with two nuts from an AT cylinder head shipping plate.
6. Oil the bushing hole and drill a 1/4" hole 3/4" (19 mm) deep using the bushing as a guide. Oil the drill bit as necessary while drilling.
7. Remove the 1/4" bushing from the drill fixture. Place the 7/16" bushing into the drill fixture. Oil the bushing hole and drill a 7/16" hole 3/4" (19 mm) deep using the bushing as a guide. Oil the drill bit as necessary while drilling.

8. Remove the 7/16" bushing from the drill fixture.
 9. Use a 5/8" drill bit to put a slight chamfer on the 7/16" drilled hole.
 10. Clean debris from the hole.
 11. Place the 31/64" bushing into the drill fixture.
 12. Oil tap and place tap into bushing on drill fixture. Tap hole until tap just touches bottom. Oil as necessary while tapping. Remove the tap and clean threaded hole.
- NOTE:** To prevent tap breakage, do not force tap against bottom of blind hole.
13. Use bottoming tap to finish tapping hole. Remove tap.
 14. Remove the 31/64" bushing from the drill fixture.
 15. Remove the drill fixture from the studs.
 16. Thoroughly clean hole and area around tapped hole. Make sure knock sensor mounting surface is free of paint.

CAUTION Drilled and tapped hole (knock sensor surface) must be flat, smooth (RMS 125), and be perpendicular to the drilled hole. Make sure knock sensor mounting surface is free of paint. If the knock sensor is not mounted flush with the cylinder head surface or if the cylinder head surface is not within RMS 125, the knock sensor WILL provide incorrect signals to the DSM system.

CAUTION Do not drop or mishandle knock sensor. Knock sensor damage may occur if knock sensor is mishandled.

17. Install knock sensor into the threaded hole. Torque knock sensor to 20 - 25 ft-lb (27 - 34 N·m). Verify that the knock sensor is seated flat against the head surface. Knock sensor MUST have full-face contact with mounting surface. Imperfections in the surface that the sensor mounts against can cause higher sensor output.

CAUTION Do not over-tighten knock sensor. Over-tightening will cause damage to the knock sensor.

18. Repeat this mounting procedure for each cylinder head.

VHP SERIES ENGINES

The following items are needed for field installation of the knock sensors on an engine crankcase without predrilled knock sensor mounting holes:

- Drill/Tap Fixture (Tool P/N 474021)
- 1-1/4" Spot face
- 1/4" Drill bit
- 7/16" Drill bit
- 5/8" Drill bit
- 1/2"-13 x 2-1/4" Capscrews (2)
- Tap and Bottoming Tap, 12 mm x 1.25

VHP Knock Sensor Mounting Steps

The knock sensors are installed just below the intake ports on the sides of the engine crankcase (see Figure 2.00-8 and Figure 2.00-9). As of April 1994, all VHP crankcases are drilled at the factory to accommodate the installation of the knock sensors. If the knock sensor holes are predrilled, continue with Step 18. If the knock sensor holes are not predrilled, continue with Step 1.

NOTE: A knock sensor with its connector will extend about two inches away from the surface of the crankcase. There should be at least three inches of clearance perpendicular to the knock sensor surface.

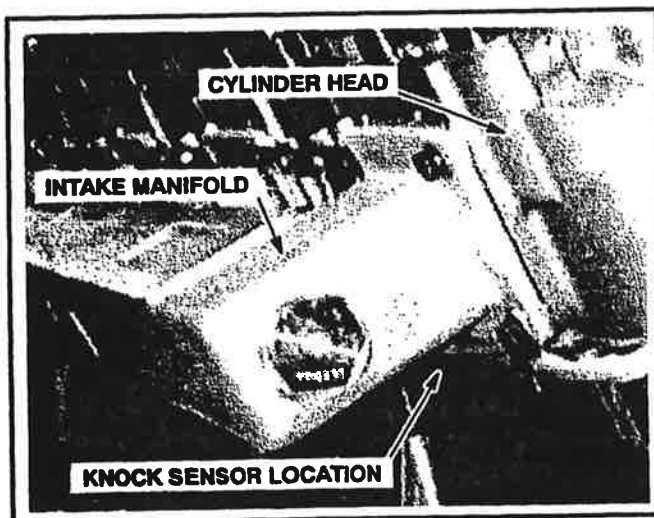


Figure 2.00-8. Knock Sensor Location - VHP Series

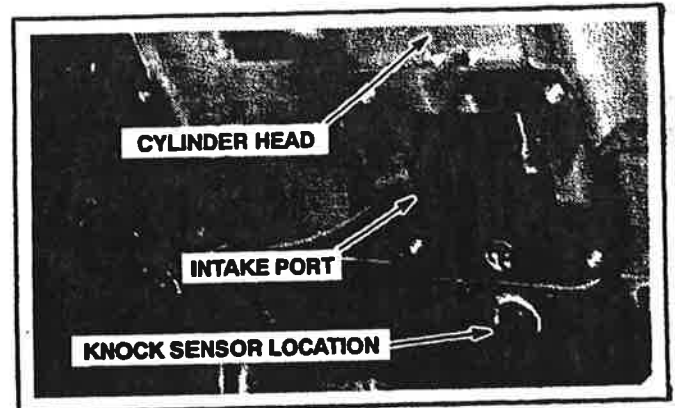


Figure 2.00-9. Pre-Drilled Knock Sensor Location With Intake Manifold Removed - VHP Series

1. Remove the lower two capscrews that secure the intake manifold to the cylinder head. Secure any brackets, tubing, or wiring that may be connected to these capscrews.

2. Examine the crankcase area directly below the intake manifold connection. This area must be free of obstruction and paint. Secure any loose wires or tubes that may be in the area.

CAUTION All harnesses must be routed at least four inches away from ignition or other high voltage wiring (including ignition coil primary wiring). If knock sensor wires are bundled with other wires, electrical interference may result, affecting the performance of the DSM system.

3. Using the two 1/2"-13 x 2-1/4" capscrews, secure the drill fixture onto the intake manifold flange using the two lower bolt holes (see Figure 2.00-10 and Figure 2.00-11). Tighten capscrews.

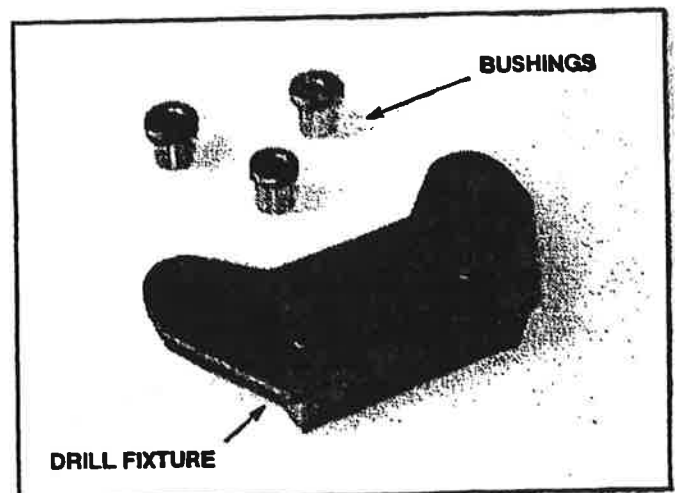


Figure 2.00-10. Drill/Tap Fixtures For Mounting Knock Sensors - VHP Series (Tool P/N 474021)

MOUNTING DSM SYSTEM COMPONENTS

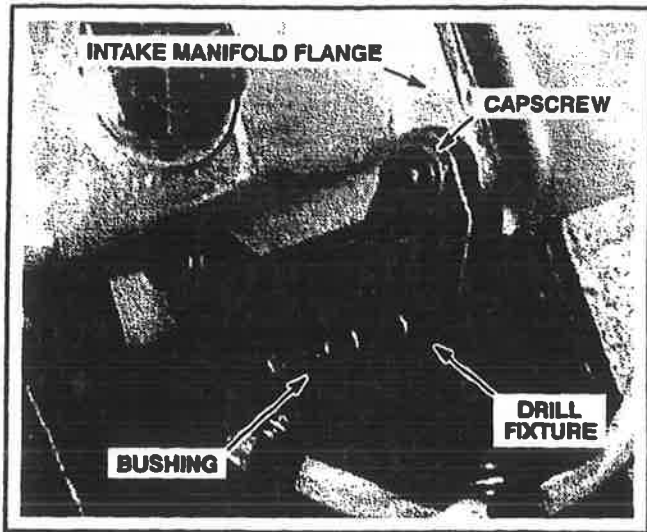


Figure 2.00-11. Drill Fixture Mounting - VHP Series

4. Place the 1/4" bushing into the drill fixture.

CAUTION Do not drill deeper than 3/4" (20 mm) deep or the drill bit will break through the water jacket.

5. Oil the bushing hole and drill a 1/4" hole 3/4" (20 mm) deep using the bushing as a guide. Oil drill bit as necessary while drilling.

6. Remove the 1/4" bushing from the drill fixture. Place the 7/16" bushing into the drill fixture. Oil the bushing hole and drill a 7/16" hole 3/4" (20 mm) deep using the bushing as a guide. Oil drill bit as necessary while drilling.

7. Remove the 7/16" bushing from the drill fixture.

8. Use a 5/8" drill bit to put a slight chamfer on the 7/16" drilled hole.

9. Clean debris from the drilled hole.

10. Using a 1-1/4" spot face, carefully spot face the area around the 7/16" hole until the area is smooth and free from paint. This surface must be free of burrs, have a finish of RMS 125 or better, and be perpendicular to the drilled hole.

NOTE: If the spot face in Step 10 has removed the slight chamfer on the drilled hole, reapply chamfer using the 5/8" drill bit.

11. Clean debris from the drilled hole.

12. Place the 31/64" bushing into the drill fixture.

13. Oil tap and place tap into bushing. Tap hole until tap just touches bottom. Oil as necessary while tapping. Remove the tap and clean threaded hole.

NOTE: To prevent tap breakage, do not force tap against bottom of blind hole.

14. Use bottoming tap to finish tapping hole. Remove tap.

15. Remove the 31/64" bushing from drill fixture.

16. Remove the drill fixture from the intake manifold flange.

17. Reconnect intake manifold flange to cylinder head using the two 1/2"-13 capscrews removed in Step 1.

18. Thoroughly clean hole and area around tapped hole. Make sure knock sensor mounting surface is free of paint.

CAUTION Drilled and tapped hole (knock sensor surface) must be flat, smooth (RMS 125), and be perpendicular to the drilled hole. Make sure knock sensor mounting surface is free of paint. If the knock sensor is not mounted flush with the cylinder head surface or if the cylinder head surface is not within RMS 125, the knock sensor WILL provide incorrect signals to the DSM system.

CAUTION Do not drop or mishandle knock sensor. Knock sensor damage may occur if knock sensor is mishandled.

19. Install knock sensor into the threaded hole. Torque knock sensor to 20 - 25 ft-lb (27 - 34 N·m). Verify that the knock sensor is seated flat against the spot face. Knock sensor **MUST** have full-face contact with mounting surface. Imperfections in the surface that the sensor mounts against can cause higher sensor output.

CAUTION Do not over-tighten knock sensor. Over-tightening will cause damage to the knock sensor.

20. Repeat this mounting procedure for each cylinder.

VGF SERIES ENGINES - 12 AND 16 CYLINDER

The following items are needed for field installation of the knock sensors on an engine crankcase without predrilled knock sensor mounting holes:

- Drill/Tap Fixture (Tool P/N 472070)
- 1/4" Drill bit
- 7/16" Drill bit
- 5/8" Drill bit
- 10 mm Capscrews (2)
- 12 mm Capscrew (1)

VGF Knock Sensor Mounting Steps

The knock sensors are installed between every other cylinder just below the intake port on the side of the engine crankcase (see Figure 2.00-12). On VGF engines, one knock sensor is mounted for two adjacent cylinders (see Figure 2.00-14). On 12 cylinder VGF engines there are a total of 6 knock sensors; 8 knock sensors on 16 cylinder engines. As of April 1997, all 12 and 16 cylinder VGF crankcases are drilled at the factory to accommodate the installation of the knock sensors. If the knock sensor holes are predrilled, continue with Step 20. If the knock sensor holes are not predrilled, continue with Step 1.

NOTE: Although there is one knock sensor installed for adjacent cylinders, when detonation is detected ignition timing is still adjusted on an individual cylinder basis. Individual timing is possible because the engine alternately fires a cylinder on each engine bank but the knock sensor works for adjacent cylinders on the same engine bank. On 16 cylinder VGF engines, two cylinders will always retard together due to DSM system design.

NOTE: One knock sensor is mounted for two adjacent cylinders. Refer to Figure 2.00-14 for location of knock sensors on crankcase.

1. Remove the upper right and upper left capscrews of the two adjacent camshaft access covers. Secure any brackets, tubing, or wiring that may be connected to these capscrews.
2. Examine the crankcase area directly above the auxiliary rocker arm locknut. Secure any loose wires or tubes that may be in the area.

CAUTION

All harnesses must be routed at least four inches away from ignition or other high voltage wiring (including ignition coil primary wiring). If knock sensor wires are bundled with other wires, electrical interference may result, affecting the performance of the DSM system.

3. Hold the drill fixture against the bolt holes to determine the location where the drill fixture will rest against the engine crankcase (see Figure 2.00-13). Mark the area and remove drill fixture.

4. Using a stiff scraper, remove the paint in the area marked in Step 3. The drill fixture must rest against the crankcase free of paint.

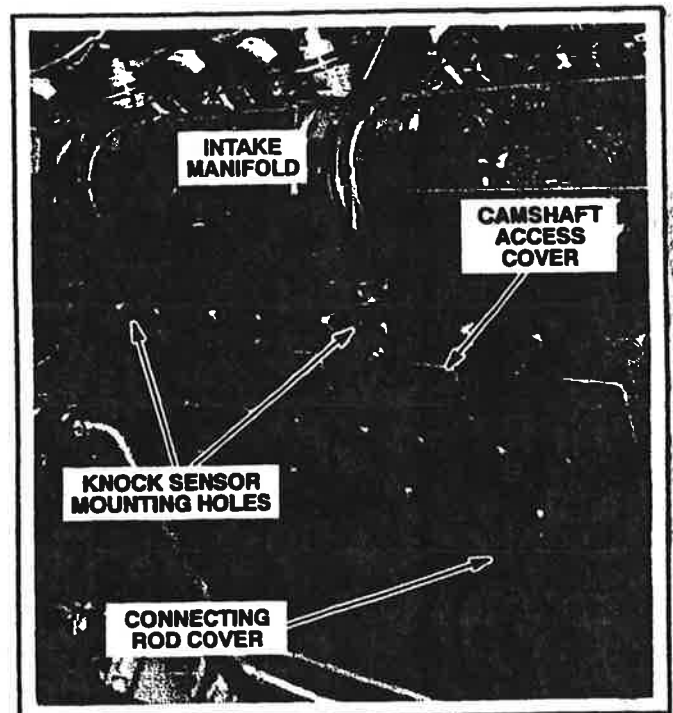


Figure 2.00-12. Knock Sensor Locations - VGF Series

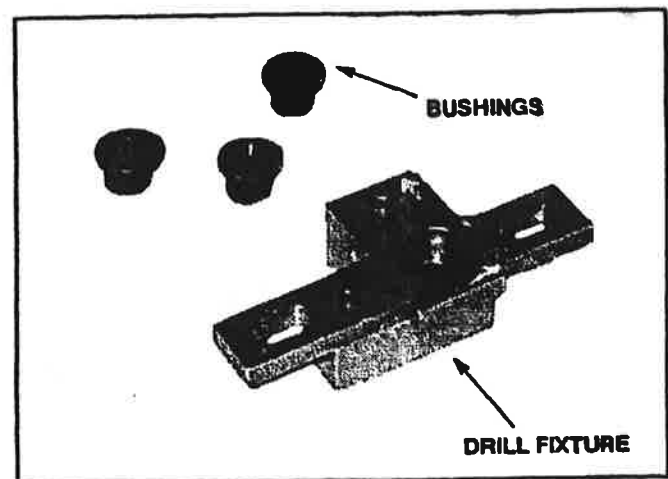


Figure 2.00-13. Drill/Tap Fixtures For Mounting Knock Sensors - VGF Series (Tool P/N 472070)

MOUNTING DSM SYSTEM COMPONENTS

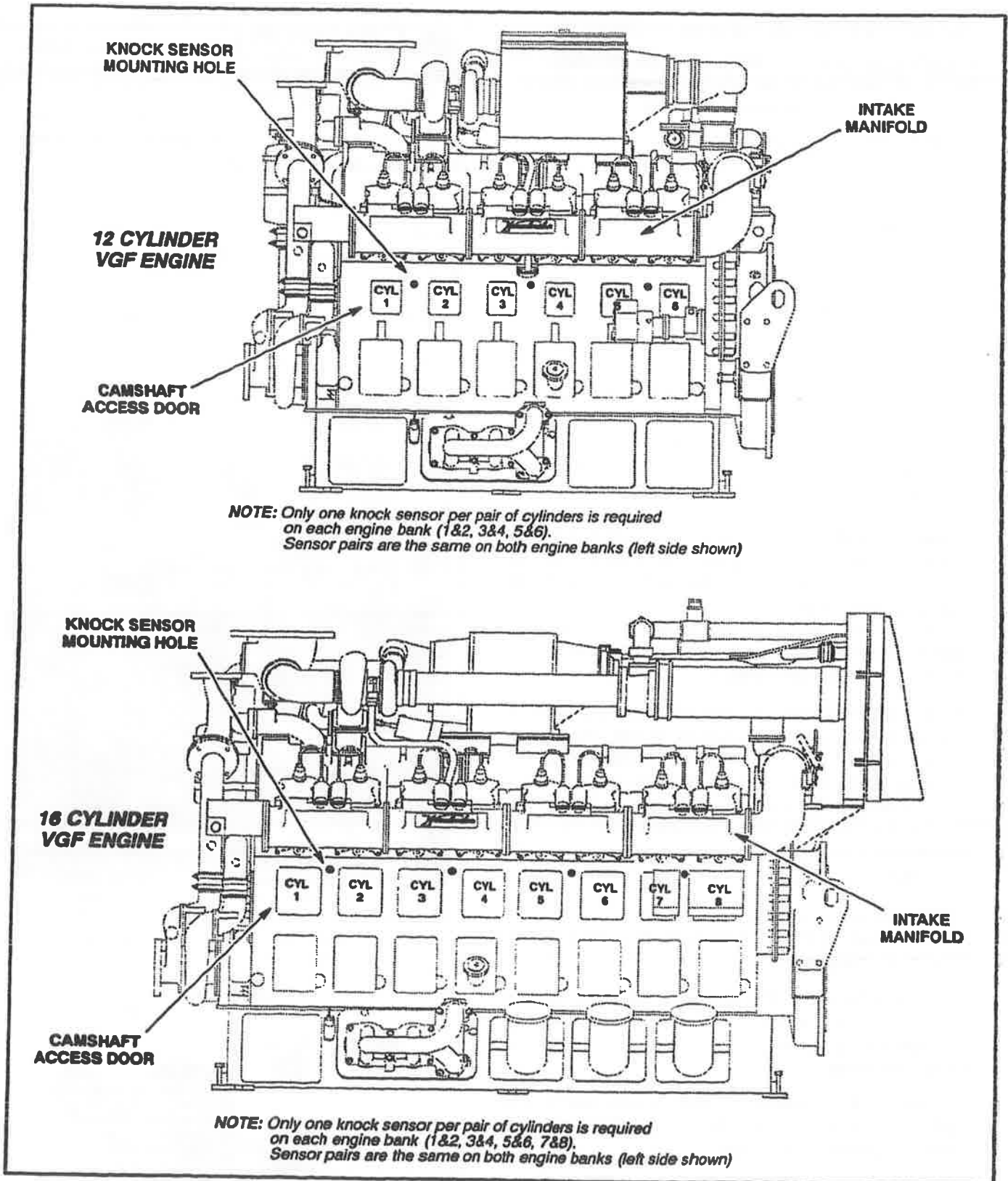


Figure 2.00-14. Knock Sensor Locations On VGF Engines

CAUTION Ensure that the drill fixture is properly aligned on the crankcase with the auxiliary rocker arm locknut **BEFORE** drilling knock sensor mounting hole. Misalignment of the drill fixture could cause damage to the crankcase when drilling and/or provide incorrect signals to the DSM system.

5. Place drill fixture against the bolt holes of the camshaft access cover and align drill fixture with the auxiliary rocker arm locknut. The sensor mounting hole to be drilled must be inline with the center of the auxiliary rocker arm locknut as shown in Figure 2.00-15.

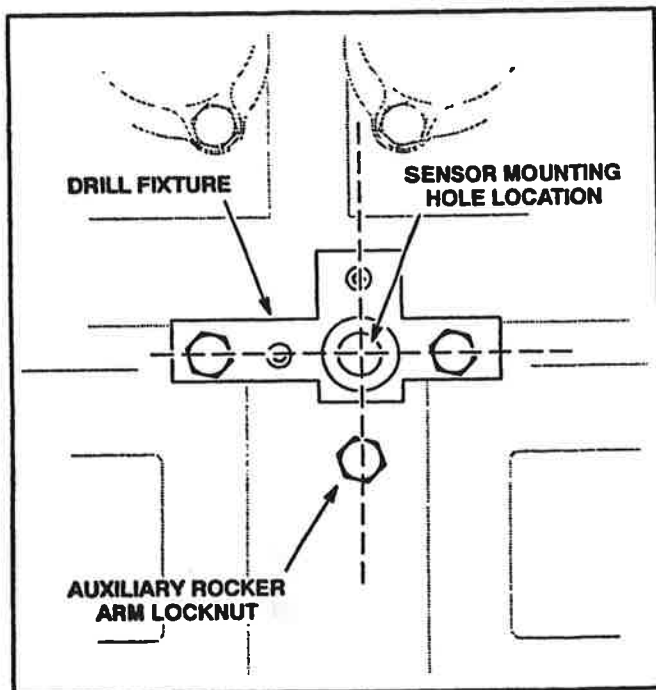


Figure 2.00-15. Drill Fixture Alignment - VGF Engines

6. Using the two 10 mm capscrews, secure the drill fixture onto the adjacent door bolt holes of the camshaft access covers (see Figure 2.00-16). Tighten capscrews.

NOTE: On crankcases built before 1995, use the 12 mm capscrew to secure the drill fixture to the fifth camshaft access cover bolt hole on a 16 cylinder engine and the fourth cover bolt hole on a 12 cylinder engine. These camshaft access covers on pre-1995 crankcases vary in design and require the larger capscrew when using the drill fixture.

7. Place the 1/4" bushing into the drill fixture.

8. Oil the bushing hole and drill a 1/4" hole 3/4" (20 mm) deep using the bushing as a guide. Oil drill bit as necessary while drilling.

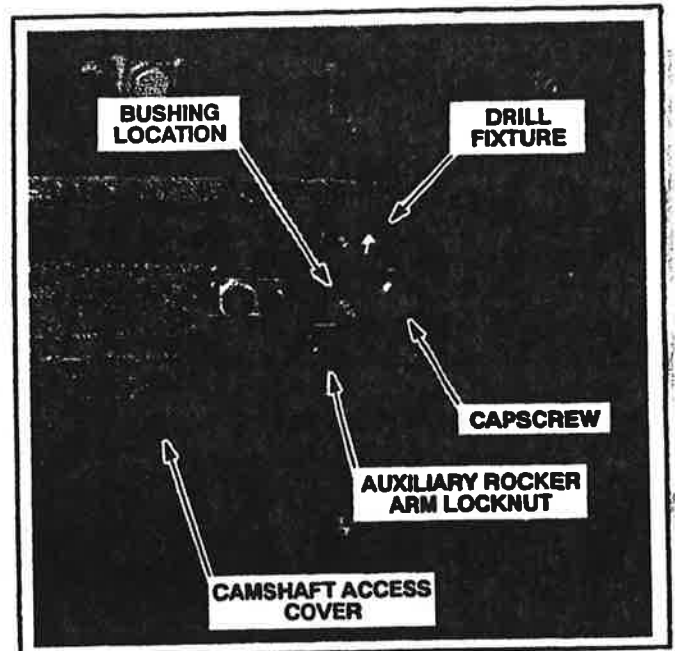


Figure 2.00-16. Drill Fixture Mounting - VGF Series

CAUTION Do not drill deeper than 3/4" (20 mm) deep or the drill bit will break through the crankcase.

9. Remove the 1/4" bushing from the drill fixture. Place the 7/16" bushing into the drill fixture. Oil the bushing hole and drill a 7/16" hole 3/4" (20 mm) deep using the bushing as a guide. Oil drill bit as necessary while drilling.

10. Remove the 7/16" bushing from the drill fixture.

11. Use a 5/8" drill bit to put a slight chamfer on the 7/16" drilled hole.

12. Clean debris from the drilled hole.

13. Closely examine the surface. This surface must be free of burrs and have a finish of RMS 125 or better.

14. Place the 31/64" bushing into the drill fixture.

15. Oil tap and place tap into bushing. Tap hole until tap just touches bottom. Oil as necessary while tapping. Remove the tap and clean threaded hole.

NOTE: To prevent tap breakage, do not force tap against bottom of blind hole.

16. Use bottoming tap to finish tapping hole. Remove tap.

17. Remove the 31/64" bushing from drill fixture.

18. Remove the drill fixture from the crankcase.

MOUNTING DSM SYSTEM COMPONENTS

19. Refasten the camshaft access doors using the capscrews removed in Step 1.

20. Thoroughly clean hole and area around mounting hole.

CAUTION Drilled and tapped hole (knock sensor surface) must be flat, smooth (RMS 125), and be perpendicular to the drilled hole. Make sure knock sensor mounting surface is free of paint. If the knock sensor is not mounted flush with the cylinder head surface or if the cylinder head surface is not within RMS 125, the knock sensor WILL provide incorrect signals to the DSM system.

CAUTION Do not drop or mishandle knock sensor. Knock sensor damage may occur if knock sensor is mishandled.

CAUTION Do not over-tighten knock sensor. Over-tightening will cause damage to the knock sensor.

NOTE: A knock sensor with its connector will extend about two inches away from the surface of the crankcase. There should be at least three inches of clearance perpendicular to the knock sensor surface.

21. Install knock sensor into the threaded hole. Torque knock sensor to 20 - 25 ft-lb (27 - 34 N-m). Verify that the knock sensor is seated flat against the crankcase surface. **Knock sensor MUST have full-face contact with mounting surface. Imperfections in the surface that the sensor mounts against can cause higher sensor output.**

22. Repeat this mounting procedure for each knock sensor mounting location.

SECTION 2.05

DSM SYSTEM COMPONENT CONNECTIONS

COMPONENT CONNECTIONS

In this section, you will be interconnecting the DSM system components with the various DSM harnesses. This section includes the steps required to connect the knock sensors, DSM filter, and DSM module. Power connections are completed in Section 2.10, *DSM System Power, Alarm, And Ground Connections*.

Figure 2.05-1 and Figure 2.05-2 illustrate the DSM system connections that will be completed following the steps in this section.

Continue with "Knock Sensor And Filter Connections" on the next page.

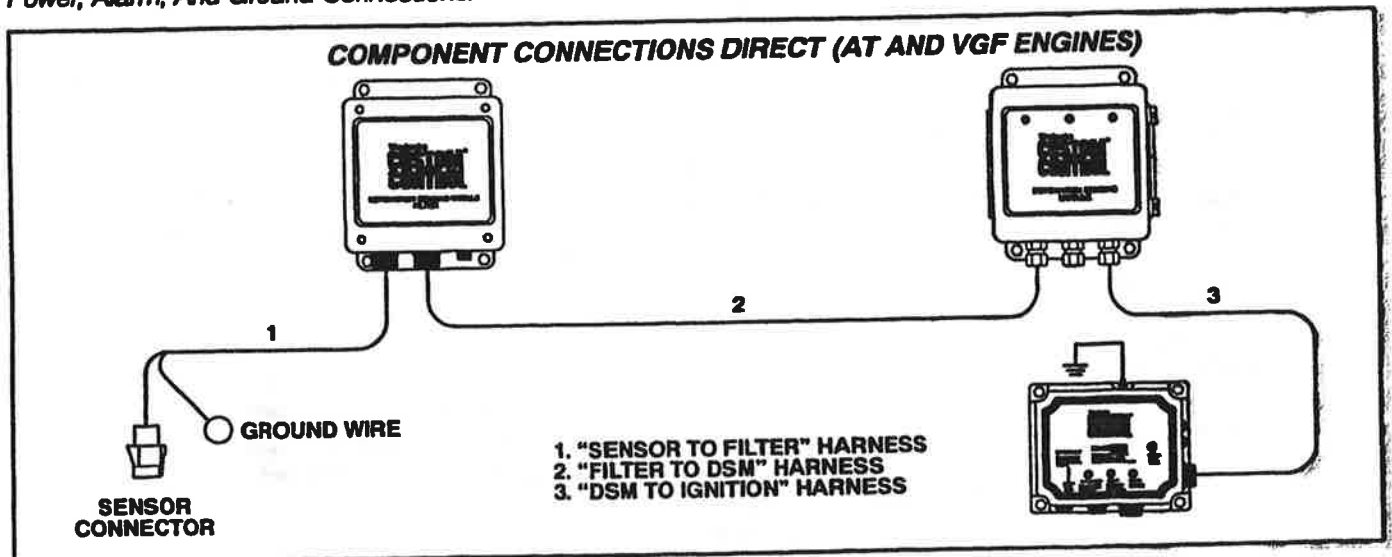


Figure 2.05-1. Component Connections Direct - AT And VGF Engines

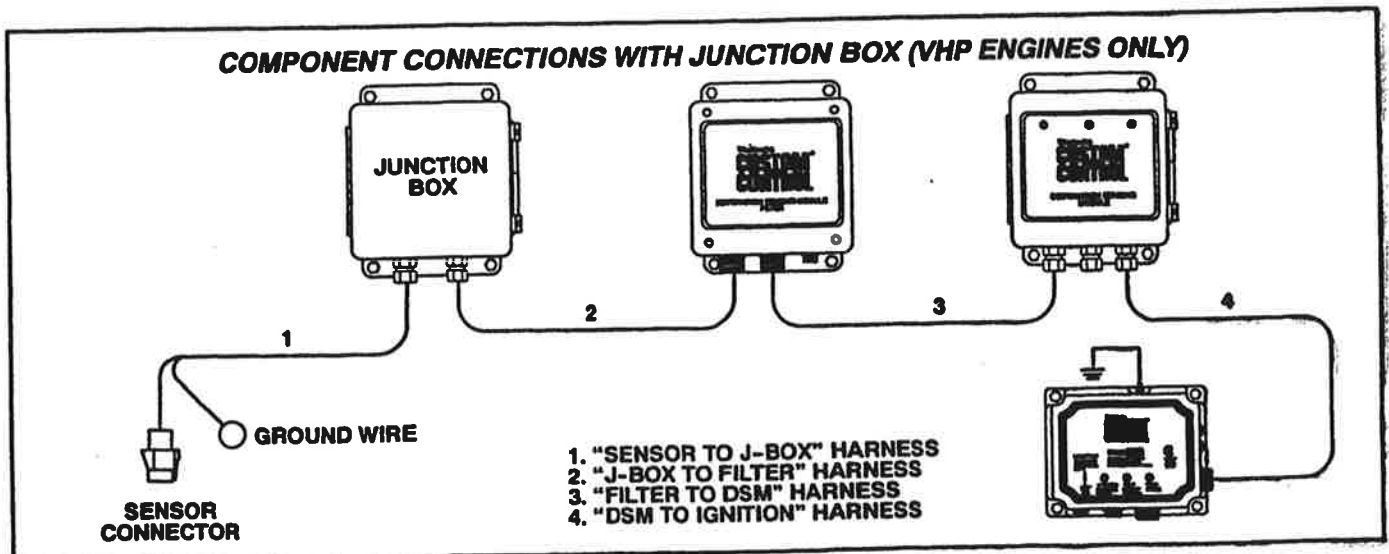


Figure 2.05-2. Component Connections With Junction Box - VHP Engines Only

DSM SYSTEM COMPONENT CONNECTIONS

KNOCK SENSOR AND FILTER CONNECTIONS

COMPLETING THE KNOCK SENSOR AND FILTER CONNECTIONS

On AT and VGF engines, individual sensor wires are routed directly to the DSM filter. Complete the steps in "Connections Routed Directly To The DSM Filter - AT And VGF Engines."

On VHP engines, individual sensor wires are routed through an engine mounted junction box and then to the DSM filter. Complete the steps in the section entitled, "Connections Routed Through An Engine Mounted Junction Box - VHP Engines."

The components of the DSM system are connected with several different wire harnesses. In the steps that follow, the harness name is enclosed in quotation marks (Example: "sensor to J-box" harness).

Connections Routed Directly To The DSM Filter - AT And VGF Engines

CAUTION All harnesses must be routed at least four inches away from ignition or other high voltage wiring including ignition coil primary wiring. If knock sensor wires are bundled with other wires, electrical interference may result, affecting the performance of the DSM system.

NOTE: The wiring diagrams included in this manual are to be used as a reference only. For additional reference, use the wiring diagrams received with the DSM system when making connections.

1. Verify that the knock sensors are mounted and installed properly. The sensors must be torqued to the correct specification. Refer to Section 2.00 *Mounting DSM System Components* "Mounting The Knock Sensors" for mounting instructions and specifications.

2. Locate the "sensor to filter" harness (see Figure 2.05-3).

NOTE: Actual shape (elbow or straight) of the 19 pin connector varies due to engine configuration and DSM installation requirements.

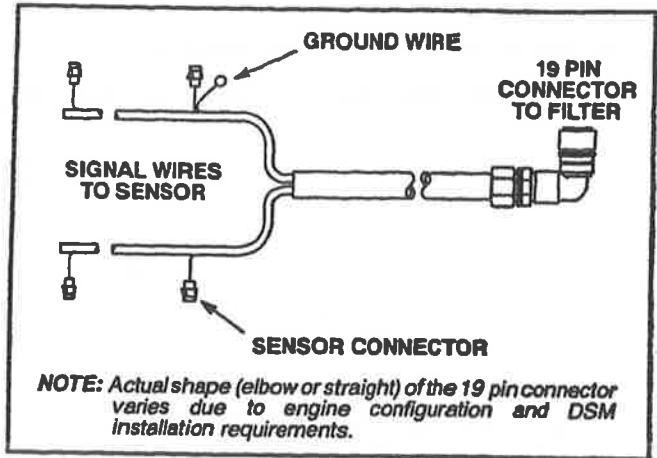


Figure 2.05-3. "Sensor To Filter" Harness

3. Attach each sensor connector of the "sensor to filter" harness to the sensor of its corresponding cylinder (or corresponding cylinder pair on VGF engines) (see Figure 2.05-3). The signal wires from the "sensor to filter" harness are labeled for their corresponding cylinders or cylinder pairs and have plastic connectors that attach to each sensor. There are also labeled ground wires.

4. Attach each labeled ground wire of the "sensor to filter" harness to the engine crankcase. Each ground wire must be securely attached to the engine crankcase at a place where surface paint has been removed.

5. Attach the 19 pin connector of the "sensor to filter" harness to the input connector on the DSM filter (see Figure 2.05-4). The input connector is the only 19 pin metal connector on the filter. The length of this harness must not be altered.

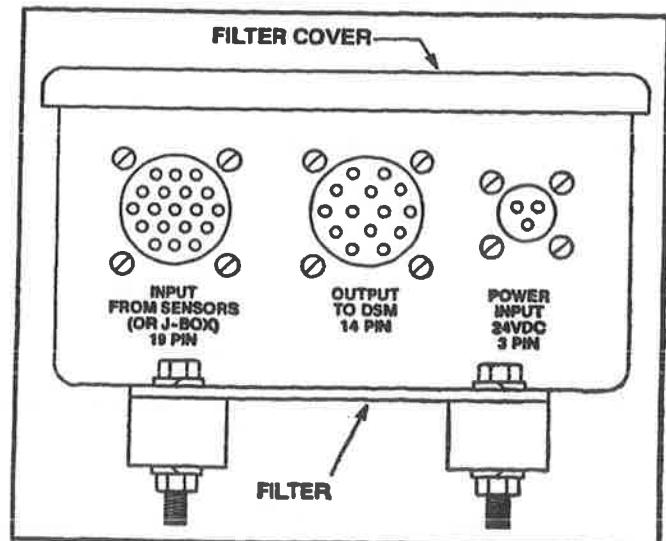


Figure 2.05-4. DSM's Filter Input Connectors

6. Locate the "filter to DSM" harness (see Figure 2.05-5).

NOTE: Actual shape (elbow or straight) of the 14 pin connector varies due to engine configuration and DSM installation requirements.

7. Attach the 14 pin cylindrical connector of the "filter to DSM" harness to the output connector on the filter (see Figure 2.05-4 and Figure 2.05-5). The output connector is the only 14 pin metal connector on the filter.

8. Continue with the next section "DSM Module Connections."

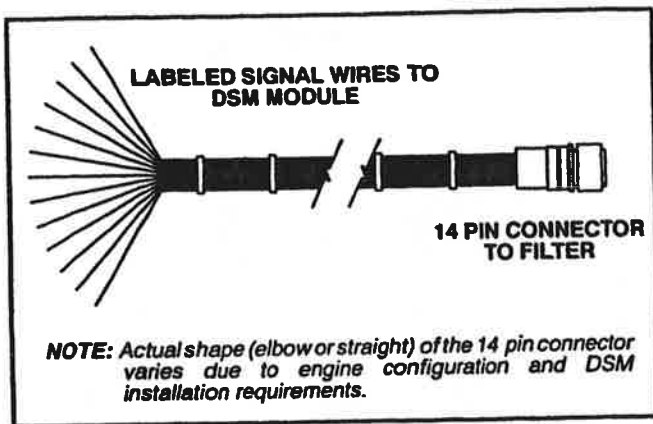


Figure 2.05-5. "Filter To DSM" Harness

Connections Routed Through An Engine Mounted Junction Box - VHP Engines

On VHP engines, individual sensor wires are routed through an engine mounted junction box and then to the DSM filter.

CAUTION All harnesses must be routed at least four inches away from ignition or other high voltage wiring including ignition coil primary wiring. If knock sensor wires are bundled with other wires, electrical interference may result, affecting the performance of the DSM system.

NOTE: The wiring diagrams included in this manual are to be used as a reference only. For additional reference, use the wiring diagrams received with the DSM system when making connections.

1. Locate the "sensor to J-box" harness (see Figure 2.05-6).

2. Attach each plastic connector of the "sensor to J-box" harness to the knock sensor of its corresponding cylinder as labeled (see Figure 2.05-6). The signal wires of the "sensor to J-box" harness are labeled with their corresponding cylinder numbers and have plastic connectors that attach to each sensor. There are also labeled ground wires.

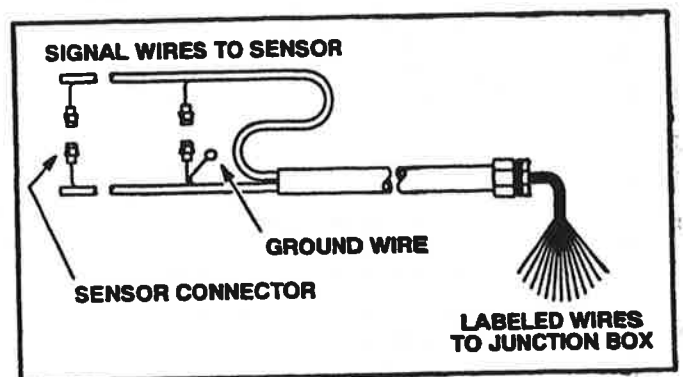


Figure 2.05-6. "Sensor To J-Box" Harness

3. Attach each labeled ground wire of the "sensor to J-box" harness to the engine crankcase. Each ground wire must be securely attached to the engine crankcase at a place where surface paint has been removed.

4. Attach the individual sensor and ground wires of the "sensor to J-box" harness in the engine mounted junction box (see Figure 2.05-7). Connect these wires to a terminal strip in numerical order with the ground wires dispersed evenly between the sensor wires.

NOTE: The junction box in Figure 2.05-7 is shown as an example only. Junction box varies with engine model.

NOTE: The individual sensor and ground wires of the "sensor to J-box" harness may be shortened if necessary.

DSM SYSTEM COMPONENT CONNECTIONS

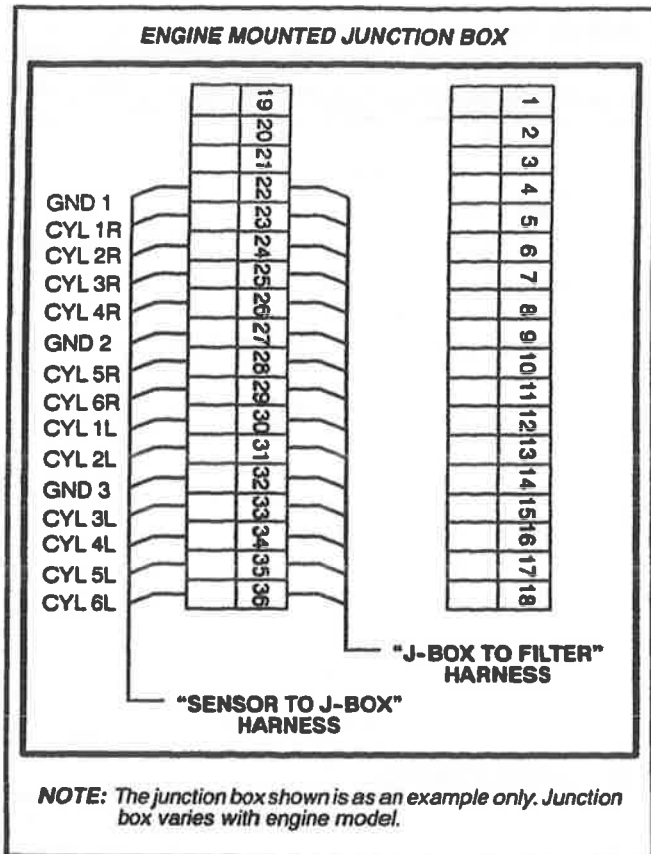


Figure 2.05-7. "Sensor To J-Box" Harness Connections In Junction Box

5. Locate the "J-box to filter" harness (see Figure 2.05-8).

NOTE: Actual shape (elbow or straight) of the 19 pin connector varies due to engine configuration and DSM installation requirements.

NOTE: The wires of the "J-box to filter" harness may be shortened if necessary. The wires of the "J-box to filter" harness MUST be run through conduit.

6. Attach the wires of the "J-box to filter" harness to the corresponding inputs inside the engine mounted junction box (see Figure 2.05-7 and Figure 2.05-8). For example, CYL 1R on the "sensor to J-box" harness corresponds to CYL 1R on the "J-box to filter" harness.

7. Attach the 19 pin cylindrical connector of the "J-box to filter" harness to the input connector on the DSM filter (see Figure 2.05-9). The input connector is the only 19 pin metal connector on the filter.

8. Locate the "filter to DSM" harness (see Figure 2.05-10).

NOTE: Actual shape (elbow or straight) of the 14 pin connector varies due to engine configuration and DSM installation requirements.

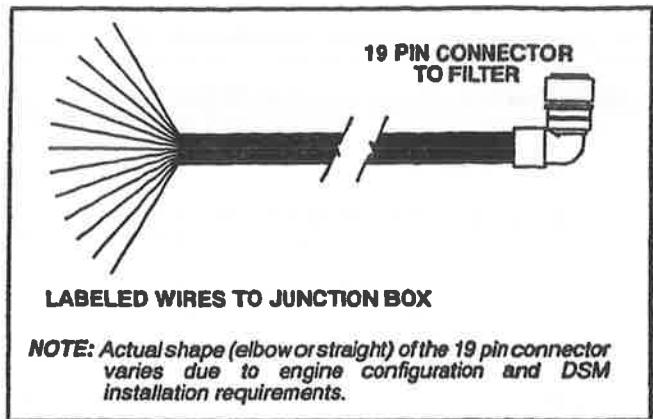


Figure 2.05-8. "J-Box To Filter" Harness

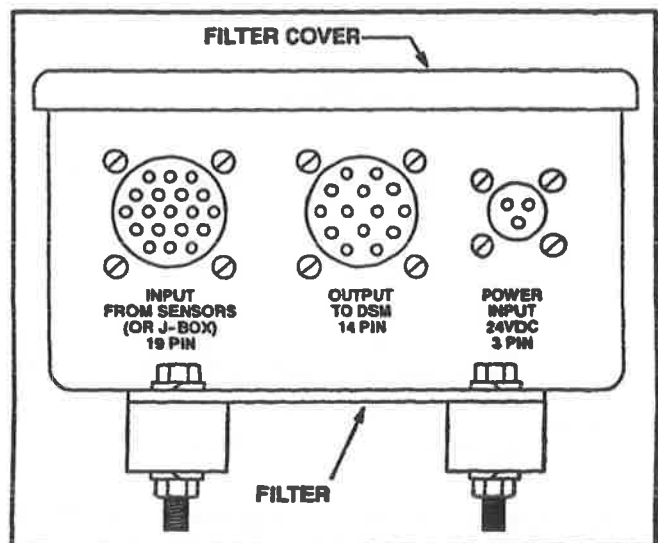


Figure 2.05-9. DSM's Filter Input Connectors

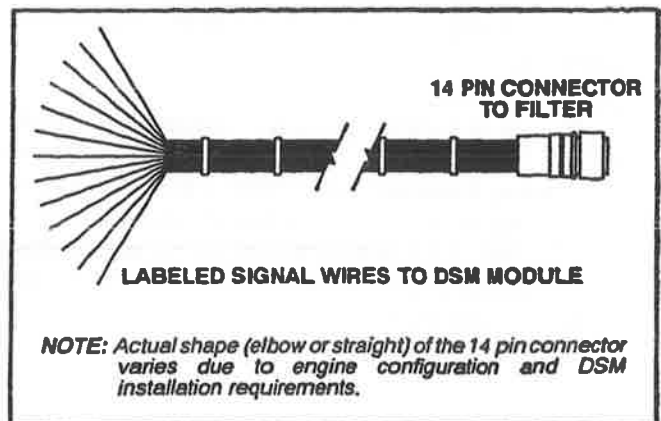


Figure 2.05-10. "Filter To DSM" Harness

9. Attach the 14 pin cylindrical connector of the "filter to DSM" harness to the output connector on the DSM filter (see Figure 2.05-9 and Figure 2.05-10). The output connector is the only 14 pin metal connector on the filter.

10. Continue with "DSM Module Connections" in this section.

DSM MODULE CONNECTIONS

CAUTION All harnesses must be routed at least four inches away from ignition or other high voltage wiring including ignition coil primary wiring. If sensor wires are bundled with other wires, electrical interference may result, affecting the performance of the DSM system.

CAUTION Do not cut any new holes in the DSM module. The wires must be directed through the holes provided in the bottom of the DSM module. If the wires are routed through the wrong port, electrical interference may result, affecting the performance of the DSM system.

NOTE: See Figure 2.05-11 for proper wire routing of the DSM module.

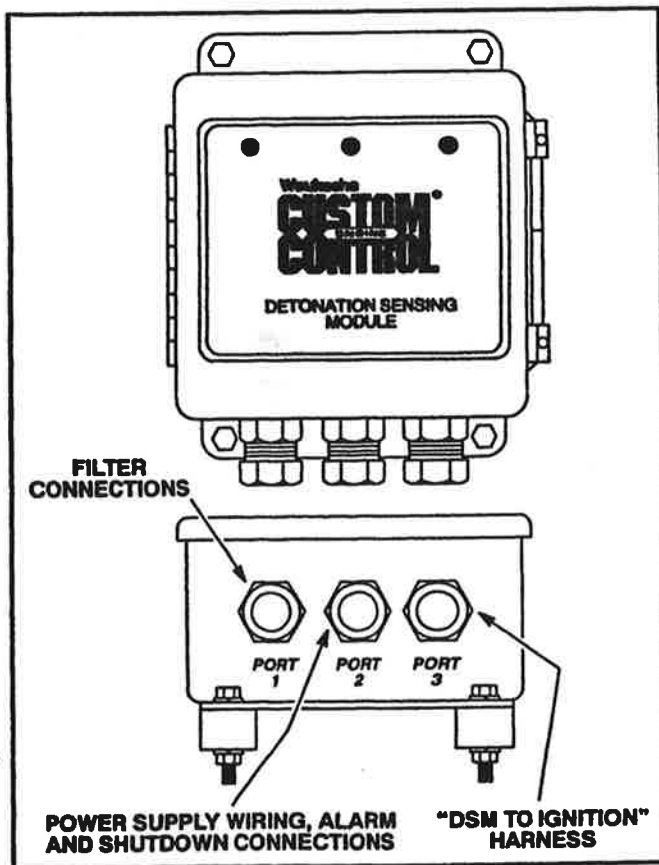


Figure 2.05-11. DSM Module Conduit Ports

DSM MODULE TO IGNITION MODULE

1. Locate the "DSM to ignition" harness (see Figure 2.05-12).

NOTE: Actual shape (elbow or straight) of the 14 pin connector varies due to engine configuration and DSM installation requirements.

2. Route the "DSM to ignition" harness to the Ignition Module (see Figure 2.05-12 and Figure 2.05-13).

NOTE: Do not connect the "DSM to ignition" harness to the Ignition Module at this time. The "DSM to ignition" harness will be connected to the Ignition Module when programming the DSM system following the steps in Chapter 3 Detonation Sensing Module System Programming.

3. Route conduit and the wires of the "DSM to ignition" harness from the Ignition Module to the DSM module.

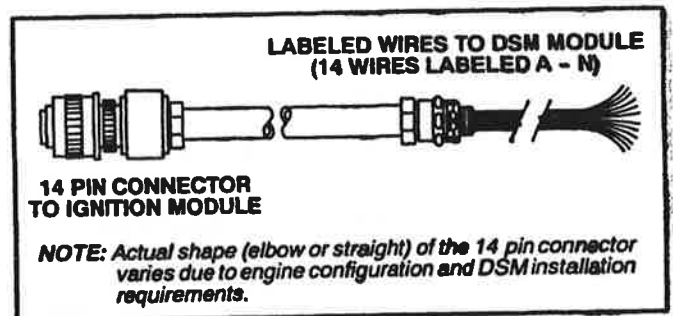


Figure 2.05-12. "DSM To Ignition" Harness

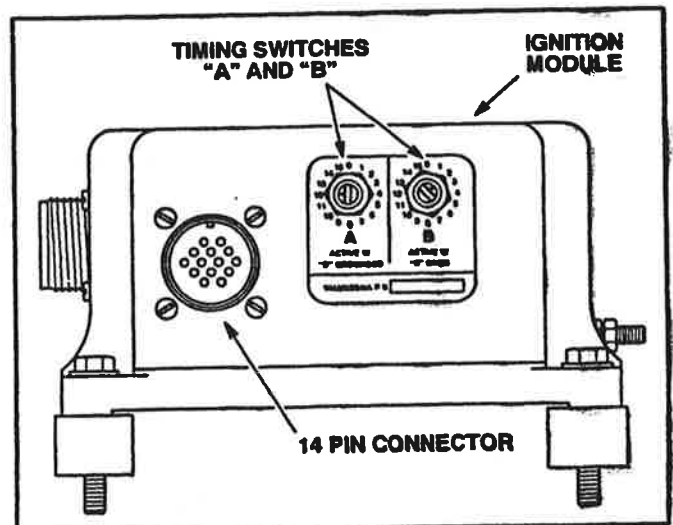


Figure 2.05-13. "DSM To Ignition" Harness Connection To Ignition Module

DSM SYSTEM COMPONENT CONNECTIONS

CAUTION Route the DSM system wires through the correct port on the DSM module. The wires must be directed through the holes provided in the bottom of the DSM module. If the wires are routed through the wrong port, electrical interference may result, affecting the performance of the DSM system.

4. Direct the wires of the "DSM to ignition" harness through port 3 on the DSM module (see Figure 2.05-14).

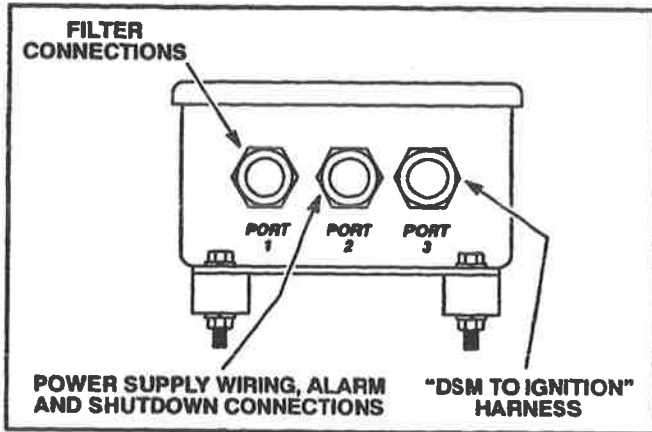


Figure 2.05-14. DSM Module Conduit Ports

5. Attach the conduit to the conduit connector attached to port 3. Secure the loose conduit.

6. Cut the wires to length and connect them to the Ignition Module terminal strip inside of the DSM module as shown in Figure 2.05-15.

FILTER TO DSM MODULE

1. Locate the "filter to DSM" harness (see Figure 2.05-16).

NOTE: The signal wires of the "filter to DSM" harness are labeled for their corresponding cylinders/cylinder pairs and ground wires.

NOTE: The wires of the "filter to DSM" harness must be run through conduit.

2. Route the "filter to DSM" harness wires to the DSM module.

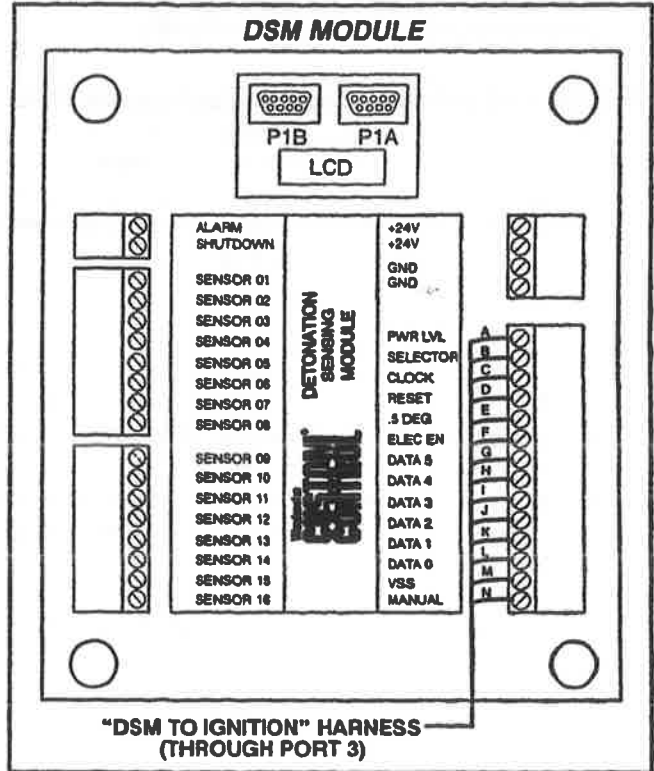


Figure 2.05-15. "DSM To Ignition" Harness Connections in DSM Module

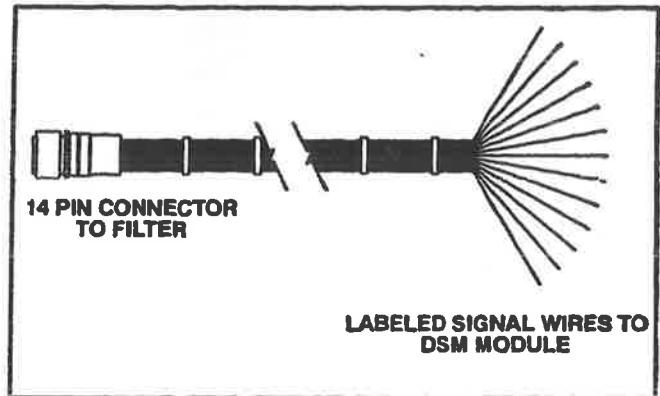


Figure 2.05-16. "Filter To DSM" Harness

CAUTION Route the DSM system wires through the correct port on the DSM module. The wires must be directed through the holes provided in the bottom of the DSM module. If the wires are routed through the wrong port, electrical interference may result, affecting the performance of the DSM system.

3. Direct the wires through port 1 on the DSM module (see Figure 2.05-14).

DSM SYSTEM COMPONENT CONNECTIONS

4. Attach the conduit to the connector attached to port 1. Secure the loose conduit.

5. Determine the firing order of your engine (see Table 2.05-1).

6. Measure and cut the signal wires of the "filter to DSM" harness to length. The signal wires are connected to the terminal strips inside the DSM module.

7. Attach the signal wires from the "filter to DSM" harness to the appropriate SENSOR input as determined by the firing order given in Table 2.05-1. Note the following:

- For 6, 8, and 12 cylinder AT and VHP engines, sensors must be wired individually. See the sample wiring diagram in Figure 2.05-17.
- For 12 cylinder VGF engines, sensors must be jumpered in adjacent cylinder pairs as shown in Figure 2.05-18.

- For 16 cylinder AT, VHP, and VGF engines, sensors must be jumpered in pairs as shown in Figure 2.05-19.

Refer to Section 2.15 *DSM System Wiring Diagrams* for wiring diagrams for AT, VHP, and VGF engines.

NOTE: Within the DSM module the sensor inputs are labeled *SENSOR 01*, *SENSOR 02*, *SENSOR 03*. The *SENSOR* number corresponds to the sensor's position in the firing order. For example, the firing order of a 6 cylinder VHP engine is 1-5-3-6-2-4 (from Table 2.05-1). Therefore, the signal wire labeled *CYL 1* is connected to *SENSOR 01* and the signal wire labeled *CYL 5* is connected to *SENSOR 02*, etc.

8. Cut to length and attach the ground wires. Each labeled ground wire must be connected to a GND (ground) terminal inside the DSM module.

9. Continue with Section 2.10 *DSM System Power And Alarm Connections*.

Table 2.05-1. Cylinder Firing Order

SENSOR	SENSOR WIRE							
	AT25/27			VHP			VGF	
	8L	12V	16V	6V	12V	16V	12V	16V
1	CYL 1	CYL 1R	CYL 1L	CYL 1	CYL 1R	CYL 1L	CYL 1R	CYL 1L
2	CYL 4	CYL 1L	CYL 4R	CYL 5	CYL 6L	CYL 3R	CYL 6L	CYL 4R
3	CYL 7	CYL 5R	CYL 4L	CYL 3	CYL 5R	CYL 3L	CYL 5R	CYL 4L
4	CYL 6	CYL 5L	CYL 7R	CYL 6	CYL 2L	CYL 7R	CYL 2L	CYL 2R
5	CYL 8	CYL 3R	CYL 7L	CYL 2	CYL 3R	CYL 7L	CYL 3R	CYL 2L
6	CYL 5	CYL 3L	CYL 6R	CYL 4	CYL 4L	CYL 5R	CYL 4L	CYL 6R
7	CYL 2	CYL 6R	CYL 6L		CYL 6R	CYL 5L	CYL 6R	CYL 6L
8	CYL 3	CYL 6L	CYL 8R		CYL 1L	CYL 8R	CYL 1L	CYL 8R
9		CYL 2R	CYL 8L		CYL 2R	CYL 8L	CYL 2R	CYL 8L
10		CYL 2L	CYL 5R		CYL 5L	CYL 6R	CYL 5L	CYL 5R
11		CYL 4R	CYL 5L		CYL 4R	CYL 6L	CYL 4R	CYL 5L
12		CYL 4L	CYL 2R		CYL 3L	CYL 2R	CYL 3L	CYL 7R
13			CYL 2L			CYL 2L		CYL 7L
14			CYL 3R			CYL 4R		CYL 3R
15			CYL 3L			CYL 4L		CYL 3L
16			CYL 1R			CYL 1R		CYL 1R

DSM SYSTEM COMPONENT CONNECTIONS

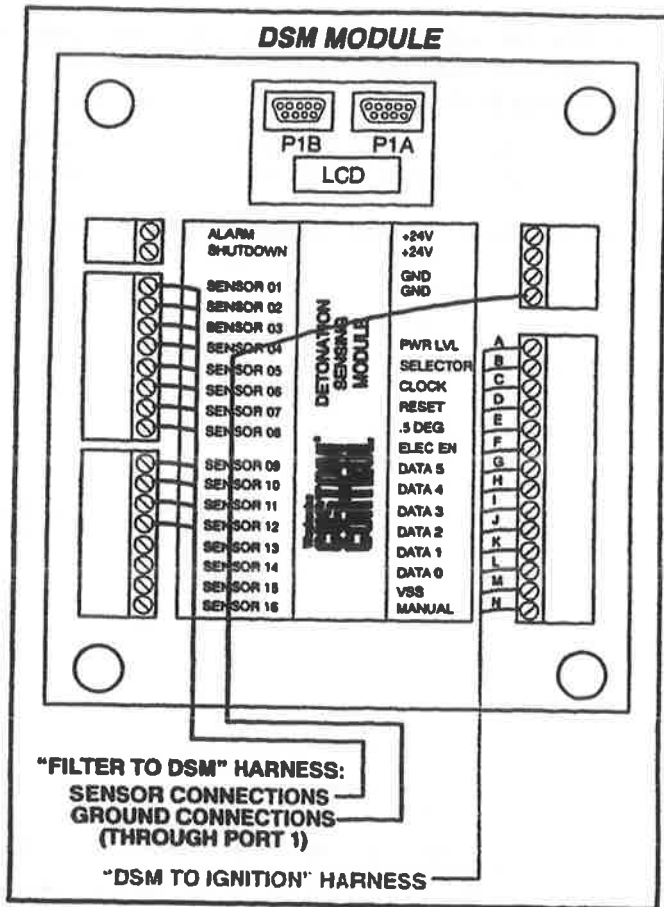


Figure 2.05-17. "Filter To DSM" Harness Connections in DSM Module - 6, 8, And 12 Cylinder VHP And AT Engines

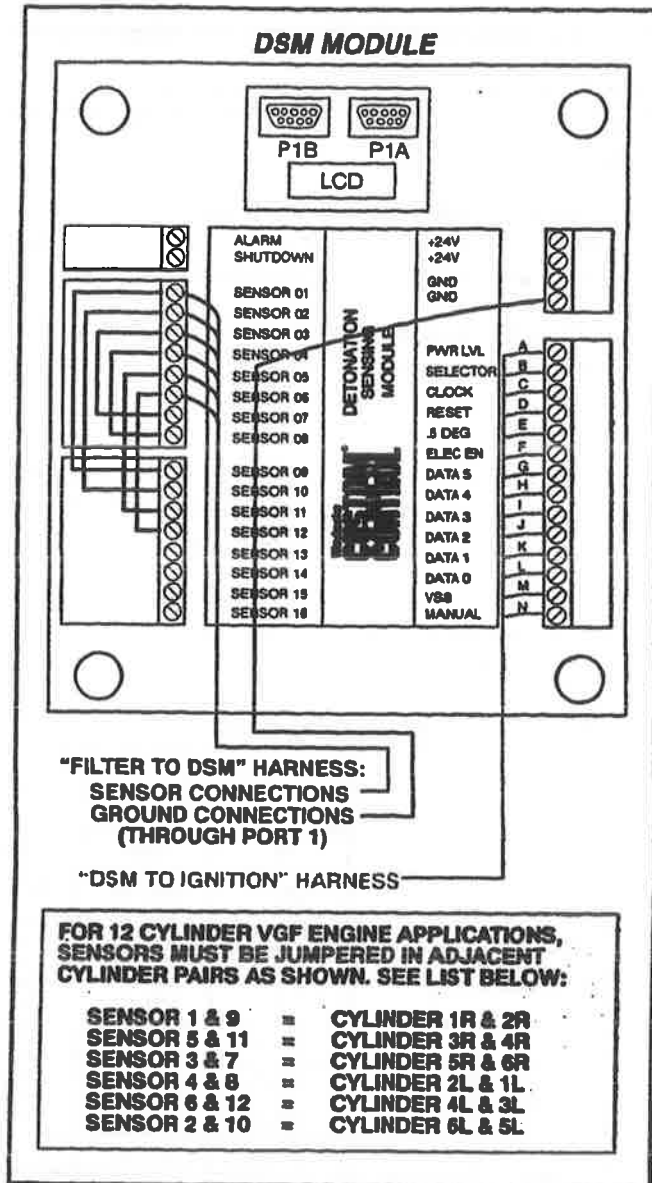


Figure 2.05-18. "Filter To DSM" Harness Connections in DSM Module - 12 Cylinder VGF Engines

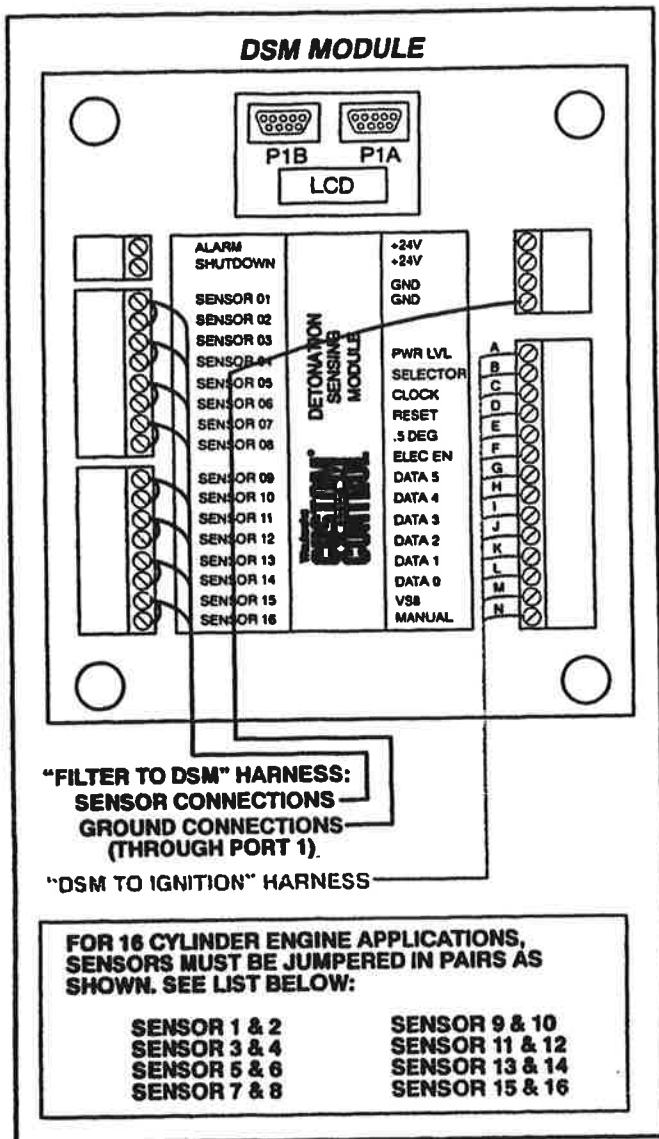


Figure 2.05-19. "Filter To DSM" Harness Connections In DSM Module - 16 Cylinder AT, VHP, VGF Engines

DSM SYSTEM COMPONENT CONNECTIONS

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SECTION 2.10

DSM SYSTEM POWER, ALARM, AND GROUND CONNECTIONS

POWER CONNECTIONS

In this section, you will be making power connections to the DSM filter and module with various DSM harnesses. Additionally, you will be making alarm and shutdown connections. DSM component connections are completed in Section 2.05 *DSM System Component Connections*.

Figure 2.10-1 and Figure 2.10-2 illustrate the connections of the DSM harnesses made after completing the power connections in this section.

Continue with "Filter Power Connections" on the next page.

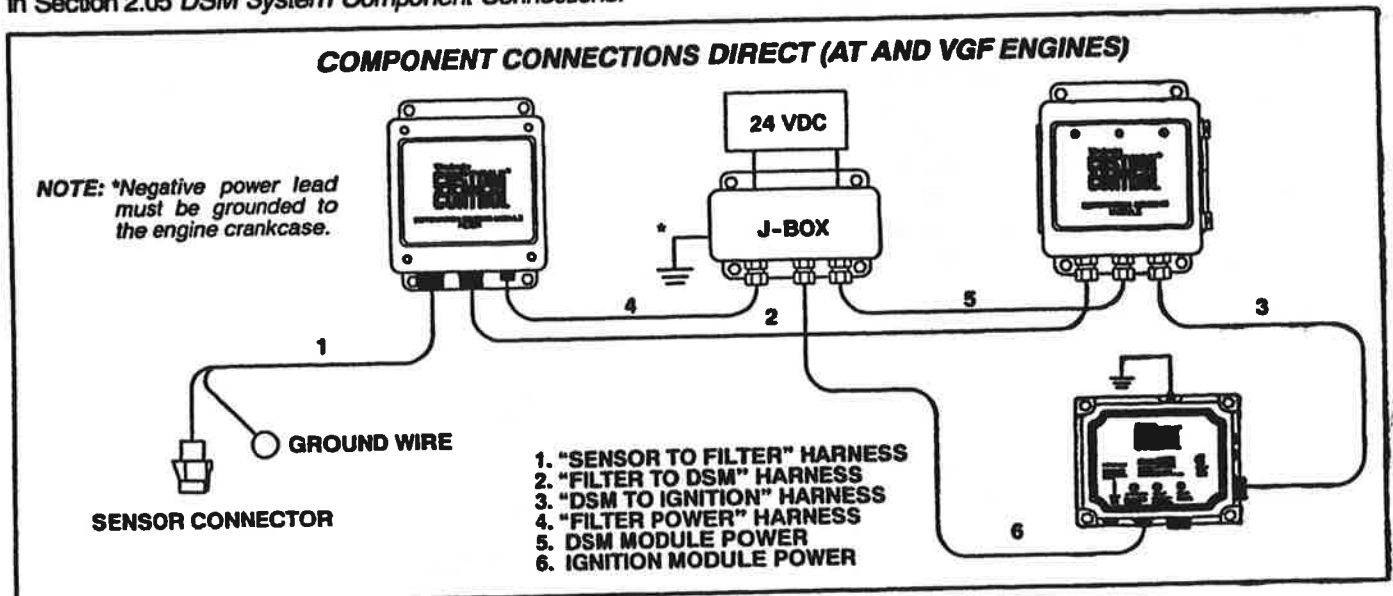


Figure 2.10-1. Component And Power Connections Direct - AT And VGF Engines

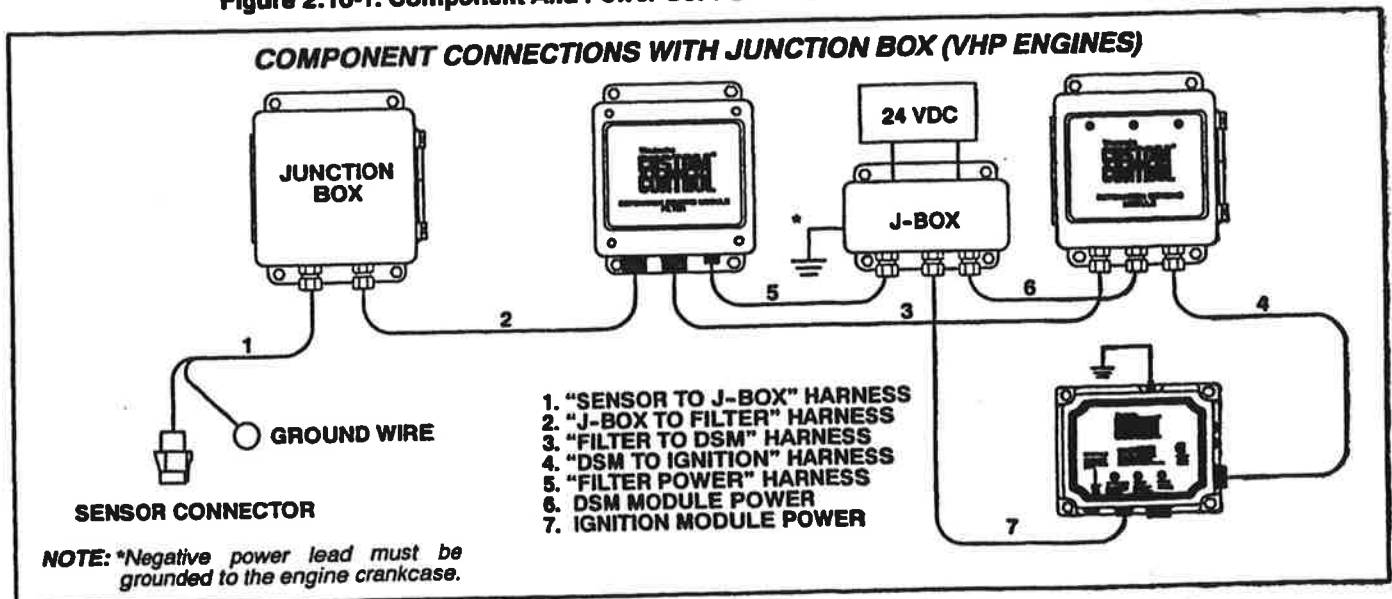


Figure 2.10-2. Component And Power Connections With Junction Box - VHP Engines

DSM SYSTEM POWER, ALARM, AND GROUND CONNECTIONS

FILTER POWER CONNECTIONS

The power connections to the DSM system filter must be in accordance with the applicable electrical codes. The DSM is suitable for installation in Canadian Standards Association (CSA) Class I, Group D, Division 2 locations. All wire sizing must be in accordance with Figure 2.10-5, Waukesha CEC Products Power Wiring Requirements.

See Table 2.10-1 for DSM filter power requirements. An oscilloscope must be used to verify that the ripple meets the listed requirement.

NOTE: The wiring diagrams included in this manual are to be used as a reference only. For additional reference, use the wiring diagrams received with the DSM system when making connections.

Refer to Section 2.15, *DSM System Wiring Diagrams*, for wiring diagrams for AT, VHP, and VGF engines.

WARNING

Do not install, set up, maintain, or operate any electrical components unless you are a technically qualified individual who is familiar with the electrical elements involved. Electrical shock can cause severe personal injury or death.

1. Locate the "filter power" harness (see Figure 2.10-3).

NOTE: The wires of the "filter power" harness must be run through conduit.

NOTE: Actual shape (elbow or straight) of the 3 pin connector varies due to engine configuration and DSM installation requirements.

2. With power supply off, connect the "filter power" harness to the customer supplied power supply through an engine mounted junction box (see Figure 2.10-3). The negative power lead must be grounded to the engine crankcase at the engine mounted junction box. The harness wires are labeled for the appropriate connection.

3. Attach the 3 pin cylindrical connector of the "filter power" harness to the power connector on the filter (see Figure 2.10-3 and Figure 2.10-4). The power connector is the only 3 pin metal connector on the filter.

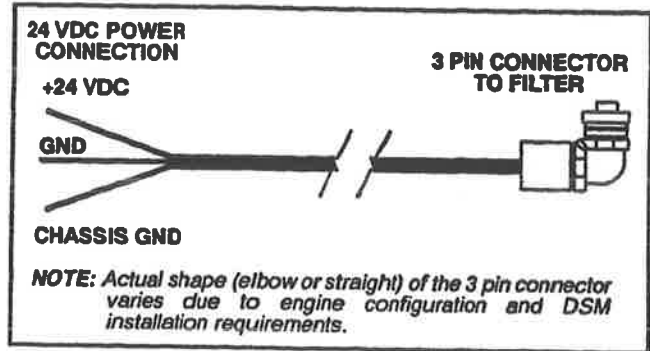


Figure 2.10-3. "Filter Power" Harness

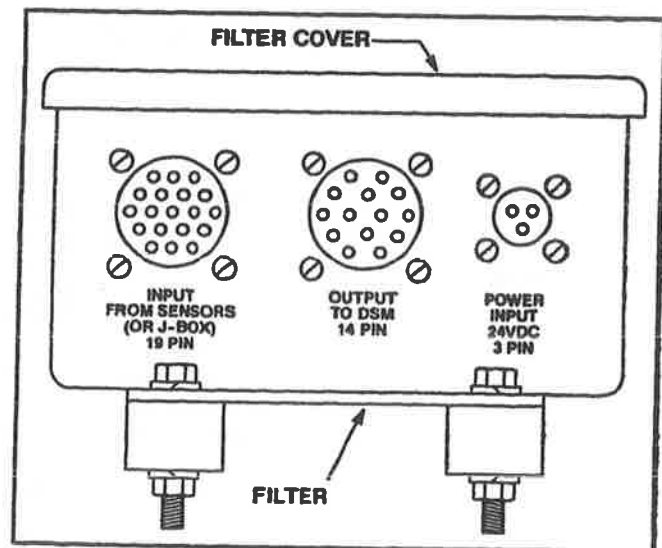


Figure 2.10-4. DSM System's Filter Input Connectors

DSM SYSTEM POWER, ALARM, AND GROUND CONNECTIONS

Table 2.10-1. Power Requirements For The DSM System

CEC PRODUCT	NOMINAL VOLTAGE (volts DC)	TOLERANCE	OPERATING RANGE (volts DC)	PEAK-TO-PEAK RIPPLE (volts AC)	OPERATING CURRENT (amps)
DSM Filter	24	+25%, -10%	21.6 - 30	less than 2	1.0 (typical)
DSM Module	24	+25%, -10%	21.6 - 30	less than 2	0.5 (typical)

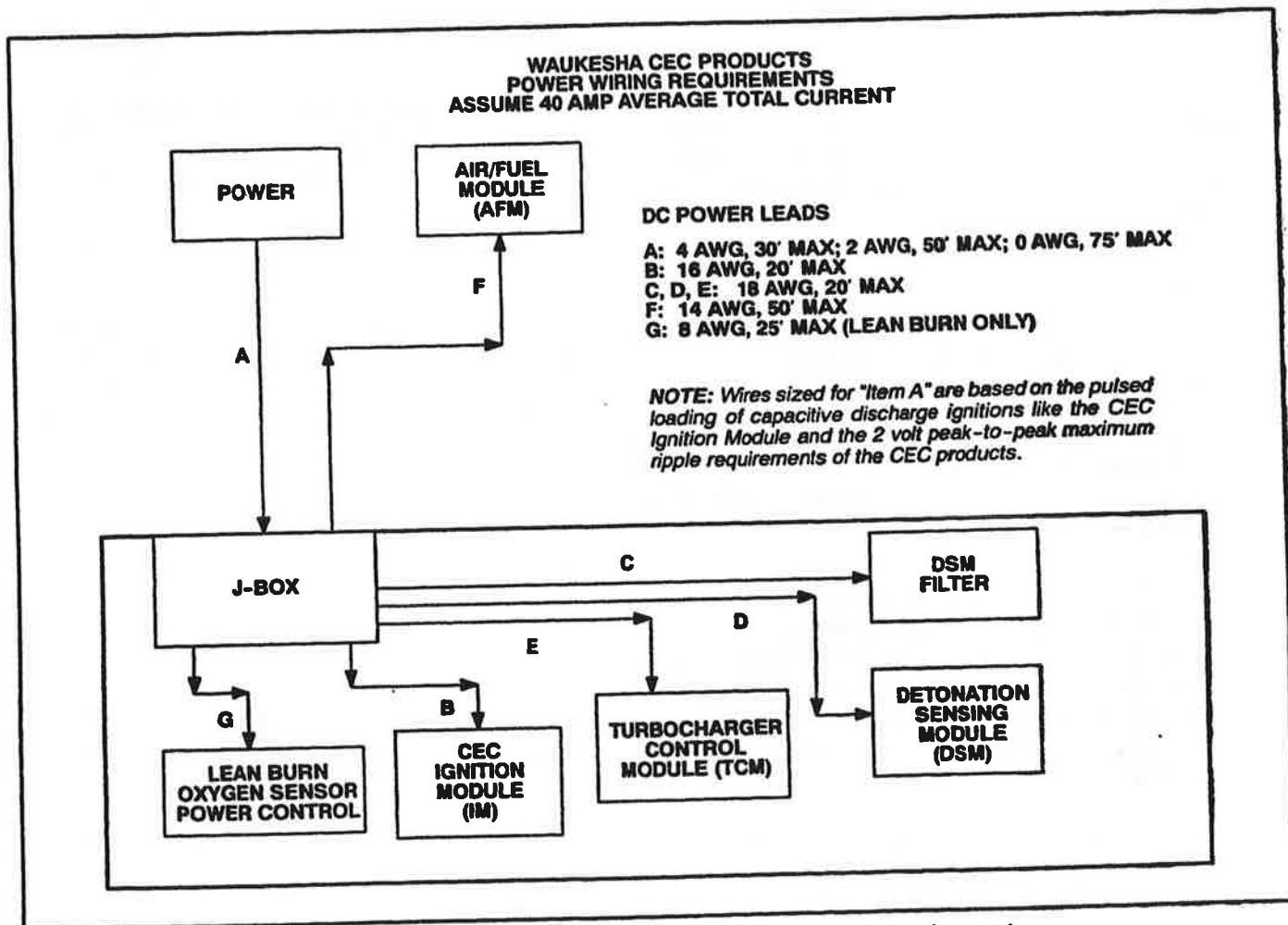


Figure 2.10-5. Waukesha CEC Products Power Wiring Requirements

DSM SYSTEM POWER, ALARM, AND GROUND CONNECTIONS

DSM MODULE POWER CONNECTIONS

The power connections to the DSM module must be in accordance with the applicable electrical codes. The DSM is suitable for installation in Canadian Standards Association (CSA) Class I, Group D, Division 2 locations. All power sizing must be in accordance with Figure 2.10-5, Waukesha CEC Products Power Wiring Requirements.

See Table 2.10-1 for DSM module power requirements. An oscilloscope must be used to verify that the ripple meets the listed requirement.

NOTE: The wiring diagrams included in this manual are to be used as a reference only. For additional reference, use the wiring diagrams received with the DSM system when making connections.

Refer to Section 2.15, *DSM System Wiring Diagrams*, for wiring diagrams for AT, VHP, and VGF engines.

WARNING

Do not install, set up, maintain, or operate any electrical components unless you are a technically qualified individual who is familiar with the electrical elements involved. Electrical shock can cause severe personal injury or death.

CAUTION

Route the DSM system wires through the correct port on the DSM module. The wires must be directed through the holes provided in the bottom of the DSM module. If the wires are routed through the wrong port, electrical interference may result, affecting the performance of the DSM system.

1. With power off, install an input power wire from the 24 VDC supply through the center conduit entry (port 2) of the DSM module (see Figure 2.10-6).

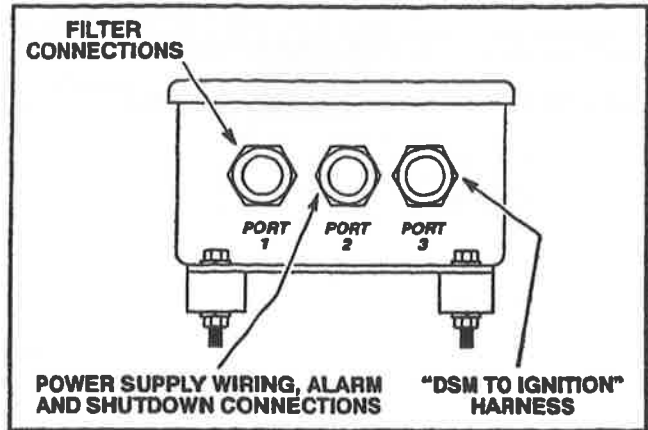


Figure 2.10-6. DSM Module Conduit Ports

2. Connect the power wire to the terminal block labeled +24V (see Figure 2.10-7).

3. Connect a wire from the crankcase to the same terminal block at the point labeled GND (ground). Run the ground wire through the center conduit entry of the DSM module to the engine mounted junction box.

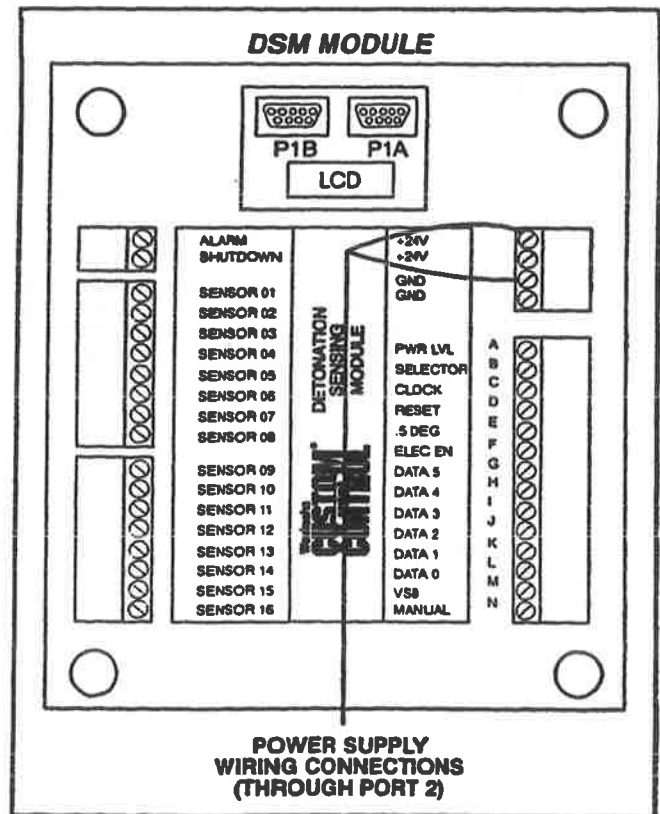


Figure 2.10-7. Power Connections In DSM Module

DSM SYSTEM POWER, ALARM, AND GROUND CONNECTIONS

ALARM AND SHUTDOWN CONNECTIONS

⚠ WARNING

Connect the DSM system to a safety engine shutdown for maximum engine protection. Failure to connect a safety engine shutdown could cause personal injury, death or engine damage.

⚠ CAUTION Route the DSM system wires through the correct port on the DSM module. The wires must be directed through the holes provided in the bottom of the DSM module. If the wires are routed through the wrong port, electrical interference may result, affecting the performance of the DSM system.

The alarm and shutdown terminals are sinking devices. A sinking device is an electronic switching device with a single terminal used to complete an electrical circuit that can be used to control (through a relay) remote devices such as alarms and lights. A sinking device completes the electrical path to ground.

The alarm and shutdown terminals are auxiliary connections that can be used to interface the DSM system to external electrical devices (see Figure 2.10-8). The alarm terminal is a sinking device with an internal circuit limit of 1 amp, 50 VDC. The alarm terminal can be used to control (through a relay) remote devices such as alarms and lights. When the DSM system is operating correctly it is in an OPEN state. Any system fault will "close" the alarm circuit. The alarm terminal will be CLOSED (connected to ground) whenever the "Alarm" LED (yellow light) on the front of the DSM module is on. The shutdown terminal operates the same as the alarm terminal and will only be activated when the "Shutdown" LED (red light) on the front of the DSM module is on. The alarm and shutdown wires must be routed through port 2 of the DSM module (see Figure 2.10-6).

You may use a relay with normally open and/or normally closed contacts as long as the logic is compatible with the devices being controlled. A separate supply for the relays may be used as long as the negative of the 24 VDC power source is grounded at the same point as the negative of the 24 VDC power source of the DSM module.

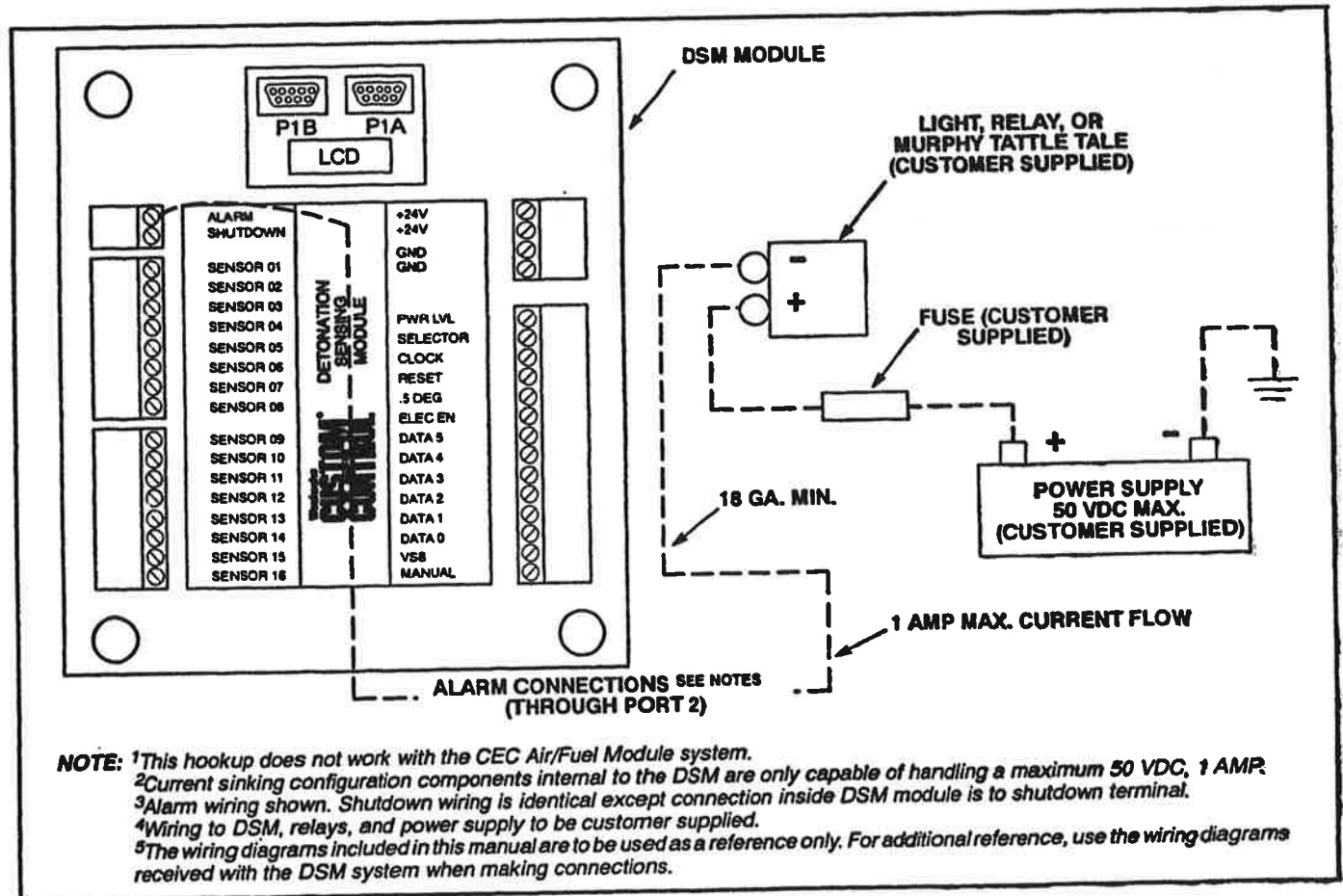


Figure 2.10-8. Alarm Wiring Schematic

DSM SYSTEM POWER, ALARM, AND GROUND CONNECTIONS

GROUND CONNECTIONS

To prevent electrical interference with the DSM system from other components (especially high current devices such as solenoid valves, ignition systems, and motors), complete the following grounding procedure.

- **Non-Junction Box Applications:** The negative side of the power source and the chassis ground of the filter must be securely attached to a clean, dry, unpainted engine crankcase surface (see Figure 2.10-9). The surface of the "Sensor to Filter" harness ground connection(s) must also be connected to a clean, dry, unpainted engine crankcase surface.

- **Junction Box Applications:** On engines using a Waukesha supplied junction box, the filter chassis ground and the negative side of the power source, for both the DSM module and filter, must be connected together in the junction box (see Figure 2.10-10). Then, this connection must be grounded to a clean, dry, unpainted engine crankcase surface.

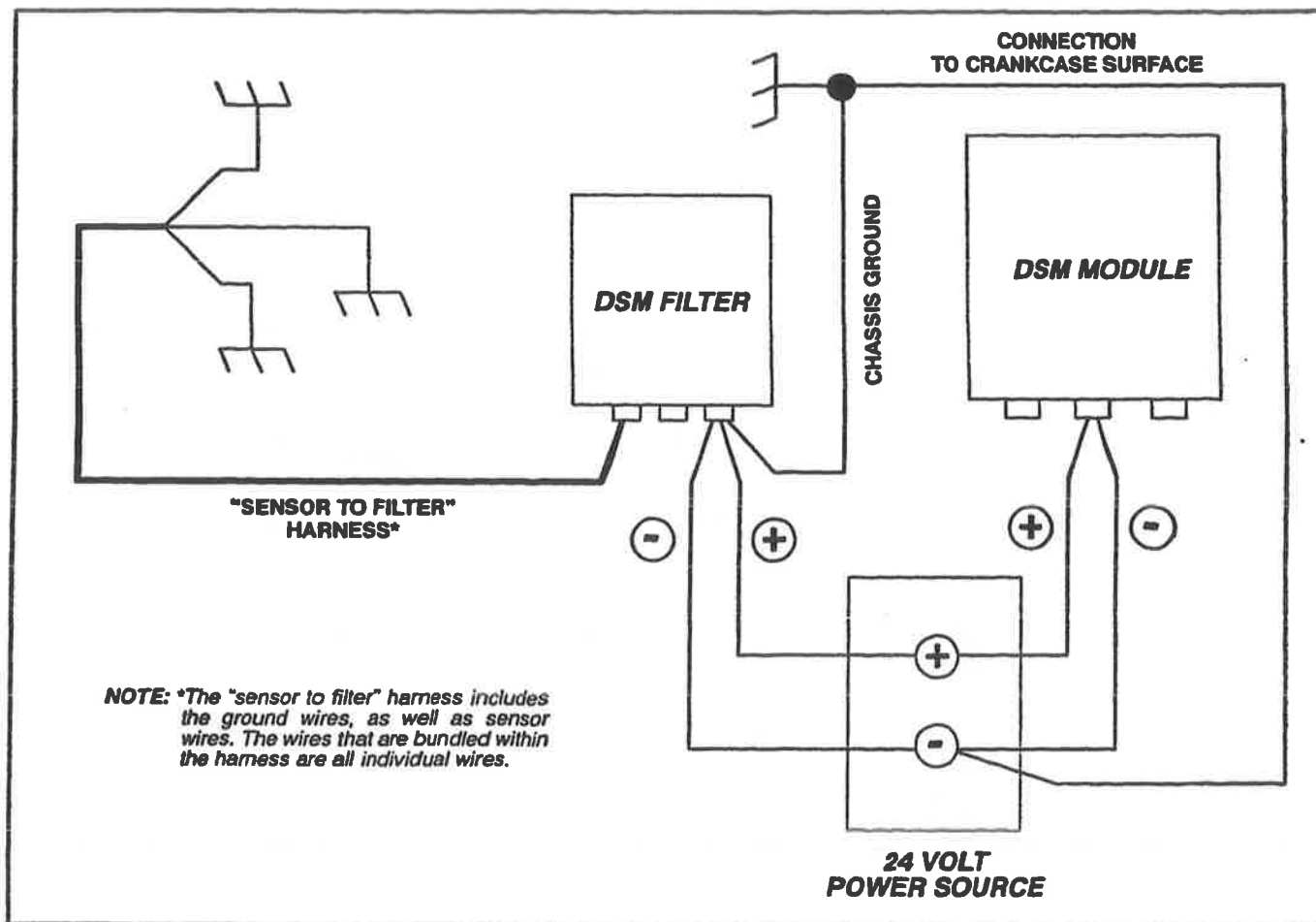


Figure 2.10-9. Ground Connections For Non-Junction Box Applications

DSM SYSTEM POWER, ALARM, AND GROUND CONNECTIONS

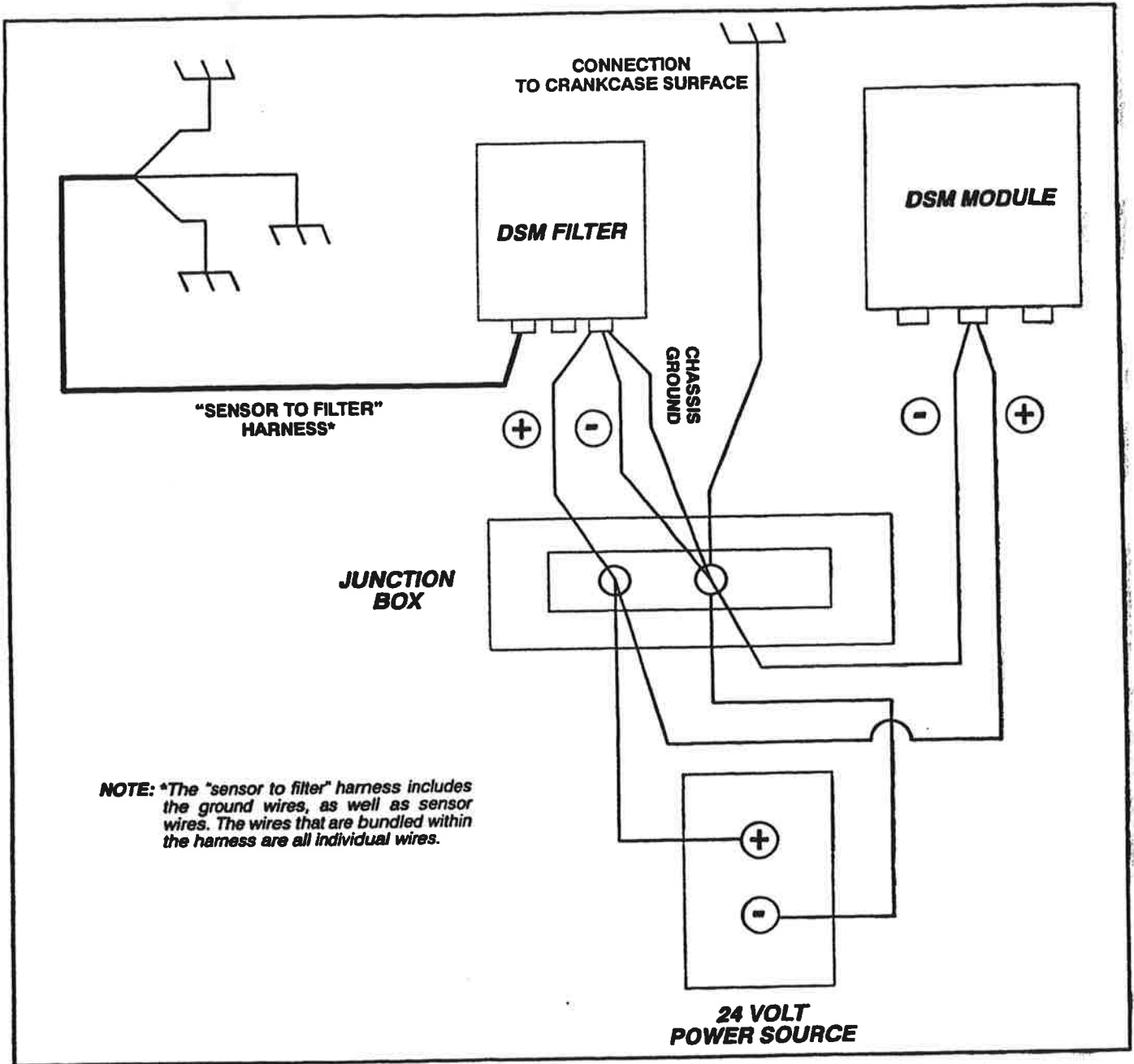


Figure 2.10-10. Ground Connections For Waukesha Supplied Junction Box Applications

DSM SYSTEM POWER, ALARM, AND GROUND CONNECTIONS

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CC

SECTION 2.15

DSM SYSTEM WIRING DIAGRAMS

DSM SYSTEM WIRING DIAGRAMS

⚠ WARNING

Do not install, set up, maintain, or operate any electrical components unless you are a technically qualified individual who is familiar with the electrical elements involved. Electrical shock can cause severe personal injury or death.

This section contains wiring diagrams for AT, VHP, and VGF engines. Figure 2.15-2 and Figure 2.15-3 illustrate the connections of the DSM harnesses.

Refer to Figure 2.15-4 through Figure 2.15-11 for DSM system wiring diagrams. Table 2.15-1 lists the page numbers of the wiring diagrams for AT, VHP, and VGF engines.

NOTE: The wiring diagrams included in this manual are to be used as a reference only. For additional reference, use the wiring diagrams received with the DSM system when making connections.

Table 2.15-1. Page Locations Of DSM Wiring Diagrams

WIRING DIAGRAM	PAGE NUMBER
Figure 2.15-3. 8L-ATGL Wiring Diagram	2.15-3
Figure 2.15-4. 12V-ATGL Wiring Diagram	2.15-4
Figure 2.15-5. 16V-ATGL Wiring Diagram	2.15-5
Figure 2.15-6. 6 Cyl. VHP Wiring Diagram	2.15-6
Figure 2.15-7. 12 Cyl. VHP Wiring Diagram	2.15-7
Figure 2.15-8. 16 Cyl. VHP Wiring Diagram	2.15-8
Figure 2.15-9. 12 Cyl. VGF Wiring Diagram	2.15-9
Figure 2.15-10. 16 Cyl. VGF Wiring Diagram	2.15-10

Refer to Section 2.00, *Mounting DSM System Components*, to mount DSM system components. Refer to Section 2.05, *DSM System Component Connections*, to make wire harness connections. Refer to Section 2.10, *DSM System Power, Alarm, And Ground Connections*, to make power connections.

⚠ CAUTION Route the DSM system wires through the correct port on the DSM module. The wires must be directed through the holes provided in the bottom of the DSM module. If the wires are routed through the wrong port, electrical interference may result, affecting the performance of the DSM system.

NOTE: See Figure 2.15-1 for proper wire routing of the DSM module.

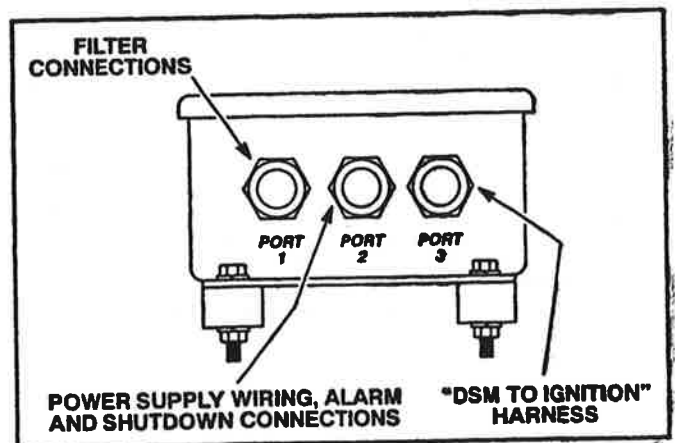


Figure 2.15-1. DSM Module Conduit Ports

DSM SYSTEM WIRING DIAGRAMS

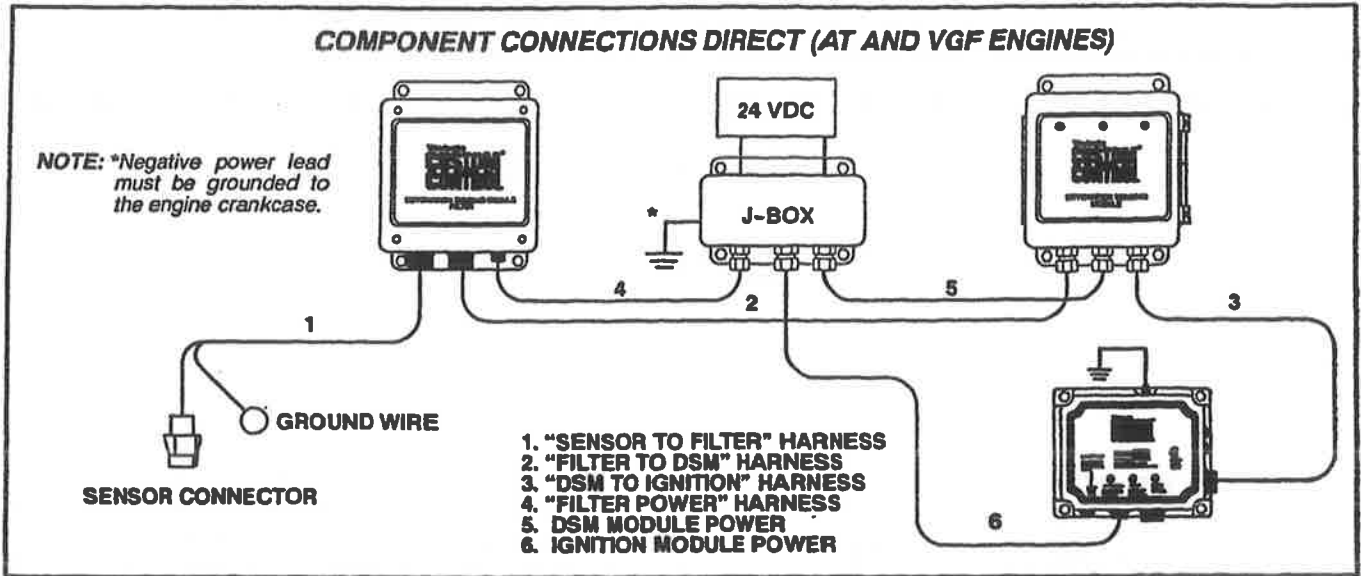


Figure 2.15-2. Component And Power Connections Direct - AT And VGF Engines

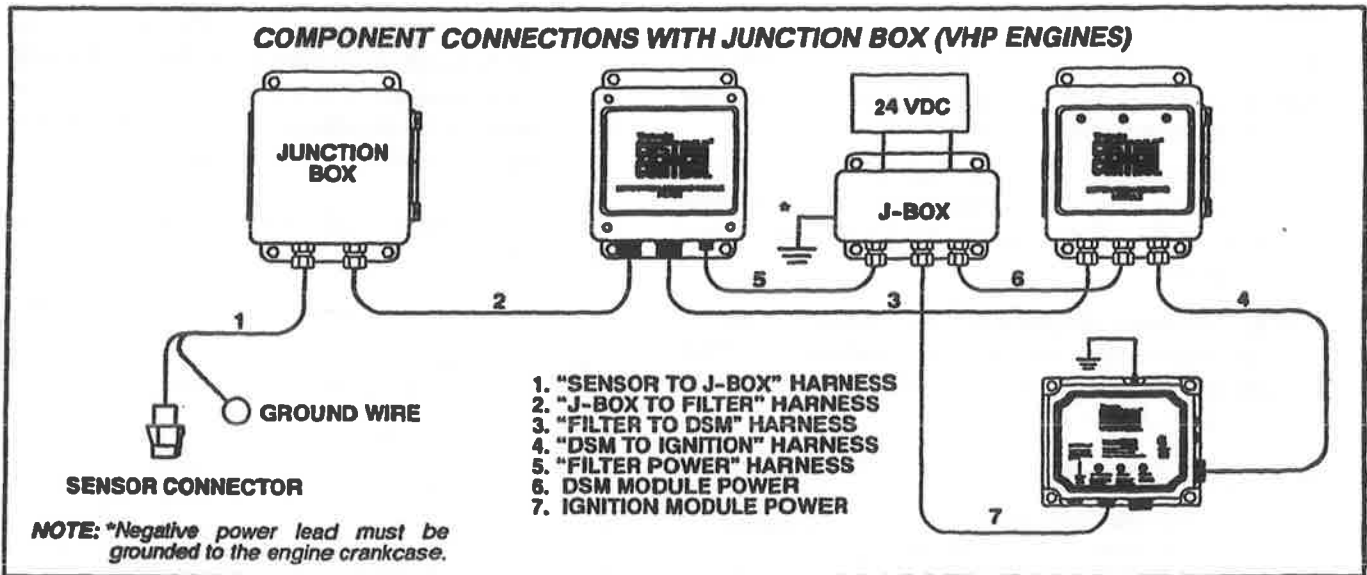


Figure 2.15-3. Component And Power Connections With Junction Box - VHP Engines

DSM SYSTEM POWER AND ALARM CONNECTIONS

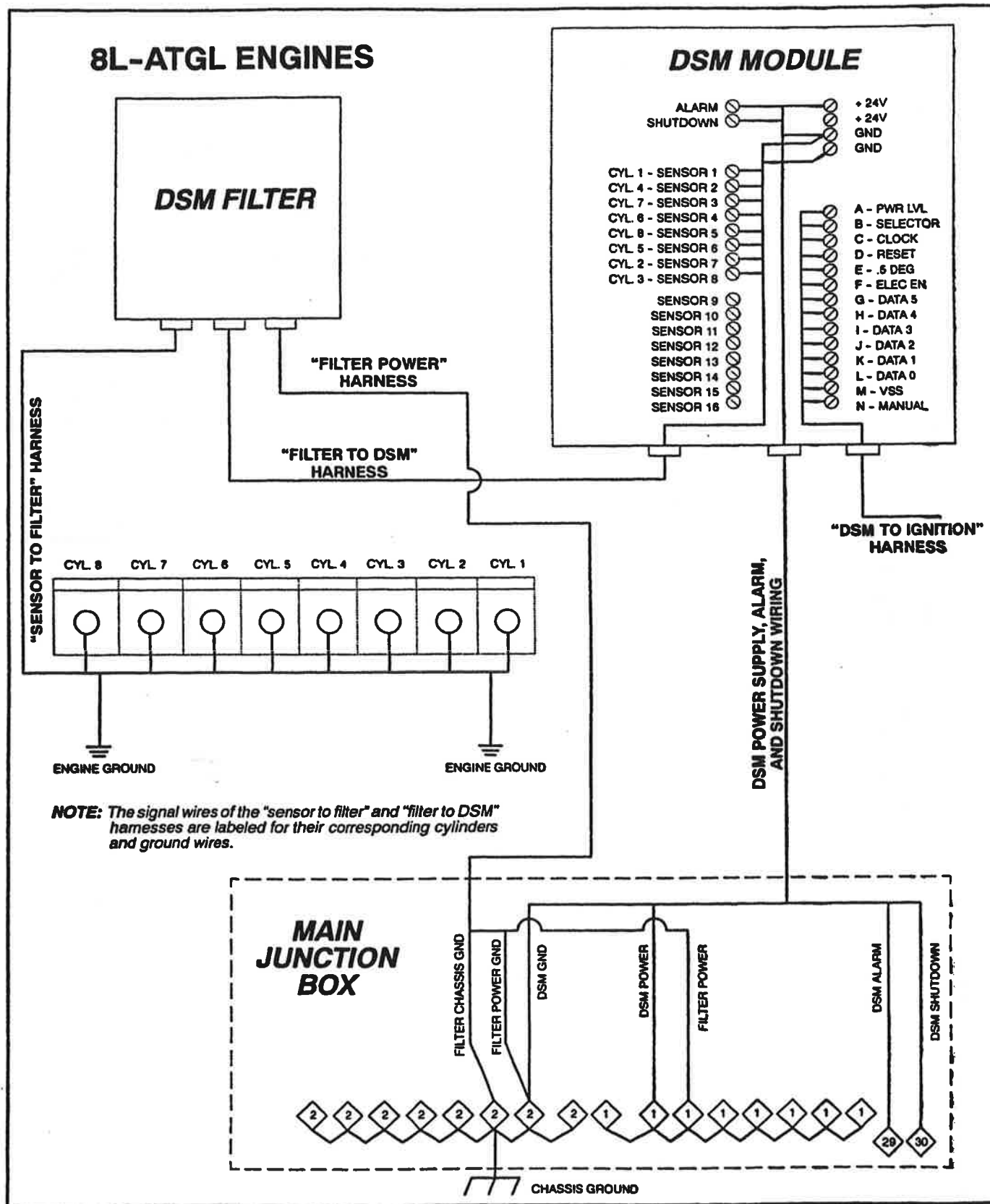


Figure 2.15-4. AT DSM System Wiring Diagram - 8L-ATGL

NOTE: The wiring diagrams included in this manual are to be used as a reference only. For additional reference, use the wiring diagrams received with the DSM system when making connections.

DSM SYSTEM WIRING DIAGRAMS

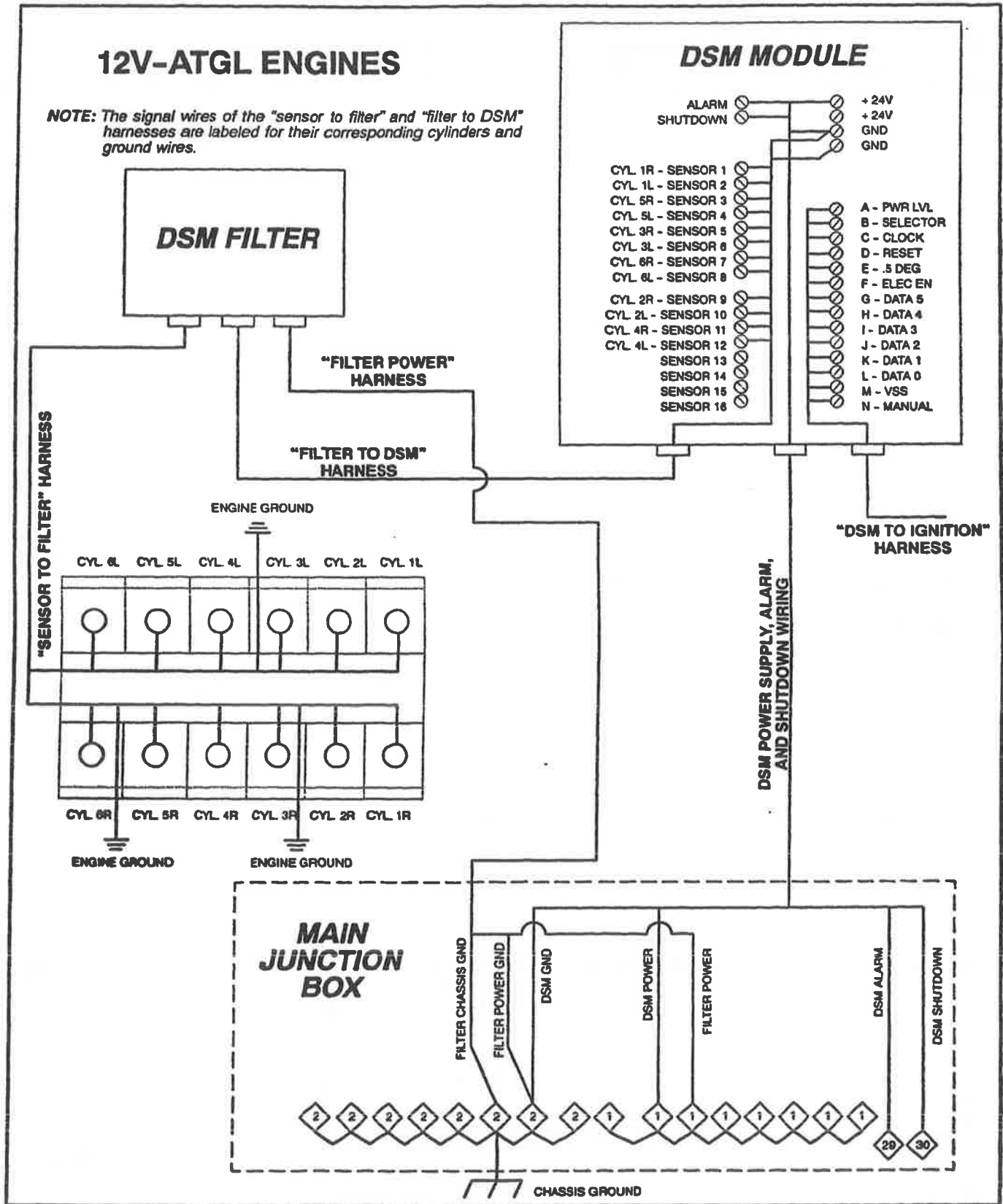


Figure 2.15-5. AT DSM System Wiring Diagram - 12V-ATGL

NOTE: The wiring diagrams included in this manual are to be used as a reference only. For additional reference, use the wiring diagrams received with the DSM system when making connections.

DSM SYSTEM POWER AND ALARM CONNECTIONS

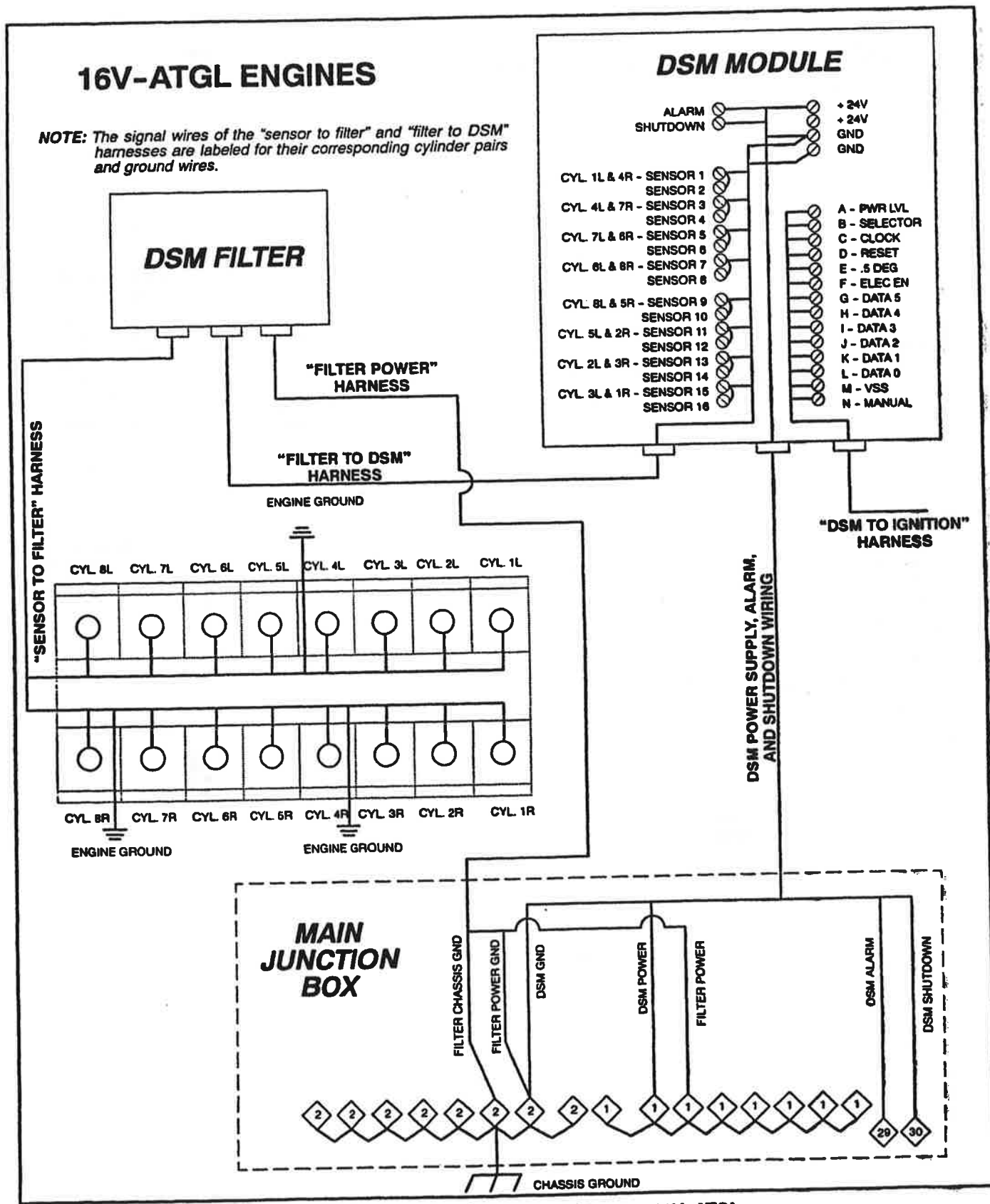


Figure 2.15-6. DSM System Wiring Diagram - 16V-ATGL

NOTE: The wiring diagrams included in this manual are to be used as a reference only. For additional reference, use the wiring diagrams received with the DSM system when making connections.

DSM SYSTEM WIRING DIAGRAMS

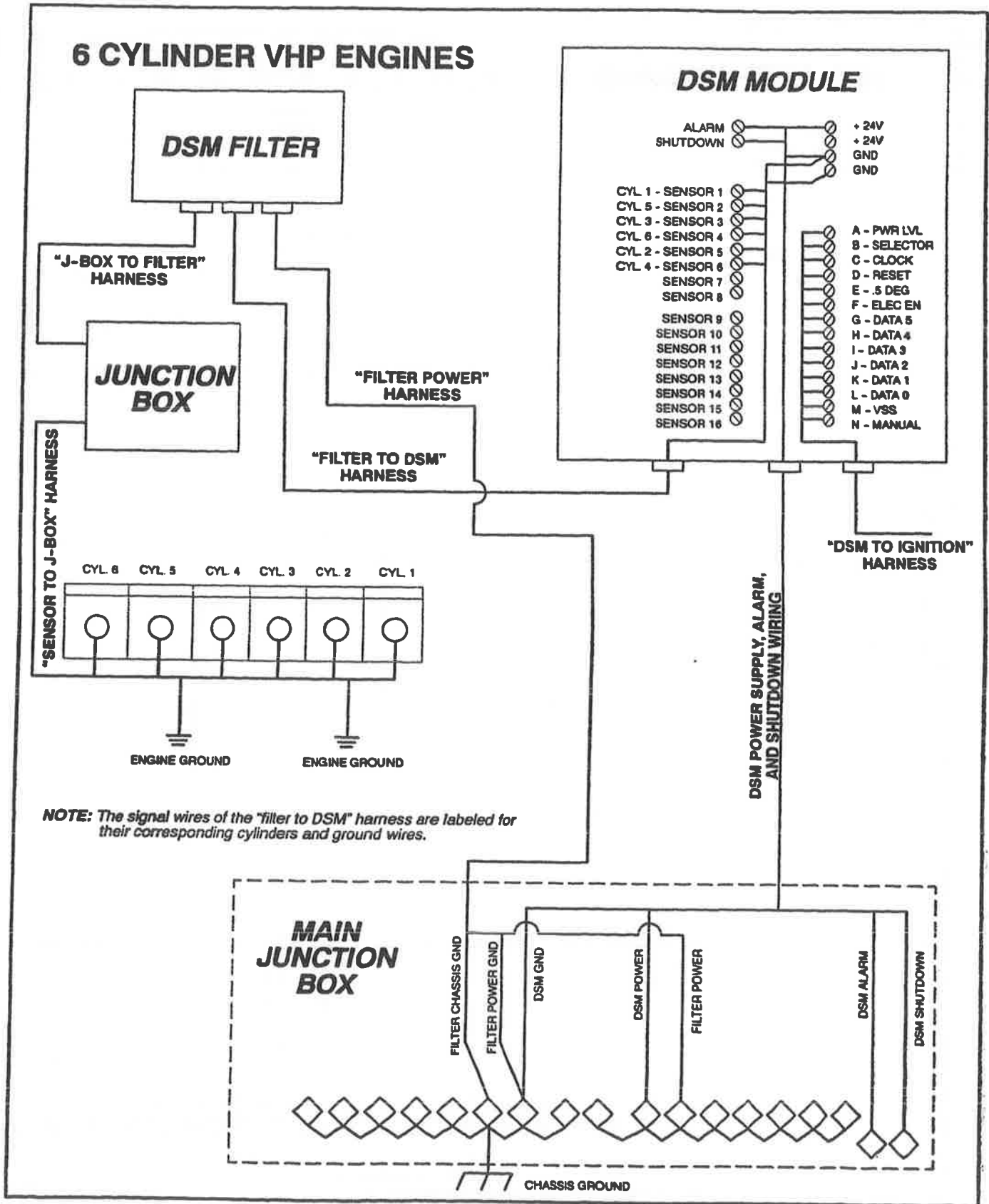


Figure 2.15-7. VHP DSM System Wiring Diagram - 6 Cylinder

NOTE: The wiring diagrams included in this manual are to be used as a reference only. For additional reference, use the wiring diagrams received with the DSM system when making connections.

DSM SYSTEM POWER AND ALARM CONNECTIONS

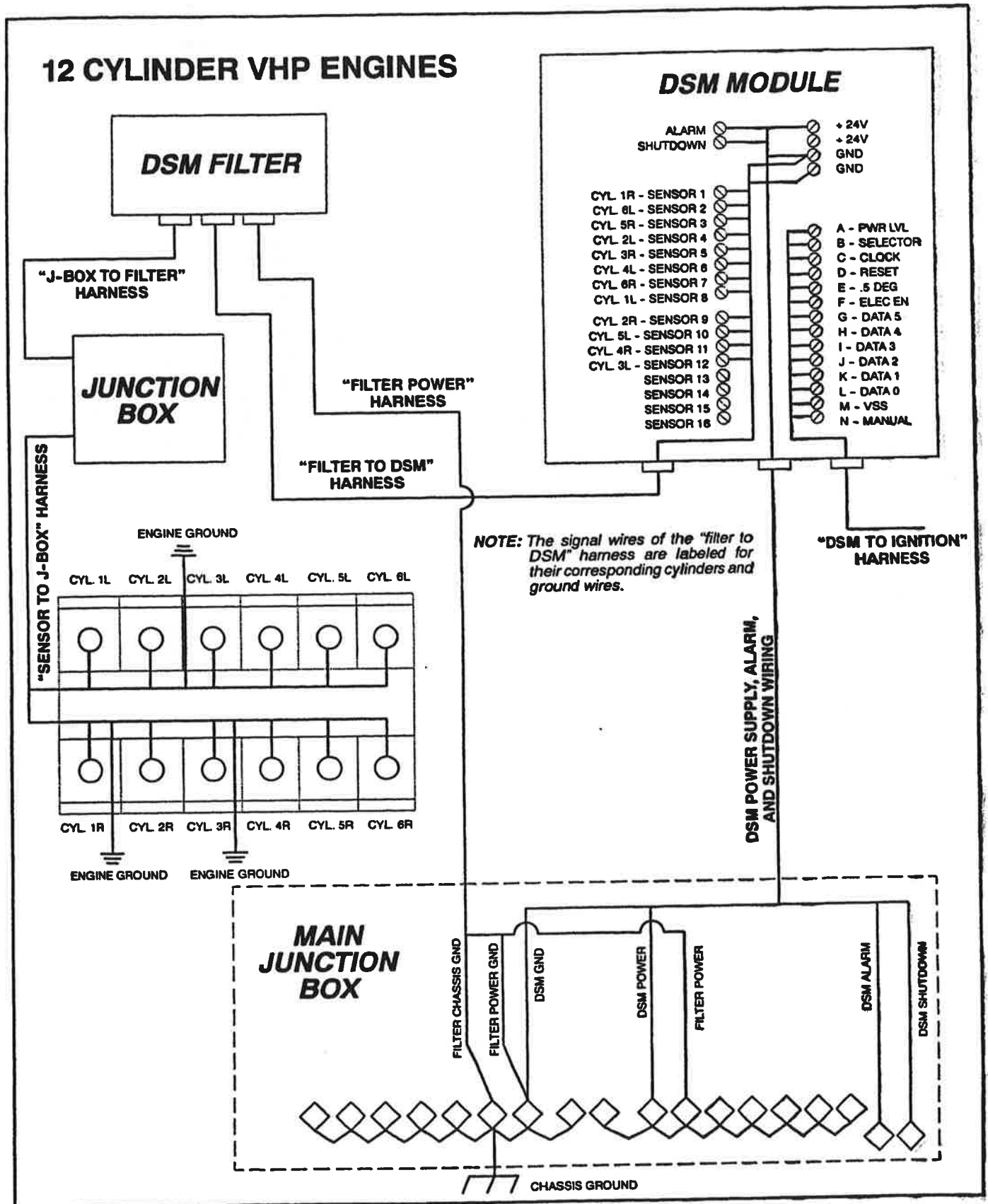


Figure 2.15-8. VHP DSM System Wiring Diagram - 12 Cylinder

NOTE: The wiring diagrams included in this manual are to be used as a reference only. For additional reference, use the wiring diagrams received with the DSM system when making connections.

DSM SYSTEM WIRING DIAGRAMS

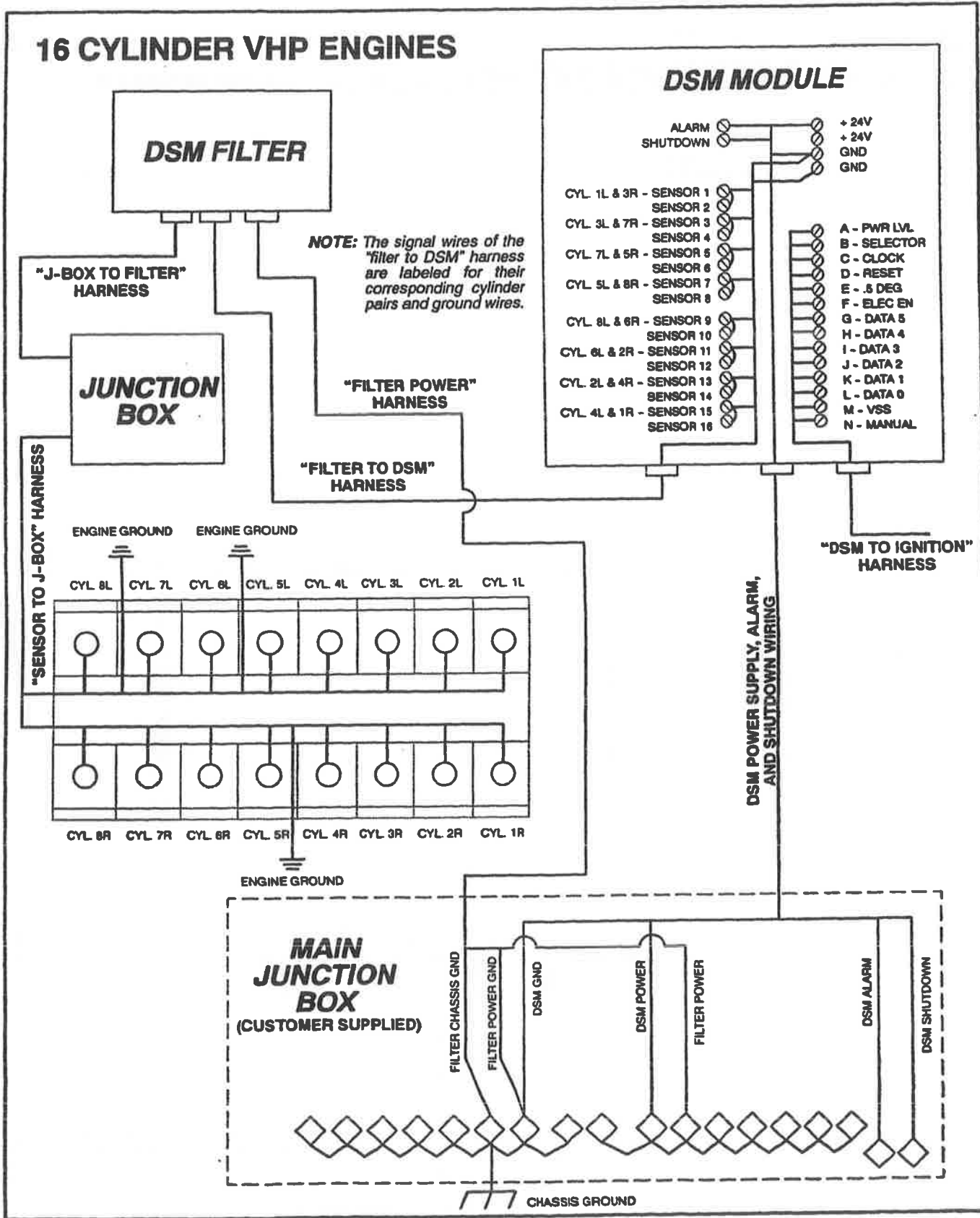


Figure 2.15-9. VHP DSM System Wiring Diagram - 16 Cylinder

NOTE: The wiring diagrams included in this manual are to be used as a reference only. For additional reference, use the wiring diagrams received with the DSM system when making connections.

DSM SYSTEM POWER AND ALARM CONNECTIONS

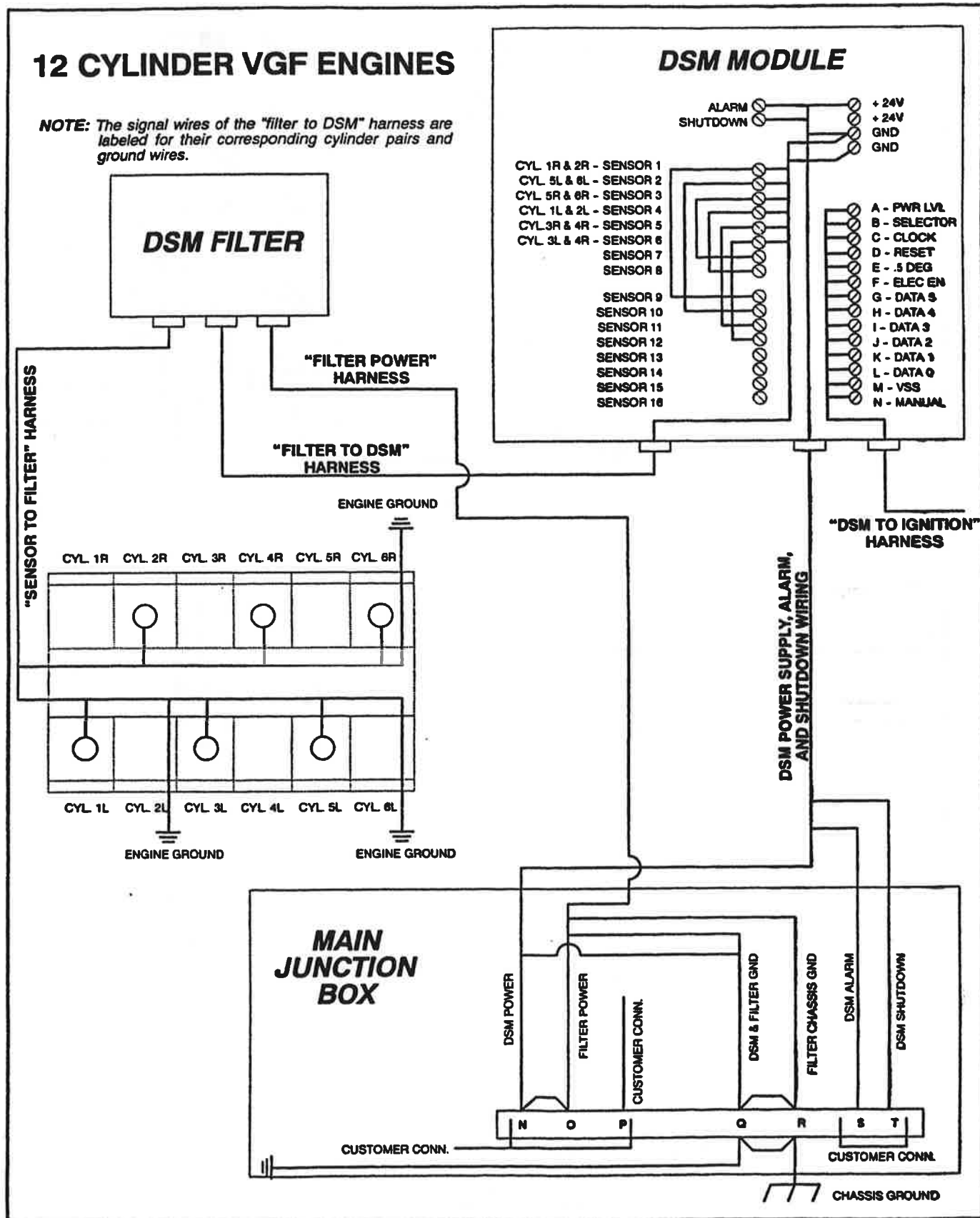


Figure 2.15-10. VGF DSM System Wiring Diagram - 12 Cylinder

NOTE: The wiring diagrams included in this manual are to be used as a reference only. For additional reference, use the wiring diagrams received with the DSM system when making connections.

DSM SYSTEM WIRING DIAGRAMS

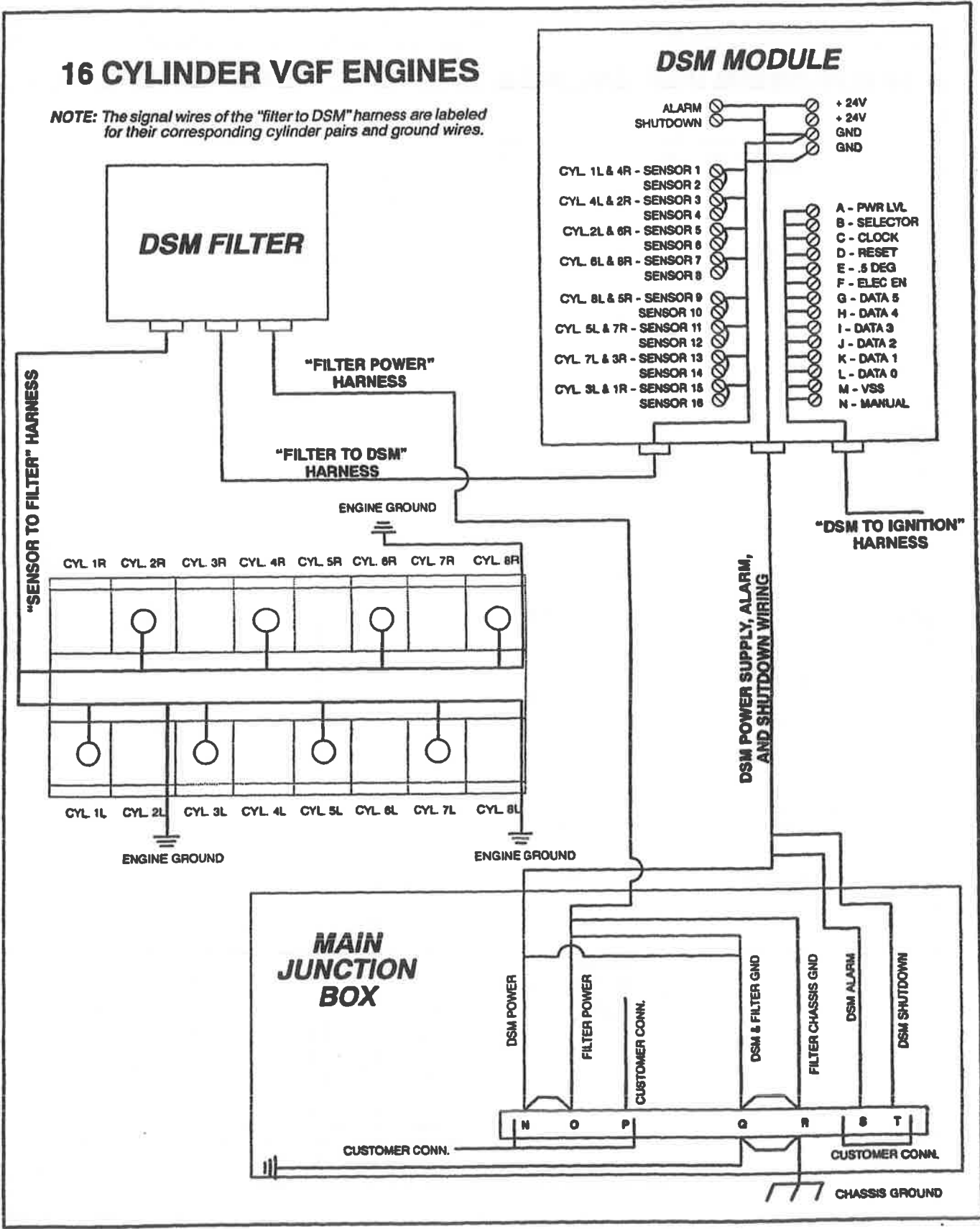


Figure 2.15-11. VGF DSM System Wiring Diagram - 16 Cylinder

NOTE: The wiring diagrams included in this manual are to be used as a reference only. For additional reference, use the wiring diagrams received with the DSM system when making connections.

CONTENTS

SECTION 3.00 - DSM INTERFACE PROGRAM OPERATION

SECTION 3.05 - EDITING AN EXISTING DSM DATA-SET

**SECTION 3.10 - PROGRAMMING THE DSM SYSTEM
FOR A NEW APPLICATION**

**SECTION 3.15 - DSM COMPUTER SCREEN AND
DATA RETRIEVAL**

05

05

SECTION 3.00

DSM INTERFACE PROGRAM OPERATION

PROGRAMMING INFORMATION

MINIMUM RECOMMENDED COMPUTER FOR DSM SYSTEM EQUIPMENT PROGRAMMING

The DSM system is customized for each engine application based on site specific information with a personal computer (PC). The following is a list of the minimum recommended computer equipment for DSM system programming:

- Portable IBM PC or Compatible Computer
- Intel 80286-12 MHz Microprocessor
- 640K RAM (512K RAM free)
- Single 3.5" High Density (1.44 MB) Floppy Drive
- RS-232 Serial Port
- Microsoft MS-DOS 3.3
- DB-9 Serial Cable (male to female)
- Optional: Printer Port (Centronics Type Parallel Port)
- Optional: Portable Printer with IBM Proprinter Emulation Mouse (Print-outs of computer screens can be used to aid in troubleshooting and filed for future reference.)

CONVENTIONS USED WITH DSM PROGRAMMING

The following is a list of conventions used in the DSM system software and documentation:

- All commands enclosed in brackets, [], are to be executed from the PC keyboard.
- In most cases, if an errant keystroke is made with the PC, simply press [Esc] to return to the previous menu.
- You can highlight menu options by using the arrow keys.
- Highlighting and then pressing [Enter] accesses a screen menu choice.

- If you have a portable printer connected to your PC, press [Print Screen] to make a copy of the screen you are viewing for reference.
- The [Return] key is the same as the [Enter] key (on some keyboards [Return] is used instead of [Enter]).

NOTE: This manual assumes you are already familiar with basic MS-DOS commands for viewing directories, copying files, and other MS-DOS concepts. If you need more information on these subjects, refer to a MS-DOS instruction manual.

OPERATOR INTERFACE

The DSM module is equipped with diagnostic features to inform site personnel of system status at any time. These diagnostic features include:

- "Power," "Alarm," and "Shutdown" lights (LED) on the front panel of the DSM module (see Figure 3.00-1)
- The green "Power" LED is lit any time power is applied to the DSM module.

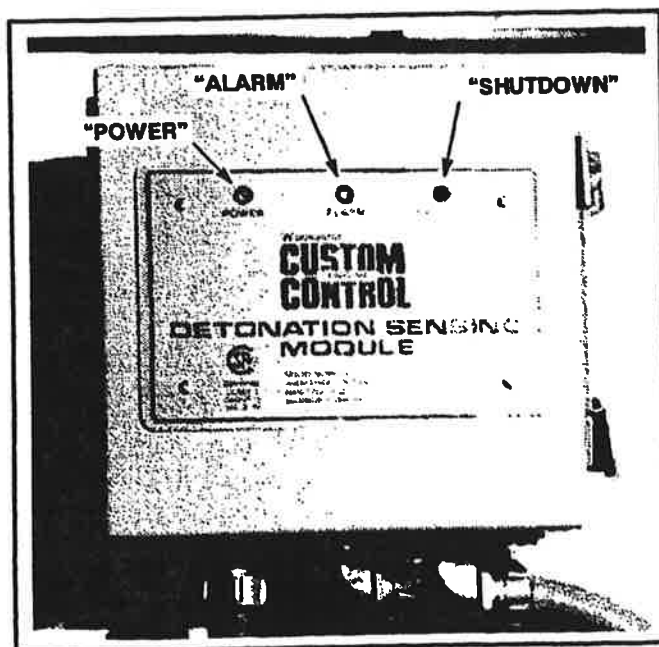


Figure 3.00-1. Detonation Sensing Module Front Panel

DSM INTERFACE PROGRAM OPERATION

- The yellow "Alarm" LED is lit when power is applied to the DSM and the engine is not running (not due to shutdown mode). The "Alarm" LED lights any time a sensor output is lost or disconnected (6, 8, and 12 cylinder engines). Additionally, the alarm LED lights when the timing is retarded to the most retarded limit (uncontrollable detonation). The alarm LED flashes when the shutdown delay expires and detonation is still present.

NOTE: For 16 cylinder engines a sensor test must be performed to detect a lost sensor. The lost sensor check procedure is explained in Section 4.10, Lost Sensor Check Test On 16 Cylinder Engines. A test for lost sensors should be performed whenever the safety controls and alarms are tested on the engine.

- The red "Shutdown" LED lights when the DSM system has reached the most retarded timing, the shutdown delay has timed out, and the engine is still in detonation.
- a liquid crystal display (LCD) located inside the DSM module which continually shows the current status of the system through specific diagnostic codes for all conditions (see Figure 3.00-2 and Table 3.00-1)

Refer to Section 4.00, *DSM System Diagnostics And Troubleshooting*, for more diagnostic and troubleshooting information.

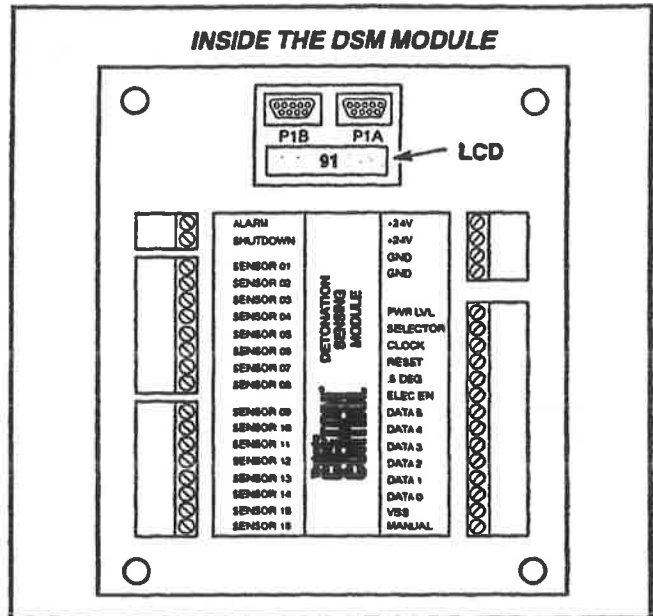


Figure 3.00-2. Detonation Sensing Module LCD

Table 3.00-1. Description Of Diagnostic Codes

OPERATIONAL CODES		
Code	Status	Description of Condition
Blank	No Power	The DSM module is not powered, system not operating.
(00)	Loss of Rotation	DSM module has sensed that the engine has stopped running.
(75)	Shutdown Active	Uncontrolled detonation present, shutdown output activated by the DSM module.
(90)	Ready to Start	DSM module is waiting for engine to be started.
(81)	Error Present	Sensor error code detected by DSM module. Sensor error for Maximum Retard or failed sensor will follow.
(91)	Normal Operation	The DSM system is running properly. Detonation is being controlled and no errors are present.
(95)	Warm-up Cycle	Warm-up delay time has not elapsed, therefore, engine is running at default timing.
PGM (PROGRAM) INTERRUPT CODES		
Code	Status	Description of Condition
(86)	Configuration Error	Configuration data or application problem if present. (Example: DSM module has been programmed for the wrong engine.)
(86)	Executing AutoCal	DSM module is establishing detonation threshold.
(97)	Serial Transfer	DSM module is communicating with the PC through serial cable.
(99)	No data	The DSM module has not yet been programmed and should not be connected to the Ignition Module while this code is active.
SENSOR CODES		
Code	Status	Description of Condition
(01-16)	Failed Sensor	The DSM module no longer senses a signal from the filter.
(21-36)	Maximum Retard	The cylinder timing for the corresponding sensor has been retarded to its most retarded timing.
(41-56)	Disabled Sensor	The DSM module has been programmed to not control the timing on the corresponding sensor. The cylinder is at default timing.

PROGRAMMING THE DSM SYSTEM

In this manual, programming is divided into three sections: Section 3.05, Section 3.10, and Section 3.15. Follow the programming steps in the section described below that meet your programming requirements:

- **Section 3.05 Editing An Existing DSM Data-Set**

The programming steps in this section should be completed when an existing data-set saved to ROM requires editing.

Engines shipped from the factory with the DSM system are initially setup at the factory. A data-set is created at the factory for testing the DSM system on the engine. If your DSM was installed and shipped from the factory, it will only be necessary to edit the data-set since the DSM system was tested on the engine at the factory.

NOTE: An *AutoCal* program, as explained in Section 4.05, must be run the first time the DSM is programmed for an engine (including engines shipped from the factory with the DSM system).

If your DSM was installed as a retrofit or was used on a different engine model, complete the steps in Section 3.10 to program the DSM for a new application.

NOTE: If the internally mounted LCD display inside the DSM module reads "99" (no data), the DSM module is sensing that a new EPROM chip is installed and no data-set exists. You will need to complete the programming steps in Section 3.10, Programming The DSM System For A New Application.

- **Section 3.10 Programming The DSM System For A New Application**

The programming steps and post-programming checks in this section must be completed in retrofit applications and whenever a DSM module is removed from one engine and installed on another engine model.

If the internally mounted LCD inside the DSM module reads "99" (no data), the DSM module is sensing that a new EPROM chip is installed and no data-set exists. You will need to complete the programming steps in Section 3.10.

- **Section 3.15 DSM System Computer Screen And Data Retrieval**

This section is to provide the steps needed to retrieve DSM computer screens to view engine performance. No programming or editing procedures are included in this section. This section explains the steps necessary to view data-sets and computer screens.

INFORMATION ON SAVING DATA-SETS TO RAM AND ROM MEMORY

The DSM system is designed to be used with many engine families of various configurations. Consequently, it must be tailored to work with site specific information. This is achieved by creating and installing a "data-set" that is appropriate for your specific site application.

Data-sets are developed on the PC with the DSM Interface Program. Once a data-set is created, the data-set can be saved to a computer disk, tested on the DSM system in RAM (temporary DSM memory), or used to configure DSM ROM (permanent DSM memory).

RAM is used to evaluate "test" data-sets before storing to ROM. The contents of RAM are lost whenever power to the DSM module is removed. Be sure to save values to ROM after a test data-set is evaluated and is found acceptable.

When saving to ROM (permanent memory), 25 data-sets can be saved before the EPROM chip must be replaced. Once a data-set is stored to ROM, the previous save to ROM is not accessible/retrievable. The DSM module can only access the most recently saved data-set. When the DSM module saves a data-set to ROM, the data-set information is not lost when power to the DSM module is removed.

NOTE: The term *EPROM* is used to describe the electrical chip that resides in the DSM module. The EPROM chip houses ROM memory.

DATA ACQUISITION MONITORING CAPABILITY

It is possible to acquire continuous streams of data about the DSM system using data acquisition software (software provided by customer). The DSM Terminal Program provides information on sensor status, diagnostic codes, and cylinder timing through the use of a PC. In addition to the information already provided by the DSM system, data serial streams are transmitted continuously from the DSM system that can be used to trend data for DSM and engine diagnostics information. The DSM serial streams are specified in Waukesha Engine specification sheet S-8484-1. Contact Waukesha Product Support for more information.

DSM INTERFACE PROGRAM OPERATION

DSM INTERFACE PROGRAM LAYOUT AND DESCRIPTION

Refer to Figure 3.00-3 for an illustrated menu layout of the DSM Interface Program.

1. COMMUNICATIONS MENU

Asks user to identify which communication port the DSM module is connected to on the PC by a DB-9 serial cable.

2. MAIN MENU

A. Edit/Create Setup

1) Retrieve from DSM

Retrieves program currently running in the DSM module to the View/Edit Control Values Screen. The memory location where the data is stored will be indicated on the PC screen (RAM or ROM# location).

2) Retrieve from Filename

Displays a list of DSM system data-sets previously saved to the same directory as the DSM Interface Program. Permits user to select a file to be retrieved into the View/Edit Control Values Screen.

3) Create New Data-Set

Allows user to create a data-set from "scratch." The data-set is blank allowing the user to create a new data-set.

NOTE: Whenever it is necessary to create a new data-set, it is recommended that the programming steps described in Section 3.10, Programming The DSM System For A New Application, be completed instead of using the "Create New Data-Set" option from the Edit/Create Setup Menu. Whenever it is necessary to edit an existing data-set, it is recommended that the programming steps described in Section 3.05, Editing An Existing Data-Set, be completed.

B. View/Edit Control Values Screen

After selecting "Retrieve from DSM," "Retrieve from Filename," or "Create New Data-Set" from the Edit/Create Setup Menu, the appropriate data-set will be displayed on the View/Edit Control Values Screen. This allows the user to view and edit the system parameters. Press [F10] to display the Save Menu.

NOTE: Editing values on the View/Edit Control Values Screen will not affect the performance of the DSM system. The edited data-set must be saved to RAM or ROM to change the DSM system operating parameters.

1) AutoCal [F5]

The AutoCal program is used to establish detonation threshold.

2) Save Menu [F10]

a) Save to Filename

Saves the data-set displayed on the View/Edit Control Values Screen to disk. The filename can be up to eight characters and is saved to the drive and directory where the DSM Interface Program is located.

b) Test Data on DSM

Allows user to save data-set to RAM (temporary memory within the DSM module). This enables the user to temporarily evaluate data-sets on the DSM module before saving them to ROM (permanent memory within the DSM module). The contents of RAM are lost when power is disconnected from the DSM module. Make sure to save your final data-set to ROM.

c) Configure DSM Memory

Allows user to save the data-set to ROM (permanent memory within the DSM). The previous data-set configured to ROM will be "replaced" with the new data-set. The contents of ROM are not lost when power is disconnected from the DSM module.

d) View Wiring Data

Displays the wiring data for the chosen engine application.

C. New Application Setup

This setup is used the first time the DSM system is programmed for an engine (typically retrofit installations). Using this setup procedure will overwrite any existing data-set.

a) Engine Model Information

Allows user to customize a DSM system for a specific application by indicating engine family, engine model, and fuel type(s). Creates "skeleton" data-set to aid in programming.

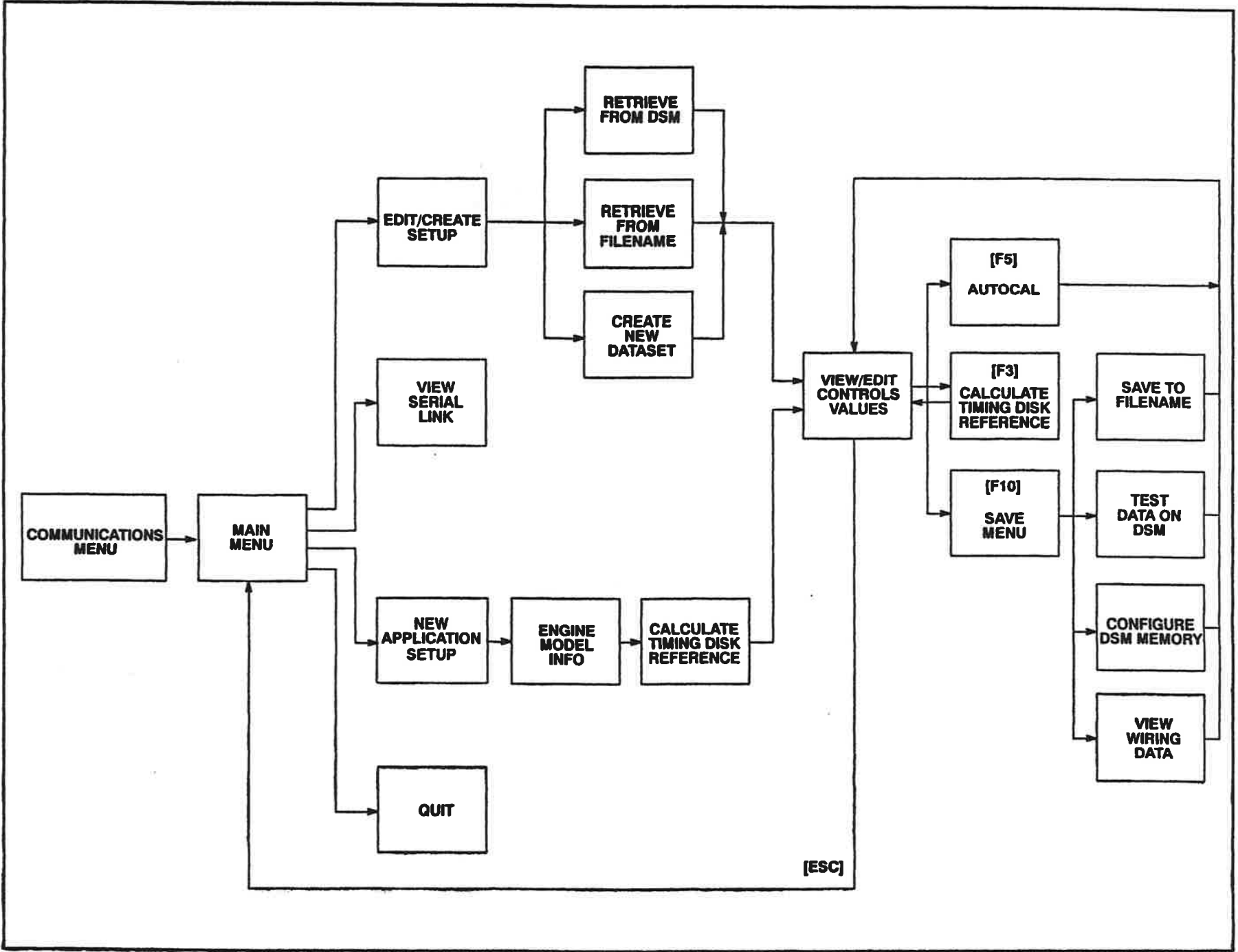
b) Calculate Timing Disk Reference

The position of the Ignition Module's timing disk is not the same on all engines. TDR is the angular relationship between the magnet for the first cylinder to fire and top dead center (example: 25° BTDC). This position has to be calculated for the DSM module to accurately control timing.

D. View Serial Link

Allows operator to monitor current system performance. Aids in troubleshooting.

Figure 3.00-3. DSM Interface Program Layout



DSM INTERFACE PROGRAM OPERATION

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SECTION 3.05

EDITING AN EXISTING DSM DATA-SET

EDITING INFORMATION

This section, Section 3.05 *Editing An Existing DSM Data-Set*, explains the steps required to edit an existing DSM data-set. The data-set that is edited following the procedures in this section is engine specific. Complete all the programming steps provided in this section.

NOTE: Engines shipped from the factory with the DSM system are initially setup at the factory. A data-set is created at the factory for testing the DSM system on the engine. Since a data-set already exists, complete the steps in this section.

NOTE: An AutoCal program, as explained in Section 4.05, must be run the first time the DSM is programmed for an engine (including engines shipped from the factory with the DSM system).

NOTE: If the internally mounted LCD inside the DSM module reads "99" (no data), the DSM module is sensing that a new EPROM chip is installed and no data-set exists. You will need to complete the programming steps in Section 3.10, Programming The DSM System For A New Application.

Section 3.10, *Programming The DSM System For A New Application*, explains the programming steps and post-programming checks to be completed in retrofit applications or whenever a DSM module is removed from one engine and installed on another engine model. By completing the programming steps in this section, any existing data-set is overwritten and an entirely new data-set is programmed.

Section 3.15, *DSM System Computer Screen And Data Retrieval*, explains the procedures necessary to access DSM system information from the DSM Interface Program using a PC. Section 3.15 does not include any programming procedures.

NOTE: This manual assumes you are already familiar with basic MS-DOS commands for viewing directories, copying files, and other MS-DOS concepts. If you need more information on these subjects, refer to a MS-DOS instruction manual.

PRE-PROGRAMMING INSTALLATION CHECKLIST

Complete the preprogramming installation checklist only if you are editing the data-set at initial engine and DSM system startup. If your engine is running with the DSM system and you are editing a saved data-set, it is not necessary to complete the preprogramming installation checklist.

Before applying power to the DSM system:

- A. Disconnect the DSM module from the Ignition Module by removing the "DSM to Ignition" harness from the 14 pin connector on the side of the Ignition Module (see Figure 3.05-1).

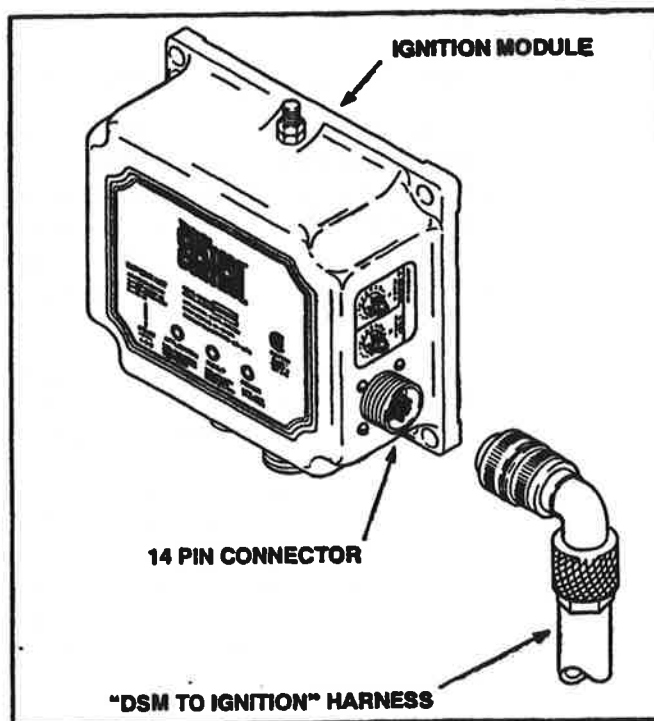


Figure 3.05-1. Disconnecting The "DSM To Ignition" Harness

EDITING AN EXISTING DSM DATA-SET

- B. Visually inspect the installation to be sure that all wiring conforms to the requirements of this manual, local codes, and regulatory bodies. Verify that each connection to the DSM module is routed through the correct conduit (see Figure 3.05-2).

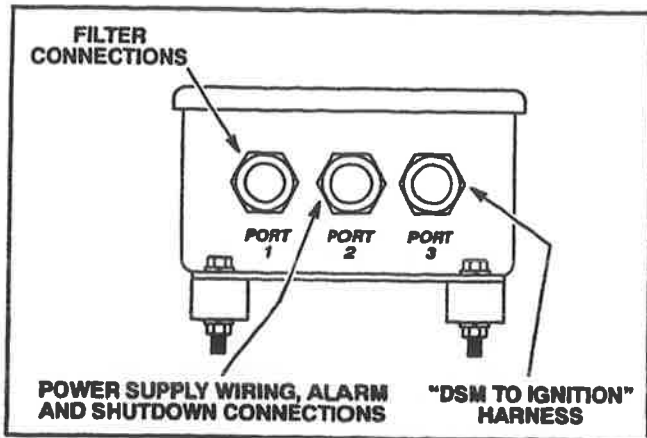


Figure 3.05-2. DSM Module Conduit Ports

- C. Verify that the power supply is within specification. Refer to Section 2.10, *DSM System Power, Alarm, And Ground Connections*, for power specifications to the DSM module. Make this measurement with an oscilloscope at the supply wires to the DSM module with the engine running.

EDITING THE DSM DATA-SET

ESTABLISHING COMMUNICATION WITH THE DSM

1. If you are editing the data-set at initial engine and DSM system startup, verify that the DSM module is disconnected from the Ignition Module before applying power. If the DSM module is not disconnected from the Ignition Module, disconnect the "DSM to ignition" harness from the 14 pin DSM connector on the side of the Ignition Module (see Figure 3.05-1).

NOTE: It is not necessary to disconnect the DSM from the Ignition Module in Step 1 when editing a data-set for an engine that has been running with the DSM system.

2. If no power is applied to the DSM module, apply power. The "Power," "Alarm," and "Shutdown" LEDs on the front cover will light for approximately five seconds. The green power LED will remain on when the alarm and shutdown LEDs go off. The internally mounted LCD display will read "90" (system OK - ready and waiting for engine to start).

NOTE: If the internally mounted LCD reads "99" (no data) instead of "90," the DSM module is sensing that a new EPROM chip is installed in the DSM module. Complete the programming steps in Section 3.10, *Programming The DSM System For A New Application*.

NOTE: If any of the alarm or shutdown LEDs come on any time during DSM system operation, see Section 4.00, *DSM System Diagnostics And Troubleshooting*.

3. The DSM module must be programmed to work with site specific information in order for the DSM system to function properly. To program the DSM module, connect a standard DB-9 serial cable (male to female) to the communications port (labeled P1A) within the DSM module. This is the communications port on the right (see Figure 3.05-3). Connect the other end of the cable to the PC's communications port. Typically, this is port 1 (also referred to as COM 1, serial A, or serial 1).

CAUTION Verify that the DB-9 serial cable is securely connected to the appropriate computer port. If the serial cable is disturbed or disconnected during the saving process, the EPROM chip in the DSM module will become corrupted and will need to be replaced.

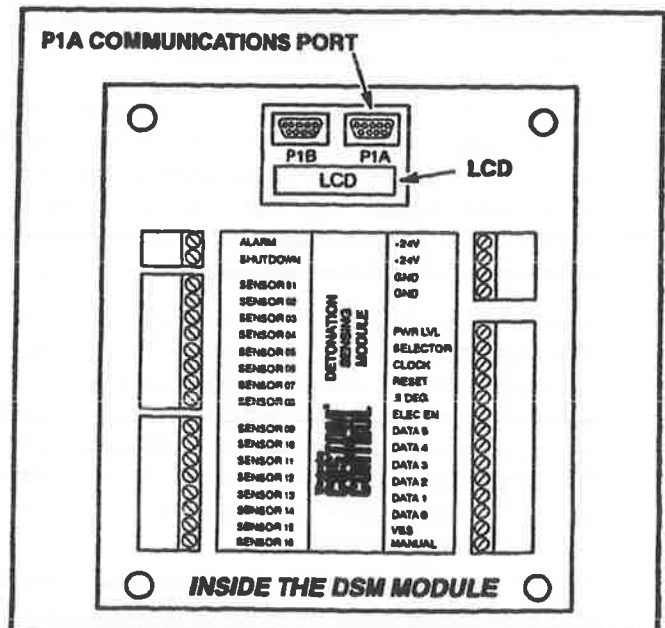


Figure 3.05-3. DB-9 Serial Cable Connection Inside DSM Module

4. Start the DSM Interface Program on your PC.

NOTE: For information on installing and/or accessing the DSM Interface Program, refer to the page at the back of this manual which holds the 3-1/2" diskette for installation and accessing instructions.

5. The "Genuine Waukesha Parts" logo screen appears briefly, followed by the screen shown in Figure 3.05-4. The bottom line of this screen indicates what version of the DSM Interface Program you are using.

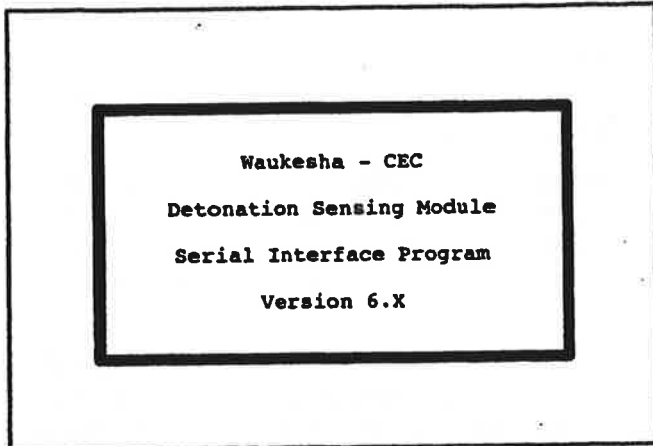


Figure 3.05-4. Software Version Identification

6. Automatically the Communications Menu appears (see Figure 3.05-5). A black dot is located in a circle next to "1" which indicates that the selected communications port on your computer is port 1. Press [Enter] to select communications port 1. If the DB-9 cable is connected to a different port on your PC, use the arrow keys on the keyboard to select the corresponding port from the Communications Menu and press [Enter] (typically: port 1 is correct).

7. The DSM Interface Program's Main Menu appears showing various program options available (see Figure 3.05-6). Highlight "Edit/Create Setup" and press [Enter]. This option allows you to view and edit the DSM system data-set that is already programmed.

8. The menu shown in Figure 3.05-7 appears. Highlight "Retrieve from DSM" from this menu and press [Enter].

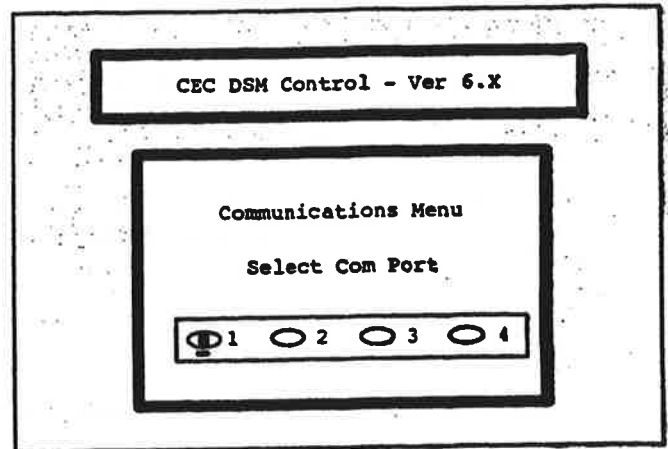


Figure 3.05-5. Communications Menu

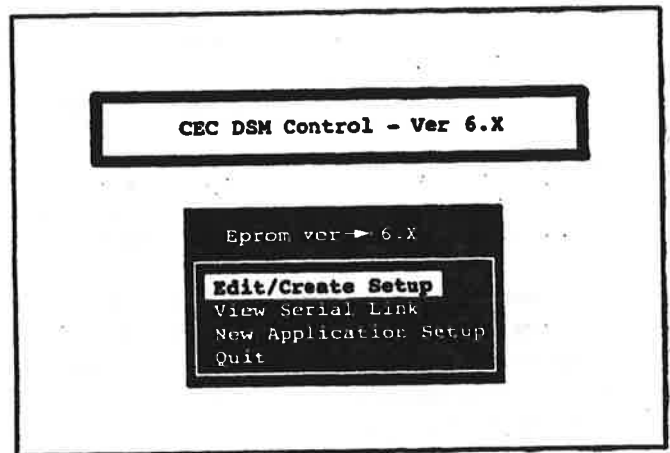


Figure 3.05-6. DSM Interface Program Main Menu

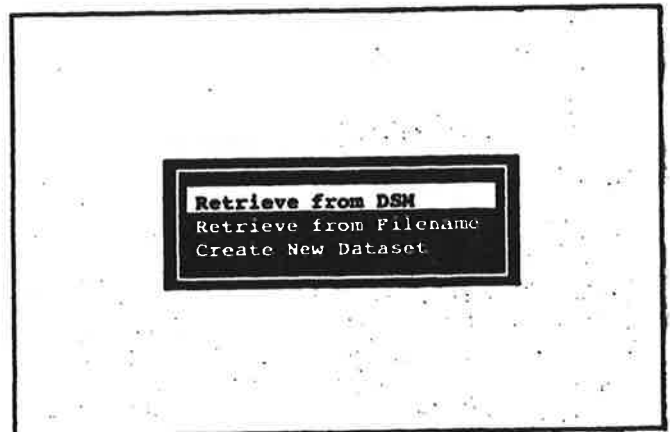


Figure 3.05-7. Edit/Create Setup Menu

EDITING AN EXISTING DSM DATA-SET

9. Several screens will appear indicating that the data is being retrieved from the DSM module. The screen shown in Figure 3.05-8 indicates what data source is being retrieved. For example, Figure 3.05-8 indicates that the data source is ROM 11.

NOTE: You can save 25 times to ROM memory (permanent memory) before replacing the EPROM chip in the DSM module.

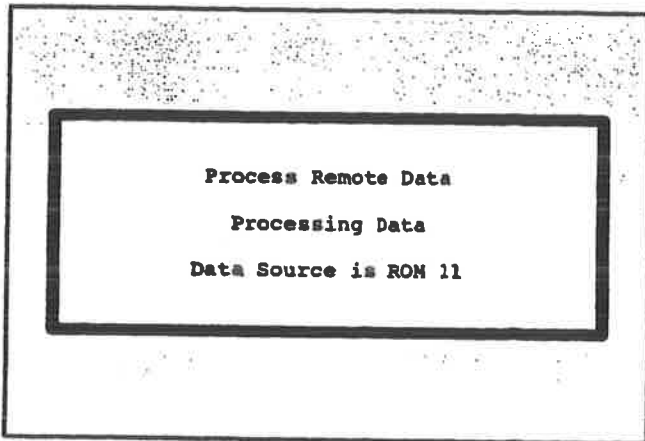


Figure 3.05-8. Processing Data Verification Screen

10. Then the View/Edit Control Data Values Screen appears (see Figure 3.05-9). This screen shows the engine data-set parameters. The information shown on the screen is stored on the DSM EPROM chip (ROM or permanent memory).

You can change data-set information on the View/Edit Control Data Values Screen by entering data as desired. To change data-set information, continue with "Editing The DSM Data-Set."

NOTE: For the purposes of this manual, the DSM module will be programmed for a 12 cylinder VHP L7042 engine. The programming steps taken in this manual are the same for whatever engine family you choose (exceptions are noted).

EDITING THE DSM DATA-SET

A data-set is a group of site specific data points that are created and then stored within the DSM module. The DSM data-set includes values for: Most Advanced Timing, Most Retarded Timing, End of Sample Window angle, retard and advanced timing values, warm-up delay time, and shutdown delay time (see Figure 3.05-9). Complete the steps that follow to edit the data-set for the engine you are programming.

NOTE: Editing values on the View/Edit Control Data Values Screen will not affect the performance of the DSM system. The edited data-set must be saved to RAM or ROM to change the DSM system's operating parameters.

NOTE: If the values in the Detonation Level Select table in the View/Edit Control Data Values Screen are above 2400 mV, the knock sensors are disabled and may indicate the knock sensors are not calibrated. Run the AutoCal program to calibrate the knock sensors. Complete the steps in Section 4.05, Running The DSM AutoCal Program, to calibrate the sensors.

You can change data points on the View/Edit Control Data Values Screen by moving the cursor with the arrow keys and entering data as desired.

View/Edit Control Data Values

Engine Family : VHP GAS ENGINE		
Engine Model : L7042 V-12		
# of Cylinders : 12		
Primary Fuel : NATURAL GAS PIPELINE QUALITY		
Secondary Fuel: DIGESTER GAS		
Comments:		
Timing Disk Reference	26 °BTDC	
	<F3> To Calculate TDR	
D-Lead Position - - ->	Grounded	Open
Most Advanced Timing	10 °BTDC	10 °BTDC
Most Retarded Timing	4 °BTDC	4 °BTDC
Default Timing	8 °BTDC	8 °BTDC
End of Sample Window	30 °ATDC	
Retard 1°	Every 1 Knock Sample(s)	
Advance 1°	Every 5 No-Knock Sample(s)	
Warm-Up Delay Time	300 Seconds	
Shutdown Delay Time	15 Seconds	

Detonation Level Select

Sensor 1	656 mV
Sensor 2	882 mV
Sensor 3	705 mV
Sensor 4	617 mV
Sensor 5	705 mV
Sensor 6	705 mV
Sensor 7	833 mV
Sensor 8	793 mV
Sensor 9	656 mV
Sensor 10	882 mV
Sensor 11	617 mV
Sensor 12	744 mV

NOTE: Entries above 2400mV result in a Disabled Sensor.

<F10> to Save
<ESC> to Main Menu
<F5> to AUTOCAL

Figure 3.05-9. View/Edit Control Data Values Screen

EDITING AN EXISTING DSM DATA-SET

1. If disconnected, reconnect the DSM module ("DSM to Ignition" harness) to the Ignition Module. After reconnecting the DSM module to the Ignition Module, ignition timing is being controlled by the DSM system so the data-set for the engine can be completed.

NOTE: It is not necessary to verify Timing Disk Reference (TDR) in Step 2 when editing a data-set for an engine that has been running with the DSM system. If you are editing the data-set at initial engine and DSM system startup, perform the TDR verification in Step 2.

2. Using a timing light, verify that the correct Timing Disk Reference (TDR) value is programmed. The TDR value is shown on the View/Edit Control Data Values Screen. Complete the following:

- A. Press [Esc] to return to the Main Menu. Highlight "View Serial Link" and press [Enter] (see Figure 3.05-10).

NOTE: If changes were made to the data-set and were not saved before pressing [Esc], the DSM program will give you an option to save BEFORE returning to the Main Menu. Save changes if desired.

- B. If engine timing does match the Timing ("BTDC) shown on the Display Serial Port Screen, continue with Step 3. If the engine timing does not match, the TDR value needs to be adjusted.
- C. If engine timing is lower than the timing shown, then decrease the TDR value by that amount. For example, if timing is set at 11° but the engine is running at 10°, then decrease the TDR value by 1°.

D. If engine timing is higher than the timing shown, then increase the TDR value by that amount. For example, if timing is set at 11° but the engine is running at 12°, then increase the TDR value by 1°.

E. Press [Esc] to return to the Main Menu. Highlight "Retrieve from DSM" and press [Enter] to return to the View/Edit Control Data Values Screen.

F. Use the arrow keys to position the cursor in the "Timing Disk Reference" field on the View/Edit Control Data Values Screen.

G. Enter the adjusted TDR value and press [Enter].

H. Press [F10] to test the new TDR value. Highlight "Test Data on DSM" on the next menu and press [Enter]. The new information is now saved to RAM (temporary memory). Press any key to continue.

NOTE: The "Test Data on DSM" option from the Save Options Menu allows a program to be run in the DSM module's temporary memory (RAM). The contents of RAM are lost whenever power to the DSM module is removed.

- I. Using a timing light, verify that the engine timing is running at the timing shown on the Display Serial Port Screen. If engine timing does match continue with Step 3. If the engine timing does not match, repeat Steps A - H. If repeating these steps does not correct engine timing, contact Waukesha Product Support.

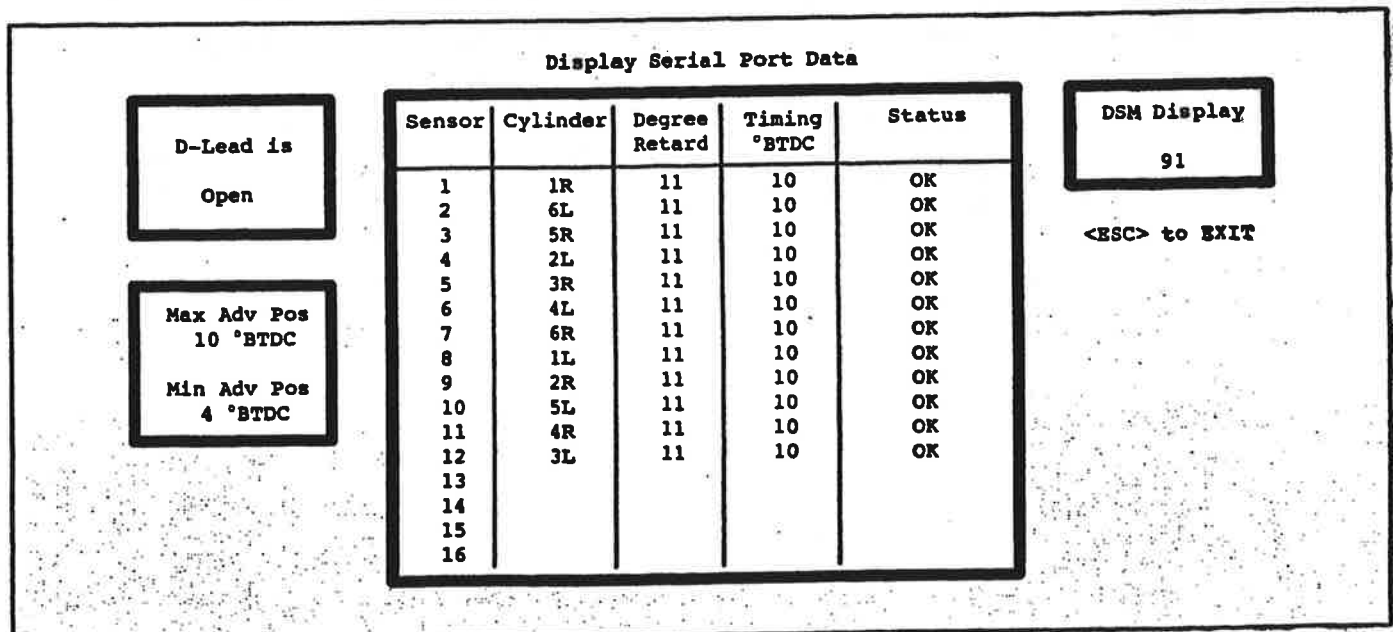


Figure 3.05-10. Display Serial Port Data Screen

EDITING AN EXISTING DSM DATA-SET

View/Edit Control Data Values

Engine Family : VHP GAS ENGINE Engine Model : L7042 V-12 # of Cylinders: 12 Primary Fuel : NATURAL GAS PIPELINE QUALITY Secondary Fuel: DIGESTER GAS Comments:		
Timing Disk Reference	26 °BTDC	
<F3> To Calculate TDR		
D-Lead Position - - ->	Grounded	Open
Most Advanced Timing	10 °BTDC	10 °BTDC
Most Retarded Timing	4 °BTDC	4 °BTDC
Default Timing	8 °BTDC	8 °BTDC
End of Sample Window	30 °ATDC	
Retard 1°	Every 1 Knock Sample(s)	
Advance 1°	Every 5 No-Knock Sample(s)	
Warm-Up Delay Time	300 Seconds	
Shutdown Delay Time	15 Seconds	

<F10> to Save
<ESC> to Main Menu
<F5> to AUTOCAL

Detonation Level Select	
Sensor 1	656 mV
Sensor 2	882 mV
Sensor 3	705 mV
Sensor 4	617 mV
Sensor 5	705 mV
Sensor 6	705 mV
Sensor 7	833 mV
Sensor 8	793 mV
Sensor 9	656 mV
Sensor 10	882 mV
Sensor 11	617 mV
Sensor 12	744 mV

NOTE: Entries above 2400mV result in a Disabled Sensor.

Figure 3.05-11. View/Edit Control Data Values Screen

3. The DSM parameters include: default timing values, retard and advance timing values and rates of change, and delay times. To edit any of the values in the data-set, position the cursor in the field for the parameter you want to edit. Then enter the new value.

Refer to Figure 3.05-11 and the correct table while editing the data-set. The values provided in the tables are the recommended data-set parameters for the DSM system. Modifications may be made based on site conditions.

- Table 3.05-1 on page 7 provides the data-set parameters for 8L-AT27GL engines.
- Table 3.05-2 on page 8 provides the data-set parameters for 12V-AT27GL engines.
- Table 3.05-3 on page 8 provides the data-set parameters for 12V-AT25GL engines.
- Table 3.05-4 on page 8 provides the data-set parameters for VHP engines.
- Table 3.05-5 on page 8 provides the data-set parameters for VGF engines.

Listed are definitions of each of the data-set parameters found on the View/Edit Control Data Values Screen.

Comments: Type in any comments regarding DSM programming or revise existing comments. Typically, comments include site, engine number, and date information.

Most Advanced Timing: The maximum advanced timing at which the system will allow the engine to operate. Enter the most advanced timing for the Ignition Module's "D" lead grounded and the most advanced timing for the "D" lead open.

NOTE: "Most Advanced Timing" may not be greater than nameplate timing.

Most Retarded Timing: The minimum timing at which the DSM system will allow a cylinder to retard in order to control detonation. Enter the most retarded timing for the Ignition Module's "D" lead grounded and the most retarded timing for the "D" lead open.

Default Timing: Default timing is the retarded ignition timing imposed by the DSM system when it is not protecting against detonation. The DSM system activates default timing for a cylinder when the cylinder's sensor is disabled, when the sensor fails, and during engine warm-up delay.

End of Sample Window: The end of sample window is a predetermined angle after top dead center (ATDC) in crankshaft degrees at which the DSM system stops looking for detonation.

Retard X° Every Y Knock Sample(s): Allows you to select how fast the timing retards by changing the "X" and "Y" values. When an individual cylinder is in detonation, the timing retards "X" degrees for every "Y" consecutive times detonation is found.

Advance X° Every Y No-Knock Sample(s): Allows you to select how fast the timing advances by changing the "X" and "Y" values. Once an individual cylinder is no longer in detonation, the timing advances "X" degrees for every "Y" consecutive times the cylinder is not found to be detonating.

Warm-Up Delay Time: Allows you to select the amount of delay between the time the engine begins rotating and when the DSM system takes control. While this delay is active, the cylinders are operating at the default timing. The purpose of this delay is to prevent misleading vibration signals, that may exist during the time the engine is warming up, from being incorrectly construed as "knock" signals. During the Warm-Up Delay Time, the DSM system is not protecting against detonation.

Shutdown Delay Time: Allows you to select the amount of delay between the moment when the cylinder reaches the Most Retarded Timing during detonation and the time the shutdown warning becomes active while still in detonation.

NOTE: Make sure to program the Shutdown Delay Time long enough to avoid unnecessary shutdowns. For example: If engine timing reaches the Maximum Retard limit AND the Shutdown Delay Time is shorter than the Advance Rate, shutdown may occur before the engine is allowed to advance at the programmed Advance Rate.

4. If you are editing the data-set at Initial engine and DSM system startup (engines shipped from the factory with the DSM system), complete an AutoCal program. The AutoCal program is the automatic calibration of the detonation threshold levels by the DSM Interface Program. Complete the programming steps in Section 4.05, *Running The DSM AutoCal Program*, to run the AutoCal program.

NOTE: If the values in the Detonation Level Select table in the View/Edit Control Data Values Screen are above 2400 mV, the knock sensors are disabled and may indicate the knock sensors are not calibrated. Run the AutoCal program to calibrate the knock sensors. Complete the steps in Section 4.05, *Running The DSM AutoCal Program*, to calibrate the knock sensors. An AutoCal should be run the first time the DSM is programmed for an engine or whenever a DSM is programmed for a new application. Additionally, the DSM system must be re-AutoCaled using the DSM Interface Program and a PC after doing any removal, repair, or replacement of engine cylinder heads, cylinder liners, cylinder gaskets, pistons, or knock sensors. This calibration **MUST BE** done using the AutoCal program.

5. Continue with the next section, "Saving Data-Set To ROM," to permanently save the edited data-set. Make sure to complete the next section. Data-sets NOT saved to ROM are lost when power is disconnected from the DSM module.

Table 3.05-1. 8L-AT27GL DSM Data-Set Parameters¹

FUEL	AIR/FUEL RATIO (% EXHAUST O ₂)	DEFAULT TIMING VALUES (°BTDC)	MAX. ADVANCE ² (°BTDC)	MAX. RETARD (°BTDC)	END OF SAMPLE WINDOW	"D" LEAD
Natural Gas	28:1 (9.8)	6°	8°	2°	30°	OPEN
	32:1 (11.4)	18°	20°	8°	30°	GROUNDING
Field Gas (115 Octane)	32:1 (11.4)	8°	10°	4°	30°	OPEN
Digester Gas	30:1 (10.5)	18°	20°	12°	30°	GROUNDING
Landfill Gas	30:1 (10.5)	18°	22°	14°	30°	GROUNDING
FUEL QUALITY:		64 WKI™ AND BELOW		64 WKI™ +		
Retard Rate		4° Every 1 Knock Sample(s)		1° Every 1 Knock Sample(s)		
Advance Rate		1° Every 5 No-Knock Sample(s)		1° Every 5 No-Knock Sample(s)		
Warm-Up Delay Time		300 Second(s)		300 Second(s)		
Shutdown Delay Time		5 Second(s)		15 Second(s)		

NOTE: ¹ The timing values listed apply to engines with the six hole prechamber cups.
² "Max. Advance" should never exceed nameplate timing.

EDITING AN EXISTING DSM DATA-SET

Table 3.05-2. 12V-AT27GL DSM Data-Set Parameters¹

FUEL	AIR/FUEL RATIO (% EXHAUST O ₂)	DEFAULT TIMING VALUES (°BTDC)	MAX. ADVANCE ² (°BTDC)	MAX. RETARD (°BTDC)	END OF SAMPLE WINDOW	"D" LEAD
Natural Gas	28:1 (9.8)	6°	8°	2°	30°	OPEN
	32:1 (11.4)	16°	18°	8°	30°	GROUNDED
Field Gas (115 Octane)	32:1 (11.4)	8°	10°	4°	30°	OPEN
Digester Gas	30:1 (10.5)	16°	18°	10°	30°	GROUNDED
Landfill Gas	30:1 (10.5)	16°	20°	12°	30°	GROUNDED
FUEL QUALITY:		64 WKI™ AND BELOW		64 WKI™ +		
Retard Rate		4° Every 1 Knock Sample(s)		1° Every 1 Knock Sample(s)		
Advance Rate		1° Every 5 No-Knock Sample(s)		1° Every 5 No-Knock Sample(s)		
Warm-Up Delay Time		300 Second(s)		300 Second(s)		
Shutdown Delay Time		5 Second(s)		15 Second(s)		

NOTE: ¹ The timing values listed apply to engines with the six hole prechamber cups.
² "Max. Advance" should never exceed nameplate timing.

Table 3.05-3. 12V-AT25GL DSM Data-Set Parameters

FUEL	AIR/FUEL RATIO (% EXHAUST O ₂)	DEFAULT TIMING VALUES (°BTDC)	MAX. ADVANCE ¹ (°BTDC)	MAX. RETARD (°BTDC)	END OF SAMPLE WINDOW	"D" LEAD
Natural Gas	28:1 (9.8)	8°	10°	4°	30°	OPEN
Digester Gas	26:1 (8.8)	12°	14°	8°	30°	OPEN
Landfill Gas	26:1 (8.8)	15°	17°	11°	30°	GROUNDED
FUEL QUALITY:		64 WKI™ AND BELOW		64 WKI™ +		
Retard Rate		3° Every 1 Knock Sample(s)		1° Every 1 Knock Sample(s)		
Advance Rate		1° Every 5 No-Knock Sample(s)		1° Every 5 No-Knock Sample(s)		
Warm-Up Delay Time		300 Second(s)		300 Second(s)		
Shutdown Delay Time		5 Second(s)		15 Second(s)		

NOTE: ¹ "Max. Advance" should never exceed nameplate timing.

Table 3.05-4. VHP DSM Data-Set Parameters

Most Advanced Timing	Nameplate Timing
Most Retarded Timing	Nameplate Timing - 6°
Default Timing	Nameplate Timing - 2°
End of Sample Window	30°
Retard X° Every Y Knock Sample(s)	Retard 1° Every 1 Sample Propane Only = Retard 3° Every 1 Sample
Advance X° Every Y No-Knock Sample(s)	1° Every 5 Samples
Warm-Up Delay Time	300 Seconds
Shutdown Delay Time	15 Seconds

Table 3.05-5. VGF DSM Data-Set Parameters

Most Advanced Timing	Nameplate Timing
Most Retarded Timing	Nameplate Timing - 6°
Default Timing	Nameplate Timing - 2°
End of Sample Window	30°
Retard X° Every Y Knock Sample(s)	Retard 2° Every 1 Sample Propane Only = Retard 3° Every 1 Sample
Advance X° Every Y No-Knock Sample(s)	1° Every 5 Samples
Warm-Up Delay Time	300 Seconds
Shutdown Delay Time	15 Seconds

SAVING DATA-SET TO ROM

1. Save the edited data-set to ROM (permanent memory) on the EPROM chip in the DSM module. Press [F10] for the Saving Options Menu.
2. Highlight "Configure DSM Memory" on the menu and press [Enter] (see Figure 3.05-12).

NOTE: The "Test Data on DSM" option from the Save Options Menu allows a program to be run in the DSM module's temporary memory (RAM). This may be used for troubleshooting so that the ROM memory space is

preserved. The contents of RAM are lost whenever power to the DSM module is removed.

3. When the Verification Screen appears as shown in Figure 3.05-13, press [Y].

CAUTION Do not disturb the serial cable or interrupt computer power while programming. If the serial cable is disturbed or disconnected during the saving process, the EPROM chip in the DSM module will become corrupted and will need to be replaced.

View/Edit Control Data Values

<p>Engine Family : VHP GAS ENGINE Engine Model : L7042 V-12 # of Cylinders: 12 Primary Fuel : NATURAL Secondary Fuel: DIGESTED Comments:</p> <p>Timing Disk Reference <F3> To Calculate For</p> <table style="width: 100%; border: none;"> <tr> <td style="width: 30%;">D-Lead Position - - -></td> <td style="width: 30%;">Grounded</td> <td style="width: 30%;">Open</td> </tr> <tr> <td>Most Advanced Timing</td> <td>10 °BTDC</td> <td>10 °BTDC</td> </tr> <tr> <td>Most Retarded Timing</td> <td>4 °BTDC</td> <td>4 °BTDC</td> </tr> <tr> <td>Default Timing</td> <td>8 °BTDC</td> <td>8 °BTDC</td> </tr> <tr> <td>End of Sample Window</td> <td>30 °ATDC</td> <td></td> </tr> </table> <p>Retard 1° Every 1 Knock Sample(s) Advance 1° Every 5 No-Knock Sample(s)</p> <p>Warm-Up Delay Time 300 Seconds Shutdown Delay Time 15 Seconds</p>	D-Lead Position - - ->	Grounded	Open	Most Advanced Timing	10 °BTDC	10 °BTDC	Most Retarded Timing	4 °BTDC	4 °BTDC	Default Timing	8 °BTDC	8 °BTDC	End of Sample Window	30 °ATDC		<p style="text-align: center;">Detonation Level Select</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>Sensor 1</td><td>656 mV</td></tr> <tr><td>Sensor 2</td><td>882 mV</td></tr> <tr><td>Sensor 3</td><td>705 mV</td></tr> <tr><td>Sensor 4</td><td>617 mV</td></tr> <tr><td>Sensor 5</td><td>705 mV</td></tr> <tr><td>Sensor 6</td><td>705 mV</td></tr> <tr><td>Sensor 7</td><td>833 mV</td></tr> <tr><td>Sensor 8</td><td>793 mV</td></tr> <tr><td>Sensor 9</td><td>656 mV</td></tr> <tr><td>Sensor 10</td><td>882 mV</td></tr> <tr><td>Sensor 11</td><td>617 mV</td></tr> <tr><td>Sensor 12</td><td>744 mV</td></tr> </table> <p style="font-size: small;">NOTE: Entries above 2400mV result in a Disabled Sensor.</p> <p style="text-align: center;"><F5> to AUTOCAL</p>	Sensor 1	656 mV	Sensor 2	882 mV	Sensor 3	705 mV	Sensor 4	617 mV	Sensor 5	705 mV	Sensor 6	705 mV	Sensor 7	833 mV	Sensor 8	793 mV	Sensor 9	656 mV	Sensor 10	882 mV	Sensor 11	617 mV	Sensor 12	744 mV
D-Lead Position - - ->	Grounded	Open																																						
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Sensor 10	882 mV																																							
Sensor 11	617 mV																																							
Sensor 12	744 mV																																							

Save Data to Filename
 Test Data on DSM
Configure DSM Memory
 View Wiring Data

<F10> to Save
<ESC> to Main Menu

Figure 3.05-12. Saving Options Menu

View/Edit Control Data Values

<p>Engine Family : VHP GAS ENGINE Engine Model : L7042 V-12 # of Cylinders: 12 Primary Fuel : NATURAL GAS PIPELINE QUALITY Secondary Fuel: Comments:</p> <p>Timing Disk Reference <F3></p> <p>D-Lead Position Most Advanced Timing Most Retarded Timing Default Timing End of Sample Window</p> <p>Retard 1° Every Advance 1° Every</p> <p>Warm-Up Delay Time 300 Seconds Shutdown Delay Time 15 Seconds</p>	<p style="text-align: center;">Detonation Level Select</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>Sensor 1</td><td>656 mV</td></tr> <tr><td>Sensor 2</td><td>882 mV</td></tr> <tr><td>Sensor 3</td><td>705 mV</td></tr> <tr><td>Sensor 4</td><td>617 mV</td></tr> <tr><td>Sensor 5</td><td>705 mV</td></tr> <tr><td>Sensor 6</td><td>705 mV</td></tr> <tr><td>Sensor 7</td><td>833 mV</td></tr> <tr><td>Sensor 8</td><td>793 mV</td></tr> <tr><td>Sensor 9</td><td>656 mV</td></tr> <tr><td>Sensor 10</td><td>882 mV</td></tr> <tr><td>Sensor 11</td><td>617 mV</td></tr> <tr><td>Sensor 12</td><td>744 mV</td></tr> </table> <p style="font-size: small;">NOTE: Entries above 2400mV result in a Disabled Sensor.</p> <p style="text-align: center;"><F5> to AUTOCAL</p>	Sensor 1	656 mV	Sensor 2	882 mV	Sensor 3	705 mV	Sensor 4	617 mV	Sensor 5	705 mV	Sensor 6	705 mV	Sensor 7	833 mV	Sensor 8	793 mV	Sensor 9	656 mV	Sensor 10	882 mV	Sensor 11	617 mV	Sensor 12	744 mV
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Sensor 6	705 mV																								
Sensor 7	833 mV																								
Sensor 8	793 mV																								
Sensor 9	656 mV																								
Sensor 10	882 mV																								
Sensor 11	617 mV																								
Sensor 12	744 mV																								

OK to Store New Values?

Yes

No esc

<F10> to Save
<ESC> to Main Menu

Figure 3.05-13. Verification Screen

EDITING AN EXISTING DSM DATA-SET

4. Several screens will appear indicating that the data-set is being saved to ROM, permanent memory on the EPROM chip inside the DSM module. Once the data-set has been saved to ROM, the message shown in Figure 3.05-14 appears.

NOTE: The DSM allows 25 saves to ROM. Once ROM has been fully configured, the EPROM chip in the DSM module must be replaced to permit further saves to permanent memory.

5. Press any key to continue and the View/Edit Control Data Values Screen appears (see Figure 3.05-15).

NOTE: Make copies of your data-set for future reference. If a printer is connected to your PC, press [Print Screen] on the keyboard.

View/Edit Control Data Values

<p>Engine Family : VHP GAS ENGINE Engine Model : L7042 V-12 # of Cylinders : 12 Primary Fuel : Secondary Fuel : Comments:</p> <p>Timing Disk Reference 26 °BTDC <F3> To Calculate TDR</p> <p>D-Lead Position - - -> Grounded Open Most Advanced Timing 10 °BTDC 10 °BTDC Most Retarded Timing 4 °BTDC 4 °BTDC Default Timing 8 °BTDC 8 °BTDC End of Sample Window 30 °ATDC</p> <p>Retard 1° Every 1 Knock Sample(s) Advance 1° Every 5 No-Knock Sample(s)</p> <p>Warm-Up Delay Time 300 Seconds Shutdown Delay Time 15 Seconds</p>	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="2" style="text-align: center;">Detonation Level Select</th> </tr> </thead> <tbody> <tr><td>r 1</td><td>656 mV</td></tr> <tr><td>r 2</td><td>882 mV</td></tr> <tr><td>r 3</td><td>705 mV</td></tr> <tr><td>r 4</td><td>617 mV</td></tr> <tr><td>r 5</td><td>705 mV</td></tr> <tr><td>r 6</td><td>705 mV</td></tr> <tr><td>r 7</td><td>833 mV</td></tr> <tr><td>r 8</td><td>793 mV</td></tr> <tr><td>r 9</td><td>656 mV</td></tr> <tr><td>r 10</td><td>882 mV</td></tr> <tr><td>r 11</td><td>617 mV</td></tr> <tr><td>r 12</td><td>744 mV</td></tr> </tbody> </table> <p style="font-size: small;">NOTE: Entries above 2400mV result in a Disabled Sensor.</p>	Detonation Level Select		r 1	656 mV	r 2	882 mV	r 3	705 mV	r 4	617 mV	r 5	705 mV	r 6	705 mV	r 7	833 mV	r 8	793 mV	r 9	656 mV	r 10	882 mV	r 11	617 mV	r 12	744 mV
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r 7	833 mV																										
r 8	793 mV																										
r 9	656 mV																										
r 10	882 mV																										
r 11	617 mV																										
r 12	744 mV																										

Starting ROM12 Program

DSM Memory has been Configured.

Program Is Running.

Press ANY KEY to Continue

<F10> to Save
<ESC> to Main Menu
<F5> to AUTOCAL

Figure 3.05-14. Verification Screen Of Save To ROM

View/Edit Control Data Values

<p>Engine Family : VHP GAS ENGINE Engine Model : L7042 V-12 # of Cylinders : 12 Primary Fuel : NATURAL GAS PIPELINE QUALITY Secondary Fuel : DIGESTER GAS Comments:</p> <p>Timing Disk Reference 26 °BTDC <F3> To Calculate TDR</p> <p>D-Lead Position - - -> Grounded Open Most Advanced Timing 10 °BTDC 10 °BTDC Most Retarded Timing 4 °BTDC 4 °BTDC Default Timing 8 °BTDC 8 °BTDC End of Sample Window 30 °ATDC</p> <p>Retard 1° Every 1 Knock Sample(s) Advance 1° Every 5 No-Knock Sample(s)</p> <p>Warm-Up Delay Time 300 Seconds Shutdown Delay Time 15 Seconds</p>	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="2" style="text-align: center;">Detonation Level Select</th> </tr> </thead> <tbody> <tr><td>Sensor 1</td><td>656 mV</td></tr> <tr><td>Sensor 2</td><td>882 mV</td></tr> <tr><td>Sensor 3</td><td>705 mV</td></tr> <tr><td>Sensor 4</td><td>617 mV</td></tr> <tr><td>Sensor 5</td><td>705 mV</td></tr> <tr><td>Sensor 6</td><td>705 mV</td></tr> <tr><td>Sensor 7</td><td>833 mV</td></tr> <tr><td>Sensor 8</td><td>793 mV</td></tr> <tr><td>Sensor 9</td><td>656 mV</td></tr> <tr><td>Sensor 10</td><td>882 mV</td></tr> <tr><td>Sensor 11</td><td>617 mV</td></tr> <tr><td>Sensor 12</td><td>744 mV</td></tr> </tbody> </table> <p style="font-size: small;">NOTE: Entries above 2400mV result in a Disabled Sensor.</p>	Detonation Level Select		Sensor 1	656 mV	Sensor 2	882 mV	Sensor 3	705 mV	Sensor 4	617 mV	Sensor 5	705 mV	Sensor 6	705 mV	Sensor 7	833 mV	Sensor 8	793 mV	Sensor 9	656 mV	Sensor 10	882 mV	Sensor 11	617 mV	Sensor 12	744 mV
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Sensor 9	656 mV																										
Sensor 10	882 mV																										
Sensor 11	617 mV																										
Sensor 12	744 mV																										

<F10> to Save
<ESC> to Main Menu
<F5> to AUTOCAL

Figure 3.05-15. View/Edit Control Data Values Screen

SAVING DATA-SET TO DISK

Data-sets are assigned filenames and saved on disk so the user can retain the data-set for future reference. Each time a new program is saved to ROM, the previous program can no longer be retrieved. The only way to keep track of old data-sets is to save to disk.

NOTE: When saving to disk, the data-set will be saved to the drive and directory where the DSM Interface Program is located.

1. Save a data-set to disk by pressing [F10] (see Figure 3.05-16).
2. Highlight "Save Data to Filename" from the menu and press [Enter].
3. Enter a filename according to the following procedure (see Figure 3.05-17). Read all three steps prior to saving the file to the disk.
 - A. Locate the engine's serial number on the nameplate.

View/Edit Control Data Values

Engine Family : VHP GAS ENGINE Engine Model : L7042 V-12 # of Cylinders: 12 Primary Fuel : NATURAL Secondary Fuel: DIGESTED Comments: <hr/> Timing Disk Reference <F3> To Calculate ROM D-Lead Position - - -> Grounded Open Most Advanced Timing 10 °BTDC 10 °BTDC Most Retarded Timing 4 °BTDC 4 °BTDC Default Timing 8 °BTDC 8 °BTDC End of Sample Window 30 °ATDC <hr/> Retard 1° Every 1 Knock Sample(s) Advance 1° Every 5 No-Knock Sample(s) <hr/> Warm-Up Delay Time 300 Seconds Shutdown Delay Time 15 Seconds	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th colspan="2" style="text-align: center;">Detonation Level Select</th> </tr> <tr><td>Sensor 1</td><td style="text-align: right;">656 mV</td></tr> <tr><td>Sensor 2</td><td style="text-align: right;">882 mV</td></tr> <tr><td>Sensor 3</td><td style="text-align: right;">705 mV</td></tr> <tr><td>Sensor 4</td><td style="text-align: right;">617 mV</td></tr> <tr><td>Sensor 5</td><td style="text-align: right;">705 mV</td></tr> <tr><td>Sensor 6</td><td style="text-align: right;">705 mV</td></tr> <tr><td>Sensor 7</td><td style="text-align: right;">833 mV</td></tr> <tr><td>Sensor 8</td><td style="text-align: right;">793 mV</td></tr> <tr><td>Sensor 9</td><td style="text-align: right;">656 mV</td></tr> <tr><td>Sensor 10</td><td style="text-align: right;">882 mV</td></tr> <tr><td>Sensor 11</td><td style="text-align: right;">617 mV</td></tr> <tr><td>Sensor 12</td><td style="text-align: right;">744 mV</td></tr> </table> <p style="font-size: small; margin-top: 5px;">NOTE: Entries above 2400mV result in a Disabled Sensor.</p>	Detonation Level Select		Sensor 1	656 mV	Sensor 2	882 mV	Sensor 3	705 mV	Sensor 4	617 mV	Sensor 5	705 mV	Sensor 6	705 mV	Sensor 7	833 mV	Sensor 8	793 mV	Sensor 9	656 mV	Sensor 10	882 mV	Sensor 11	617 mV	Sensor 12	744 mV
Detonation Level Select																											
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Sensor 9	656 mV																										
Sensor 10	882 mV																										
Sensor 11	617 mV																										
Sensor 12	744 mV																										

<F10> to Save
<ESC> to Main Menu
<F5> to AUTOCAL

Figure 3.05-16. Saving Options Menu

View/Edit Control Data Values

Engine Family : VHP GAS ENGINE Engine Model : L7042 V-12 # of Cylinders: 12 Primary Fuel : Secondary Fuel: Comments: <hr/> Timing Disk Reference <F3> D-Lead Position Most Advanced Timing Most Retarded Timing Default Timing End of Sample Window <hr/> Retard 1° Every Advance 1° Every 5 No-Knock Sample(s) <hr/> Warm-Up Delay Time 300 Seconds Shutdown Delay Time 15 Seconds	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th colspan="2" style="text-align: center;">Detonation Level Select</th> </tr> <tr><td>r 1</td><td style="text-align: right;">656 mV</td></tr> <tr><td>r 2</td><td style="text-align: right;">882 mV</td></tr> <tr><td>r 3</td><td style="text-align: right;">705 mV</td></tr> <tr><td>r 4</td><td style="text-align: right;">617 mV</td></tr> <tr><td>r 5</td><td style="text-align: right;">705 mV</td></tr> <tr><td>r 6</td><td style="text-align: right;">705 mV</td></tr> <tr><td>r 7</td><td style="text-align: right;">833 mV</td></tr> <tr><td>r 8</td><td style="text-align: right;">793 mV</td></tr> <tr><td>r 9</td><td style="text-align: right;">656 mV</td></tr> <tr><td>r 10</td><td style="text-align: right;">882 mV</td></tr> <tr><td>r 11</td><td style="text-align: right;">617 mV</td></tr> <tr><td>r 12</td><td style="text-align: right;">744 mV</td></tr> </table> <p style="font-size: small; margin-top: 5px;">NOTE: Entries above 2400mV result in a Disabled Sensor.</p>	Detonation Level Select		r 1	656 mV	r 2	882 mV	r 3	705 mV	r 4	617 mV	r 5	705 mV	r 6	705 mV	r 7	833 mV	r 8	793 mV	r 9	656 mV	r 10	882 mV	r 11	617 mV	r 12	744 mV
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r 11	617 mV																										
r 12	744 mV																										

<F10> to Save
<ESC> to Main Menu
<F5> to AUTOCAL

Figure 3.05-17. Entering Filename Of Data-Set

EDITING AN EXISTING DSM DATA-SET

- B. If the engine has a "C-" number, remove the "C-" and the "/" from the number. Example: C-10768/01 would give a root file name of "1076801." If the engine does not have a "C-" number use all six digits in the serial number for the filename.
- C. The first time the configuration is saved to the disk add an "A" to the end. This is to indicate that this is the first save of this configuration. If changes are made to the configuration, save the next file with the same numerical information and change the suffix letter to "B." Continue in this manner for each revision to the file.

Once eight characters have been entered, the file will automatically be saved to the PC disk where the DSM program resides. If the filename is less than eight characters, press [Enter] to save.

4. Press [ESC] to return to the Main Menu.

5. If the data-set for your engine has been saved to ROM and a file on disk, confirm the exit to the Main Menu by pressing [Y] (see Figure 3.05-18). The Main Menu appears. If you have not saved the data-set to ROM (permanent memory), press [N] and refer to "Saving Data-Set To ROM" in this section.

View/Edit Control Data Values

<p>Engine Family : VHP GAS ENGINE Engine Model : L7042 V-12 # of Cylinders : 12 Primary Fuel : Secondary Fuel : Comments :</p> <p>Timing Disk Refe <F3></p> <p>D-Lead Position Most Advanced T Most Retarded T Default Timing End of Sample W</p> <p>Retard 1° Eve Advance 1° Every 5 No-Knock Sample(s)</p> <p>Warm-Up Delay Time 300 Seconds Shutdown Delay Time 15 Seconds</p>	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="2" style="text-align: center;">Detonation Level Select</th> </tr> </thead> <tbody> <tr><td>r 1</td><td>656 mV</td></tr> <tr><td>r 2</td><td>882 mV</td></tr> <tr><td>r 3</td><td>705 mV</td></tr> <tr><td>r 4</td><td>617 mV</td></tr> <tr><td>r 5</td><td>705 mV</td></tr> <tr><td>r 6</td><td>705 mV</td></tr> <tr><td>r 7</td><td>833 mV</td></tr> <tr><td>r 8</td><td>793 mV</td></tr> <tr><td>r 9</td><td>656 mV</td></tr> <tr><td>r 10</td><td>882 mV</td></tr> <tr><td>r 11</td><td>617 mV</td></tr> <tr><td>r 12</td><td>744 mV</td></tr> </tbody> </table> <p style="font-size: small;">NOTE: Entries above 2400mV result in a Disabled Sensor.</p>	Detonation Level Select		r 1	656 mV	r 2	882 mV	r 3	705 mV	r 4	617 mV	r 5	705 mV	r 6	705 mV	r 7	833 mV	r 8	793 mV	r 9	656 mV	r 10	882 mV	r 11	617 mV	r 12	744 mV
Detonation Level Select																											
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r 8	793 mV																										
r 9	656 mV																										
r 10	882 mV																										
r 11	617 mV																										
r 12	744 mV																										

Exit to Main Menu

Changes Will be Lost if you Have Not Saved Them.

Do You REALLY Want to EXIT?

Yes
No esc

<F10> to Save
<ESC> to Main Menu
<F5> to AUTOCAL

Figure 3.05-18. Confirmation Of Exit

SECTION 3.10

PROGRAMMING THE DSM SYSTEM FOR A NEW APPLICATION

PROGRAMMING INFORMATION

This section, Section 3.10, *Programming The DSM System For A New Application*, explains the programming steps and post-programming checks to be completed for a "new application." A new application includes retrofit applications or whenever a DSM module is removed from one engine and installed on another engine model. By completing the programming steps in this section, any existing data-set is overwritten and an entirely new data-set is programmed. The data-set that is created following the procedures in this section is engine specific. Complete all the procedures and post-programming checks provided in this section to program the DSM system for a new application.

NOTE: If the internally mounted LCD inside the DSM module reads "99" (no data), the DSM module is sensing that a new EPROM chip is installed and no data-set exists. You will need to complete the programming steps in this section.

Section 3.05, *Editing An Existing DSM Data-Set*, explains the steps required to edit an existing DSM data-set. The data-set that is edited following the procedures in Section 3.05 is engine specific.

NOTE: Engines shipped from the factory with the DSM system are initially setup at the factory. A data-set is created at the factory for testing the DSM system on the engine. Since a data-set already exists, complete the programming steps in Section 3.05, *Editing An Existing DSM Data-Set*.

Section 3.15, *DSM System Computer Screen And Data Retrieval*, explains the procedures necessary to access DSM system information from the DSM Interface Program using a PC. Section 3.15 does not include any programming procedures.

NOTE: This manual assumes you are already familiar with basic MS-DOS commands for viewing directories, copying files, and other MS-DOS concepts. If you need more information on these subjects, refer to a MS-DOS instruction manual.

PRE-PROGRAMMING INSTALLATION CHECKLIST

Before applying power to the DSM system:

- A. **Disconnect the DSM module from the Ignition Module** by removing the "DSM to Ignition" harness from the 14 pin connector on the side of the Ignition Module (see Figure 3.10-1).

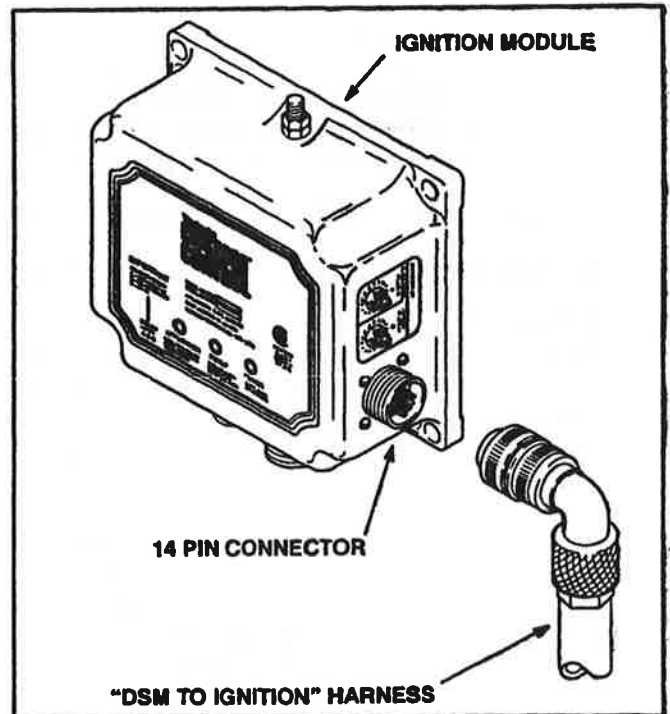


Figure 3.10-1. Disconnecting The "DSM To Ignition" Harness

PROGRAMMING THE DSM SYSTEM FOR A NEW APPLICATION

- B. Visually inspect the installation to be sure that all wiring conforms to the requirements of this manual, local codes, and regulatory bodies. Verify that each connection to the DSM module is routed through the correct conduit (see Figure 3.10-2).

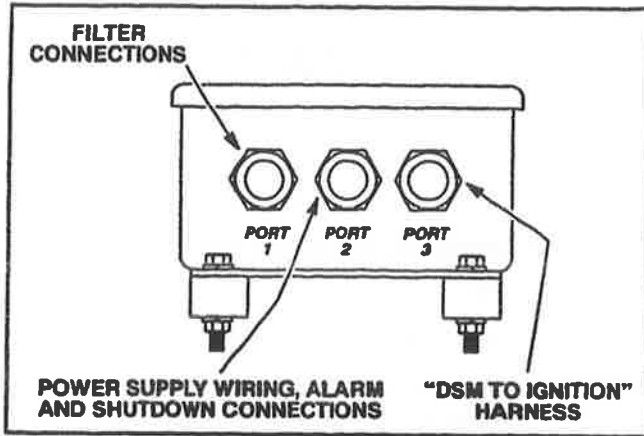


Figure 3.10-2. DSM Module Conduit Ports

- C. Verify that the power supply is within specification. Refer to Section 2.10, *DSM System Power, Alarm, And Ground Connections*, for power specifications to DSM module. Make this measurement with an oscilloscope at the supply wires to the DSM module with the engine running.

DSM INTERFACE PROGRAMMING STEPS

ESTABLISHING COMMUNICATION WITH THE DSM

1. Verify that the DSM module is disconnected from the Ignition Module before applying power. If the DSM module is not disconnected from the Ignition Module, disconnect the "DSM to ignition" harness from the 14 pin DSM connector on the side of the Ignition Module (see Figure 3.10-1).

2. Apply power to the DSM module. The "Power," "Alarm," and "Shutdown" LEDs on the front cover will light for approximately five seconds. The green power LED will remain on when the alarm and shutdown LEDs go off. The internally mounted LCD display will read "90" (system OK - ready and waiting for engine to start).

NOTE: If the internally mounted LCD reads "99" (no data) instead of "90", the DSM module is sensing that a new EPROM chip is installed in the DSM module. Continue with the DSM module programming.

NOTE: If any of the alarm or shutdown LEDs come on any time during DSM system operation, see Section 4.00, *DSM System Diagnostics And Troubleshooting*.

3. The DSM module must be programmed to work with site specific information in order for the DSM system to function properly. To program the DSM module, connect a standard DB-9 serial cable (male to female) to the communications port (labeled P1A) within the DSM module. This is the communications port on the right (see Figure 3.10-3). Connect the other end of the cable to the PC's communications port. Typically, this is port 1 (also referred to as COM 1, serial A, or serial 1).

CAUTION Verify that the DB-9 serial cable is securely connected to the appropriate computer port. If the serial cable is disturbed or disconnected during the saving process, the EPROM chip in the DSM module will become corrupted and will need to be replaced.

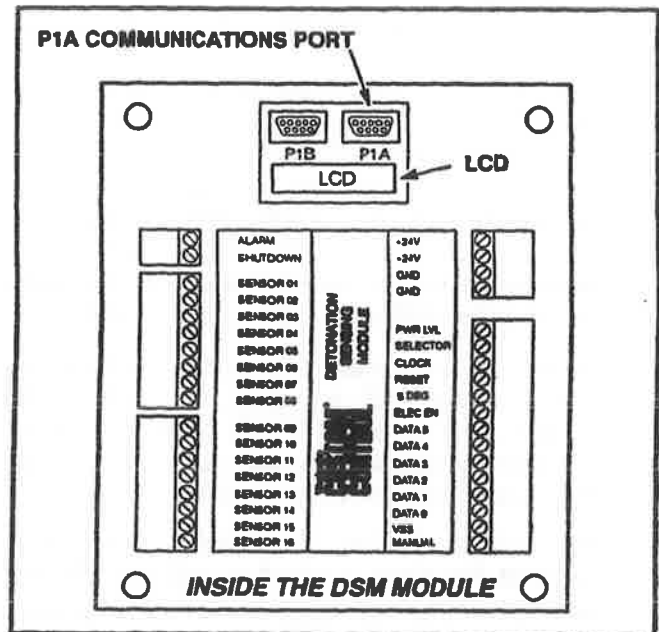


Figure 3.10-3. DB-9 Serial Cable Connection Inside DSM Module

4. Start the DSM Interface Program on your PC.

NOTE: For information on installing and/or accessing the DSM Interface Program, refer to the white card at the back of this manual which holds the 3-1/2" diskette for installation and accessing instructions.

5. The "Genuine Waukesha Parts" logo screen appears briefly, followed by the screen shown in Figure 3.10-4. The bottom line of this screen indicates what version of the DSM Interface Program you are using.

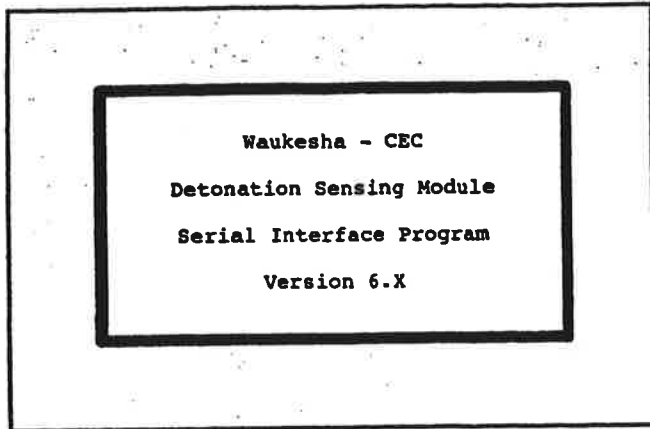


Figure 3.10-4. Software Version Identification

6. Automatically the Communications Menu appears (see Figure 3.10-5). A black dot is located in a circle next to "1" which indicates that the selected communications port on your computer is port 1. Press [Enter] to select communications port 1. If the DB-9 cable is connected to a different port on your PC, use the arrow keys on the keyboard to select the corresponding port from the Communications Menu and press [Enter] (typically: port 1 is correct).

The DSM Interface Program's Main Menu appears showing various program options available (see Figure 3.10-6).

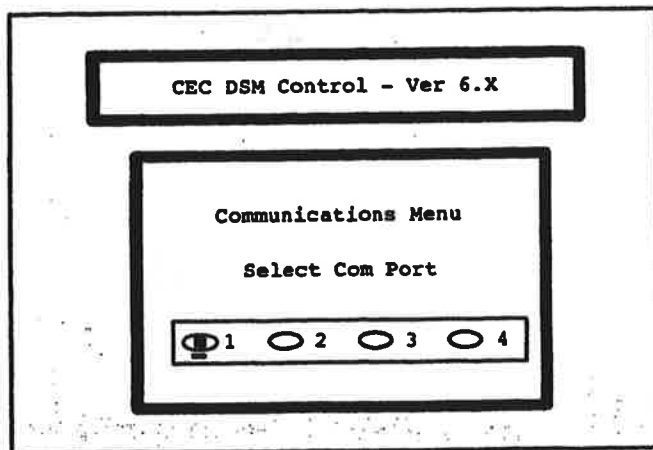


Figure 3.10-5. Communications Menu

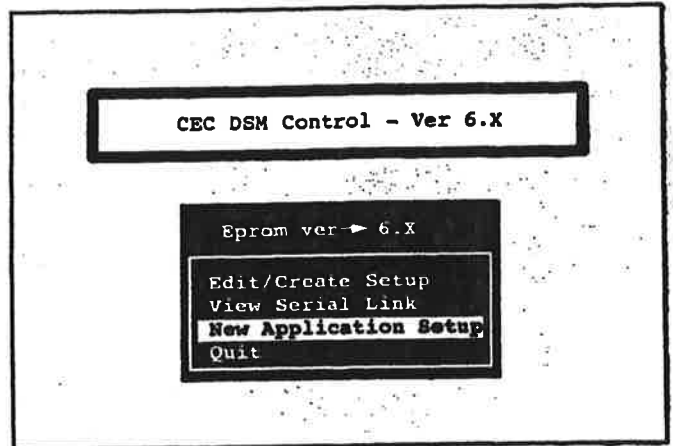


Figure 3.10-6. DSM Interface Program Main Menu

NEW APPLICATION SETUP

1. Highlight "New Application Setup" on the DSM Interface Program's Main Menu (see Figure 3.05-6) and press [Enter].

2. The DSM system will then scan the EPROM chip for a saved data-set. Several screens appear indicating the scan of the EPROM chip.

- If the DSM finds a saved data-set on the EPROM chip, the New Application Setup Verification Screen appears (see Figure 3.10-7). Because creating a new data-set will overwrite an existing data-set, the DSM Interface Program verifies that you want to continue with a new application.

If you want to setup the DSM system for a new application, highlight the "Continue" button and press [Enter]. The Engine Family Menu appears. Continue with Step 3.

If you do not want to setup the DSM system for a new application, highlight the "Cancel" button and press [Enter].

- If the DSM does not find a saved data-set on the EPROM chip, the Engine Family Menu appears. Continue with Step 3. The internally mounted LCD reads "99" (no data) when the DSM module senses a new EPROM chip is installed.

NOTE: If you simply want to edit an existing data-set, complete the steps in Section 3.05, Editing An Existing DSM Data-Set.

PROGRAMMING THE DSM SYSTEM FOR A NEW APPLICATION

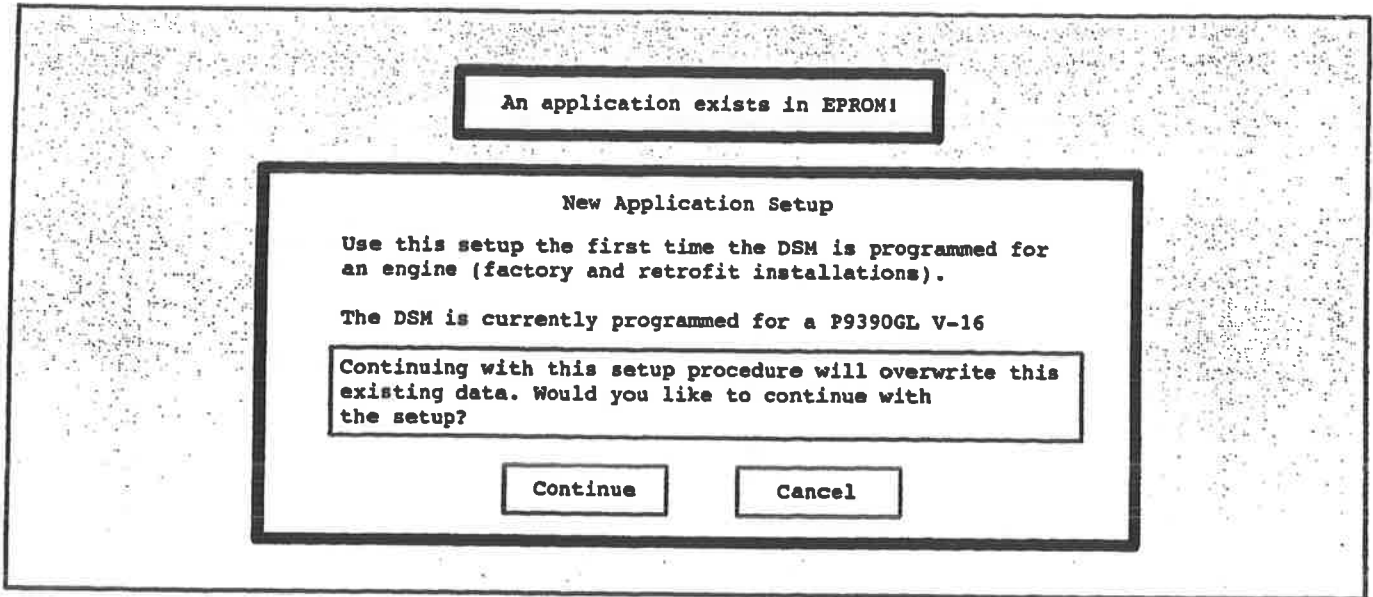


Figure 3.10-7. New Application Setup Screen

NOTE: Some DSM system programming will require you to enter engine specific information. Read these steps carefully so you enter the information that applies to the engine and DSM system you are programming.

NOTE: The filters used with the DSM system are engine specific. If an incorrect filter is installed, the DSM system will appear to work but will not protect against detonation. Detonation can cause severe engine damage.

NOTE: For the purposes of this manual, the DSM module will be programmed for a 12 cylinder VHP L7042 engine. For example, in Step 3 "VHP Gas Engines" is selected from the Engine Family Menu. The programming steps taken in this manual are the same for whatever engine family you choose (exceptions are noted).

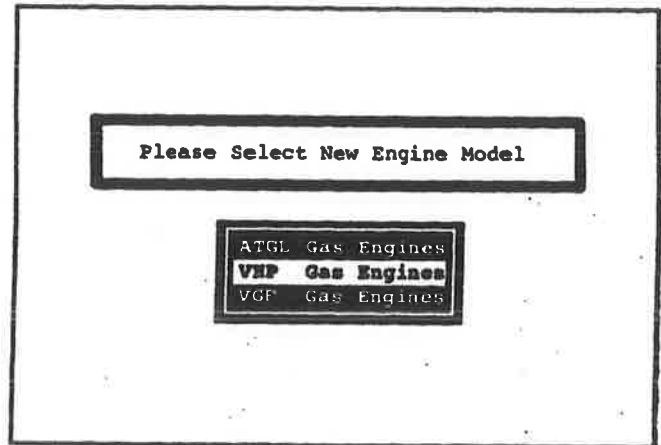


Figure 3.10-8. Engine Family Menu

3. A listing of various Waukesha Engine families appears on the screen (see Figure 3.10-8). The DSM module must be customized for each application. Highlight the appropriate engine family for your application and press [Enter].

4. On the next screen, a selection of specific engine models available for the engine family previously selected appears (see Figure 3.10-9). Highlight the applicable engine model and press [Enter].

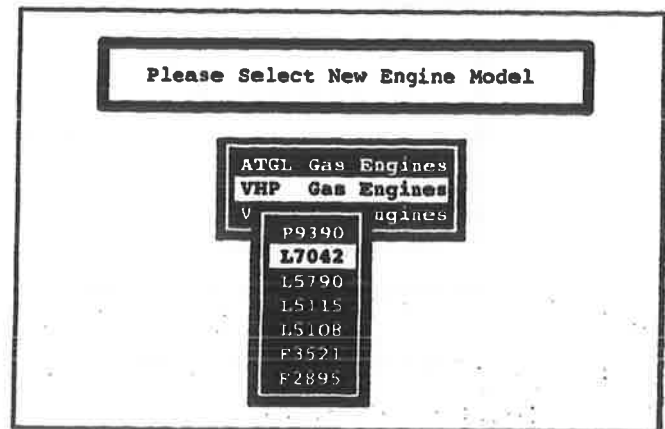


Figure 3.10-9. Engine Model Menu

PROGRAMMING THE DSM SYSTEM FOR A NEW APPLICATION

5. A selection of fuel types for the engine is listed (see Figure 3.10-10). Highlight the type of primary fuel the engine is using on the Primary Fuel Selection Menu and press [Enter].

6. A selection of fuel types for the engine is listed (see Figure 3.10-11). Highlight the type of secondary fuel the engine is using on the Secondary Fuel Selection Menu and press [Enter]. If no secondary fuel is being used or will be used, highlight "NONE" and press [Enter].

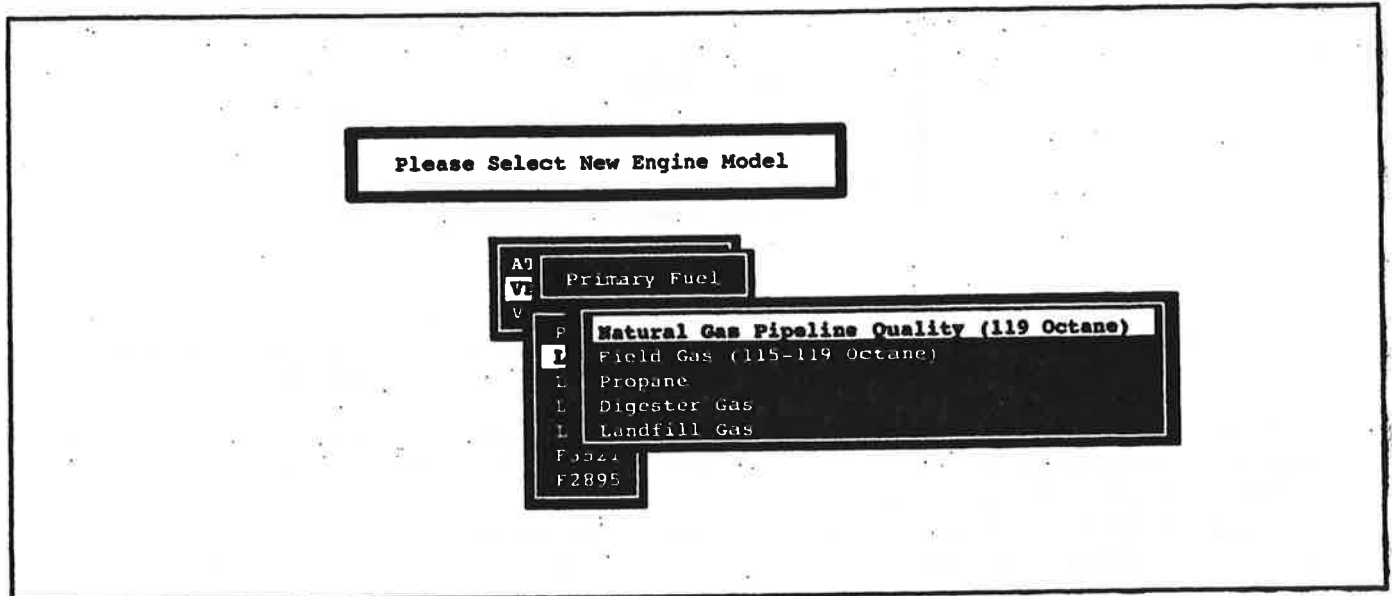


Figure 3.10-10. Primary Fuel Selection Menu

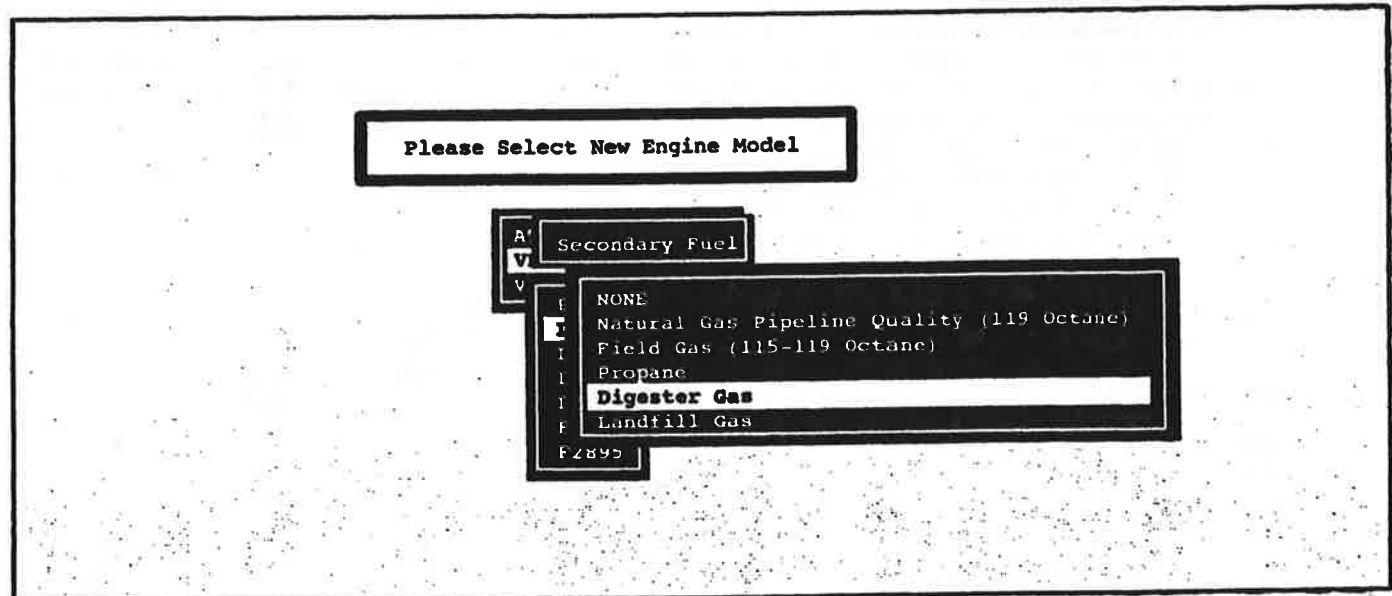


Figure 3.10-11. Secondary Fuel Selection Menu

PROGRAMMING THE DSM SYSTEM FOR A NEW APPLICATION

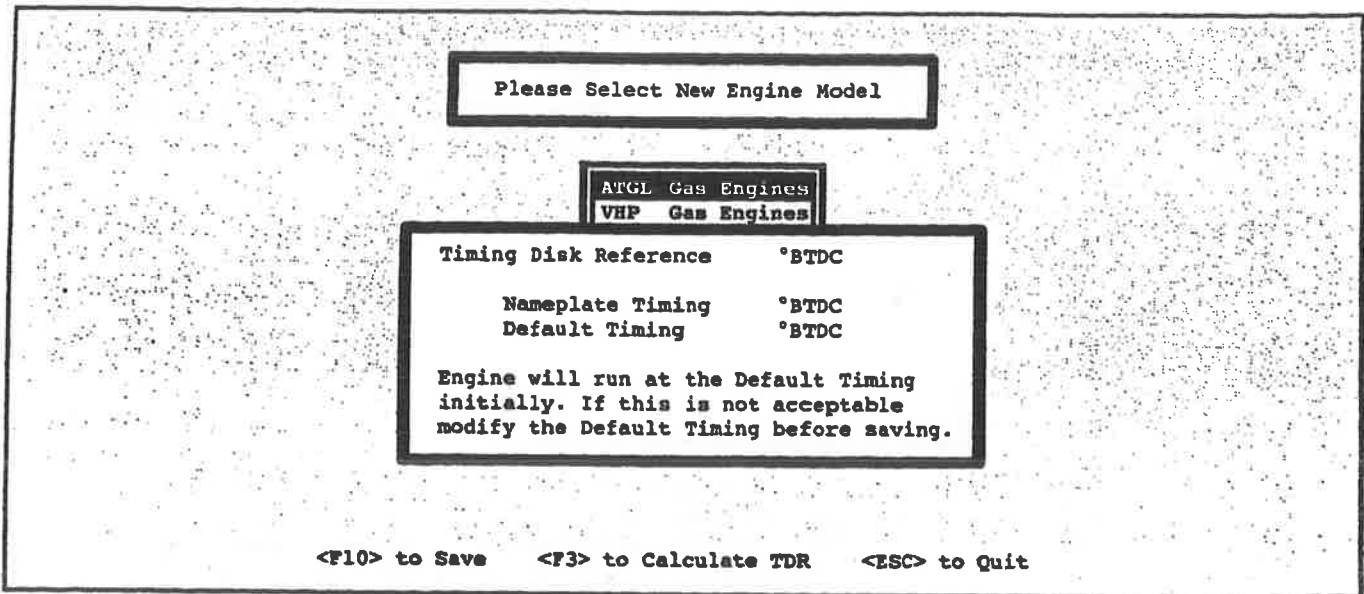


Figure 3.10-12. Entering Timing Disk And Nameplate Timing Values

7. After the engine family, model, and fuel types are selected, a screen appears requiring Timing Disk Reference (TDR) and nameplate timing values (see Figure 3.10-12). The proper TDR is required so that the DSM system can control timing.

- If you know these values, enter the TDR value and press [Enter]. Then enter nameplate timing and press [Enter]. The default timing value is automatically calculated (based on the formula: Nameplate Timing - 2° = Default Timing). Default timing is the retarded ignition timing imposed by the DSM system when it is not protecting against detonation. The DSM system activates default timing for a cylinder when the cylinder's sensor is disabled, when the sensor fails, and during engine warm-up delay. You may modify the default timing if the calculated value is not acceptable. To modify the default timing, enter the new value in the "Default Timing" field. Continue with "Saving Engine Parameters" in this section.
- If you do not know the TDR, continue with the next section, "Calculating Timing Disk Reference."

CALCULATING TIMING DISK REFERENCE

The proper Timing Disk Reference (TDR) is required so that the DSM system can accurately control timing. TDR is the angular relationship between the first cylinder to fire and top dead center (TDC) (example: 25° BTDC). The position of the Ignition Module's timing disk is not the same on all engines. Complete this section to calculate the TDR for the specific engine model you are programming.

1. To calculate the Timing Disk Reference press [F3].

CAUTION The Timing Disk Reference (TDR) will be calculated incorrectly if the DSM module is not disconnected from the Ignition Module. The TDR is essential for proper DSM system performance.

2. After pressing [F3], a message appears asking you to verify that the DSM module is disconnected from the Ignition Module (see Figure 3.10-14). If the DSM module is disconnected from the Ignition Module press [Y]. If the DSM module is not disconnected from the Ignition Module, disconnect the "DSM to Ignition" harness from the 14 pin connector on the side of the Ignition Module (see Figure 3.10-13) and press [Y].

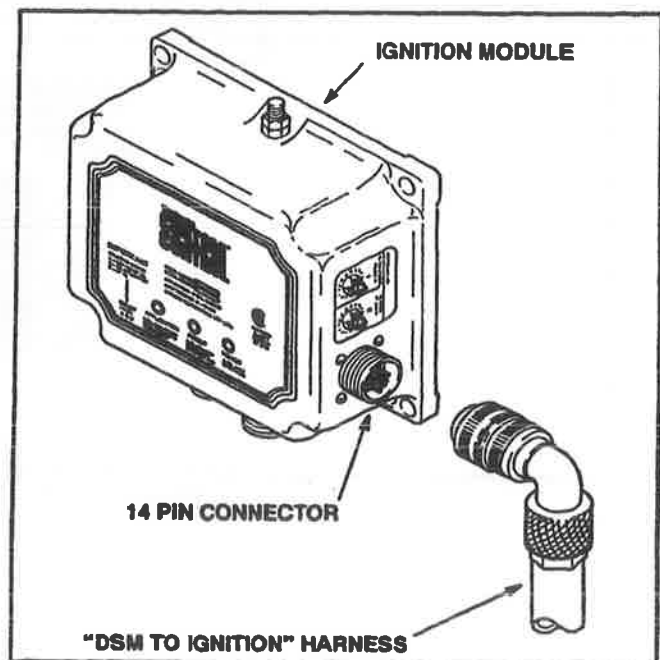


Figure 3.10-13. Disconnecting The "DSM To Ignition" Harness

PROGRAMMING THE DSM SYSTEM FOR A NEW APPLICATION

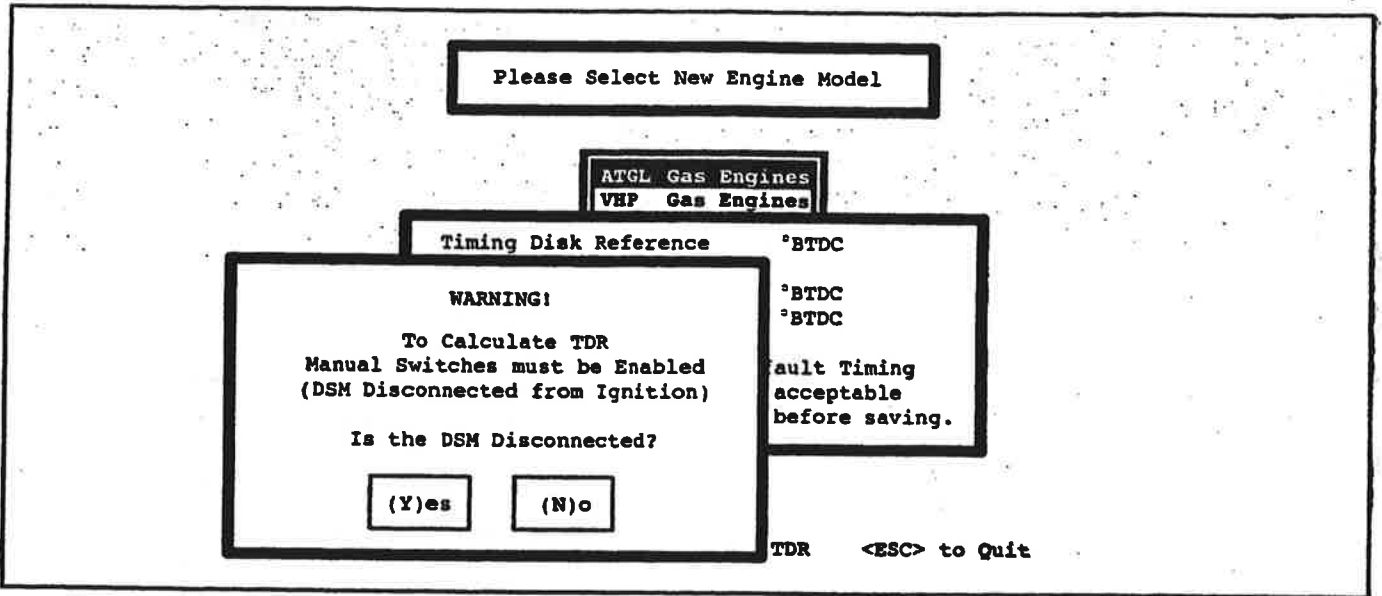


Figure 3.10-14. Verification Screen

3. To have the DSM system calculate TDR, you must enter data about engine timing on the Timing Disk Reference (TDR) Calculation Screen (see Figure 3.10-15). First, determine whether "A" or "B" is the active timing switch on the Ignition Module. When the "D" lead of the Ignition Module is grounded, timing switch "A" is the active switch. When the "D" lead is open, timing switch "B" is active.

To determine which is the active timing switch, follow the steps below.

A. Check engine timing with a timing light and record the engine timing value.

B. On the side of the Ignition Module, turn the "A" timing switch one degree (place) (see Figure 2.05-13).

C. Re-check engine timing with a timing light. If engine timing has changed one degree, the "D" lead is grounded and "A" is the active timing switch. Turn the "A" timing switch back to its previous setting and continue with Step 4. If engine timing has not changed one degree, turn the "A" timing switch back to its previous setting and continue with Step D.

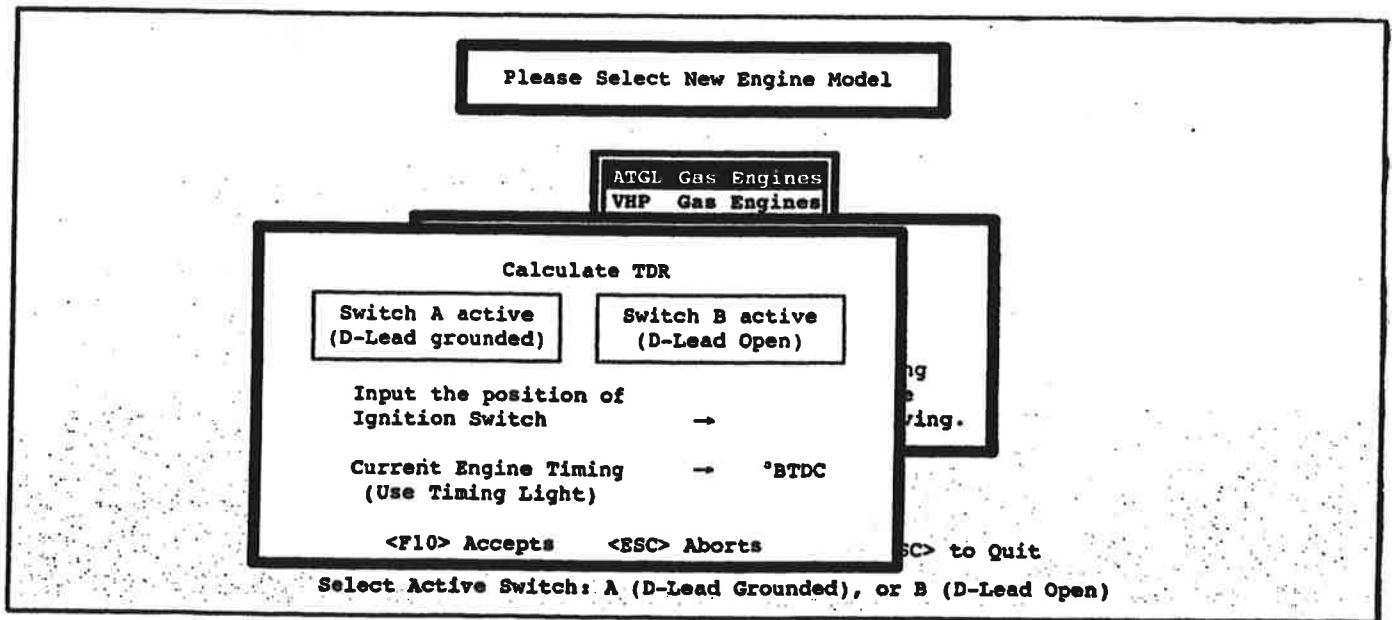


Figure 3.10-15. Timing Disk Reference Calculation Screen

PROGRAMMING THE DSM SYSTEM FOR A NEW APPLICATION

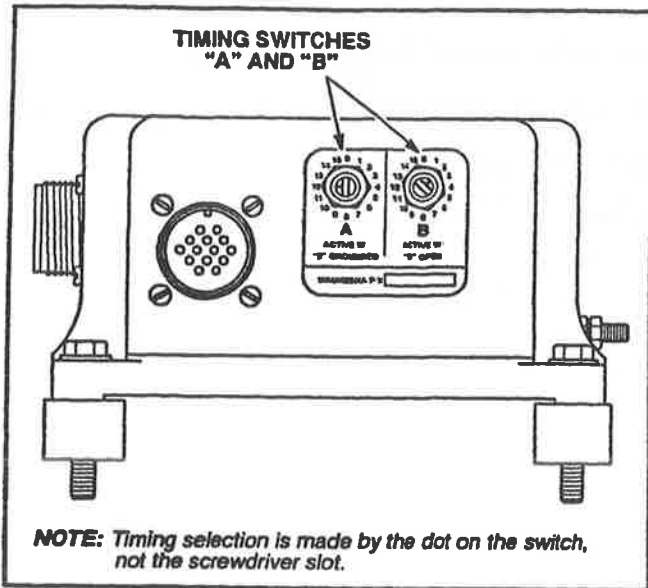


Figure 3.10-16. CEC Ignition Module Timing Switches

- D. On the side of the Ignition Module, turn the "B" timing switch one degree (place) (see Figure 3.10-16).
- E. Re-check engine timing with a timing light. If engine timing has changed one degree, the "D" lead is open and "B" is the active timing switch. Turn the "B" timing switch back to its previous setting. Continue with Step 4.

NOTE: If timing did not change when either timing switch "A" or "B" was changed, verify that the DSM module is disconnected from the Ignition Module. If the DSM module is not disconnected from the Ignition Module, disconnect the "DSM to ignition" harness from the 14 pin DSM connector on the side of the Ignition Module and repeat the TDR calculation with Step 1. If disconnected, contact Waukesha Product Support.

4. If "A" is the active timing switch on the Ignition Module, highlight the "Switch A active" button on the Timing Disk Reference Calculation Screen using the [Tab] or arrow key (see Figure 3.10-15) and press [Enter]. If "B" is the active timing switch, highlight the "Switch B active" button and press [Enter].

5. Enter the position (0 - 15) of the active timing switch (found on the side of the Ignition Module) and press [Enter]. Timing selection is made by the dot on the timing switch, not the screwdriver slot.

6. Check engine timing using a timing light.

7. Verify that engine timing from Step 6 is the same as nameplate timing. If the two timings do not match, contact Waukesha Product Support.

8. Enter engine timing on the Timing Disk Reference Calculation Screen and press [F10].

9. The Timing Disk Reference (TDR) angle is automatically calculated and entered for the application based on the switch position and timing values just entered. Press [Enter] to accept the calculated TDR angle (see Figure 3.10-17).

10. Enter nameplate timing and press [Enter]. The default timing value is automatically calculated (based on the formula: Nameplate Timing - 2° = Default Timing) (see Figure 3.10-18). Default timing is the retarded ignition timing imposed by the DSM system when it is not protecting against detonation. The DSM system activates default timing for a cylinder when the cylinder's sensor is disabled, when the sensor fails, and during engine warm-up delay. You may modify the default timing if the calculated value is not acceptable. To modify the default timing, enter the new value in the "Default Timing" field.

11. Continue with the next section, "Saving Engine Parameters."

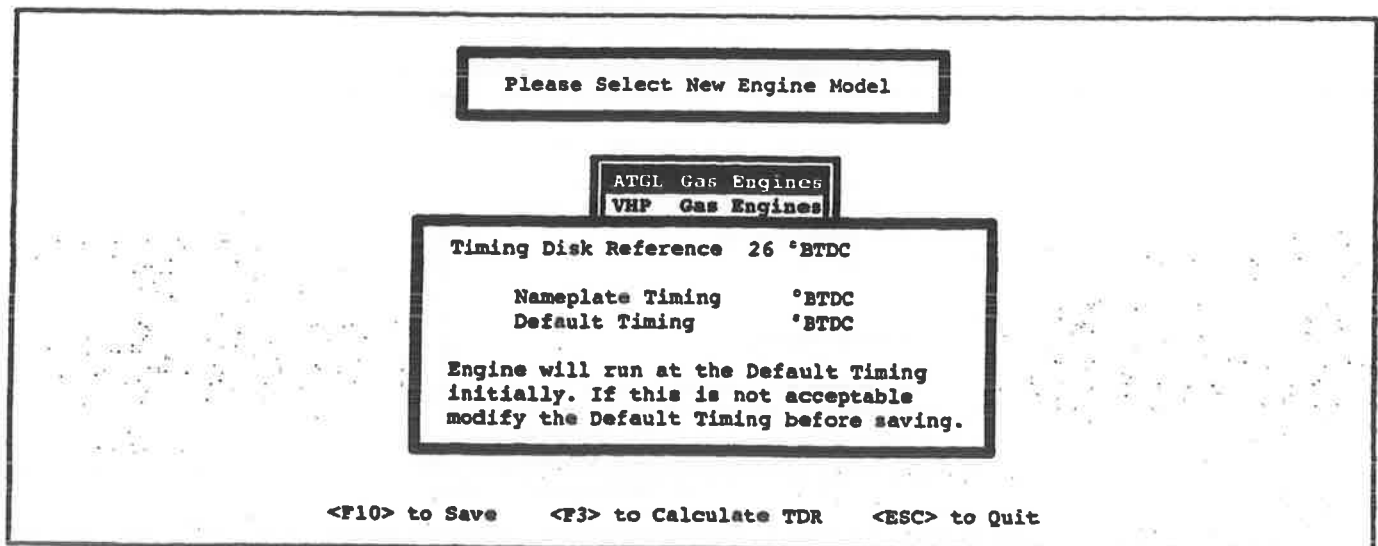


Figure 3.10-17. Entering Timing Disk And Default Timing Values

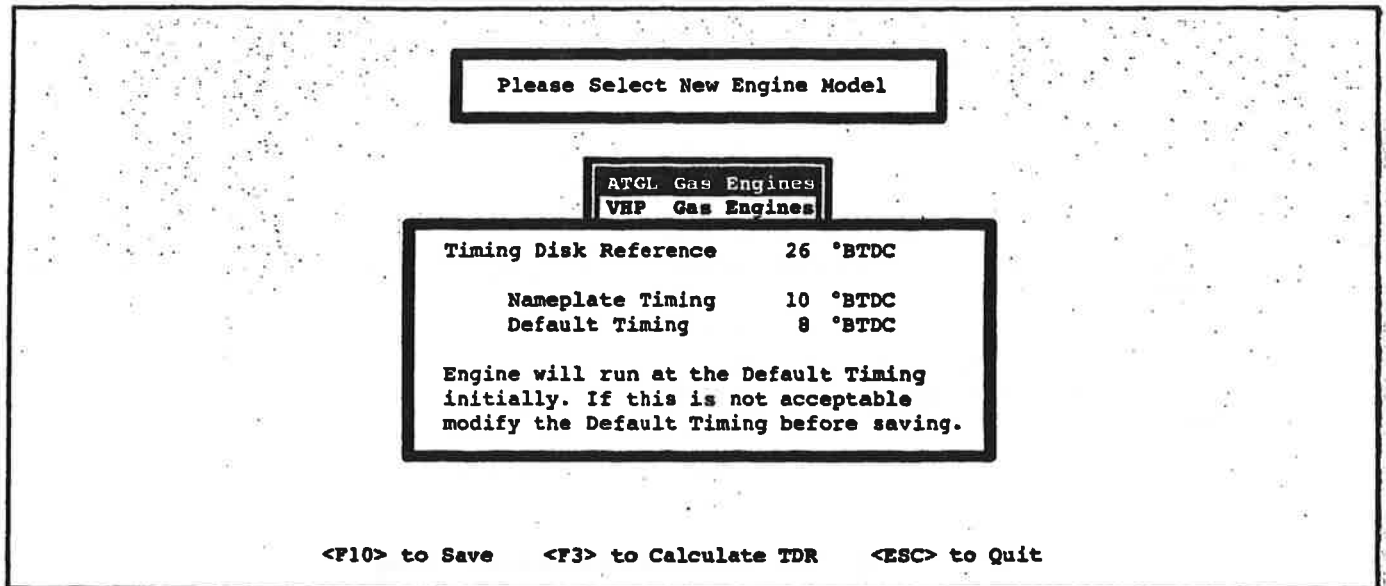


Figure 3.10-18. Calculated TDR And Default Timing Values

SAVING ENGINE PARAMETERS

Complete the following steps to save the engine model information, Timing Disk Reference value, and default timing value to read only memory (ROM), permanent memory within the DSM module (EPROM chip).

1. After the engine model information, Timing Disk Reference value, and default timing are entered, press [F10] to save the engine parameters to ROM (permanent memory). The Saving Options Menu appears.
2. Highlight "Configure DSM Memory" on the Saving Options Menu and press [Enter].

3. A screen appears confirming the save of the engine parameters to ROM (see Figure 3.10-19). Press [Y].

CAUTION Do not disturb the serial cable or interrupt computer power while programming. If the serial cable is disturbed or disconnected during the saving process, the EPROM chip in the DSM module will become corrupted and will need to be replaced.

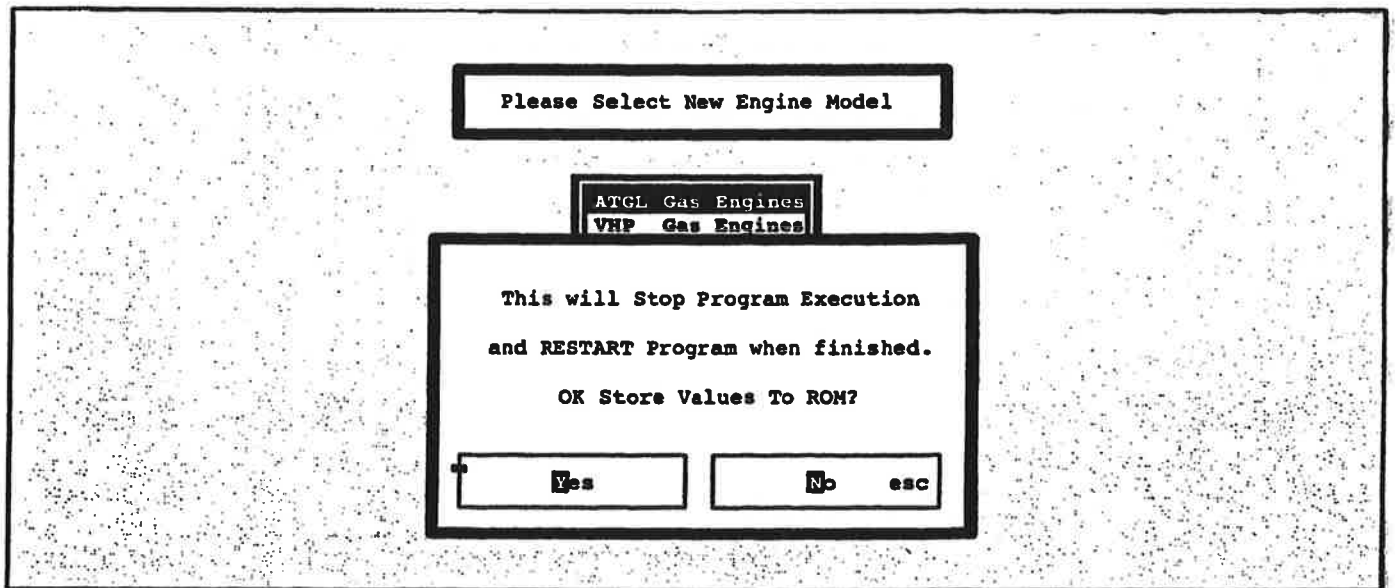


Figure 3.10-19. Saving Engine Parameters To Read Only Memory (ROM)

PROGRAMMING THE DSM SYSTEM FOR A NEW APPLICATION

4. Several screens appear indicating that the engine parameters are being saved to ROM. A screen appears indicating that the engine parameters have been saved (see Figure 3.10-20). The ROM number (ROM##) shows you which ROM location the engine parameter data has been saved to.

NOTE: Record the ROM number (ROM##) of your save so you can keep track of how many saves to ROM are still available.

NOTE: The DSM allows 25 saves to ROM. Once ROM has been fully configured, the EPROM chip in the DSM module must be replaced to permit further saves to permanent memory.

5. Press any key to continue.

6. After the engine parameters are saved to ROM, the View/Edit Control Data Values Screen appears (see Figure 3.10-21). Verify that the engine family, engine model, Timing Disk Reference value, and default timing agree with the values you entered.

7. Continue with the next section, "Editing The DSM Data-Set."

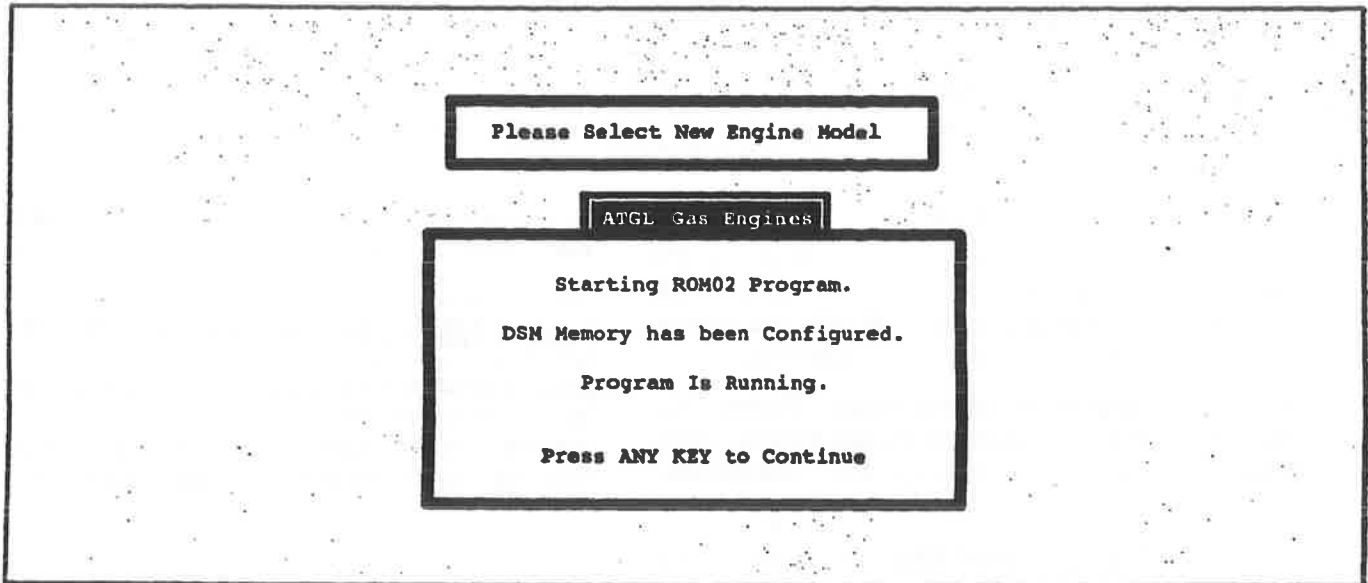


Figure 3.10-20. Confirmation Of Save To Read Only Memory (ROM)

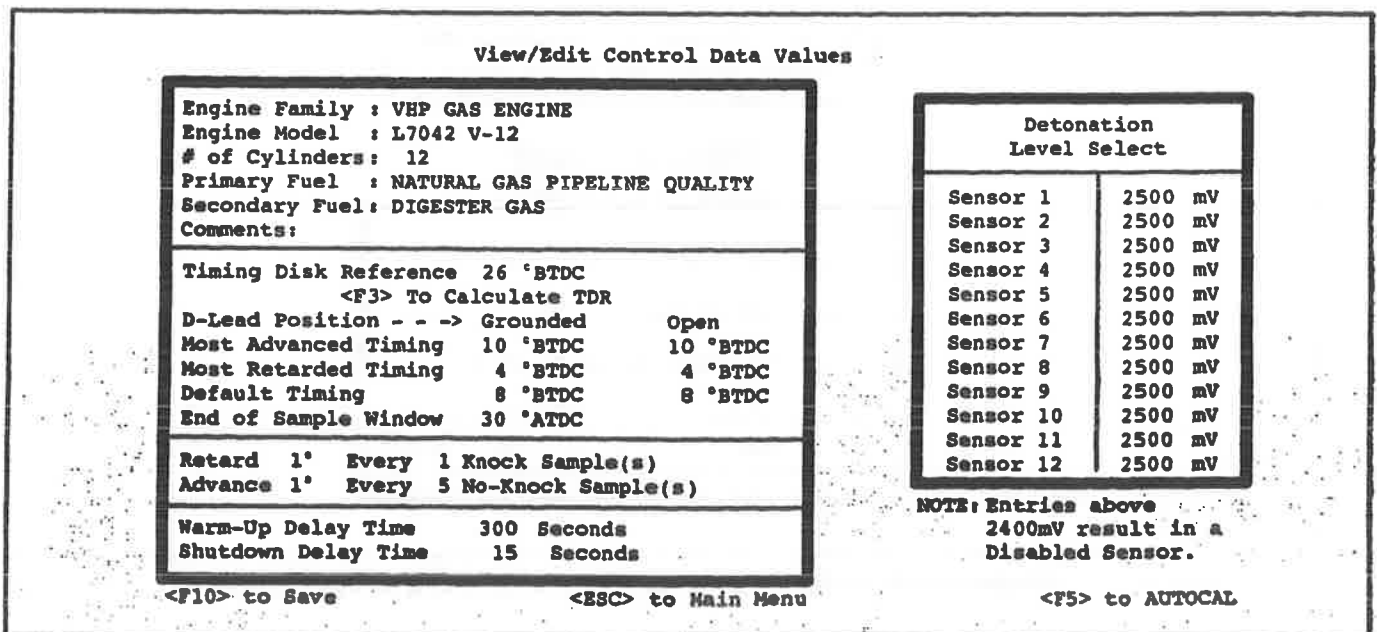


Figure 3.10-21. View/Edit Control Data Values Screen

EDITING THE DSM DATA-SET

A data-set is a group of site specific data points that are created and then stored in ROM within the DSM module. The DSM data-set includes values for: Most Advanced Timing, Most Retarded Timing, End of Sample Window angle, retard and advanced timing values, warm-up delay time, and shutdown delay time. Complete the steps that follow to edit the data-set for the engine you are programming.

NOTE: *Editing values on the View/Edit Control Data Values Screen will not affect the performance of the DSM system. The edited data-set must be saved to RAM or ROM to change the DSM system's operating parameters.*

You can change data points on the View/Edit Control Data Values Screen by moving the cursor with the arrow keys and entering data as desired.

1. Reconnect the DSM module ("DSM to ignition" harness) to the Ignition Module. After reconnecting the DSM module to the Ignition Module, ignition timing is being controlled by the DSM system so the data-set for the engine can be completed.

NOTE: *Knock sensors above 2400 mV are disabled and do not protect against detonation. Engine timing runs at the default timing. The knock sensors remain disabled until the AutoCal program is completed and new voltages are entered on the View/Edit Data Control Values Screen and saved to ROM.*

2. Using a timing light, verify that the correct Timing Disk Reference (TDR) value is programmed. The TDR value is shown on the View/Edit Control Data Values Screen (see Figure 3.10-21). Complete the following:

- A. If engine timing does match the Default Timing ($^{\circ}$ BTDC), continue with Step 3. If the engine timing does not match, the TDR value needs to be adjusted.
 - B. If engine timing is lower than the default timing shown, then decrease the TDR value by that amount. For example, if timing is set at 11° but the engine is running at 10° , then decrease the TDR value by 1° .
 - C. If engine timing is higher than the default timing shown, then increase the TDR value by that amount. For example, if timing is set at 11° but the engine is running at 12° , then increase the TDR value by 1° .
 - D. Use the arrow keys to position the cursor in the "Timing Disk Reference" field on the View/Edit Control Data Values Screen.
 - E. Enter the adjusted TDR value and press [Enter].
 - F. Press [F10] to test the new TDR value. Highlight "Test Data on DSM" on the next menu and press [Enter]. The new information is now saved to RAM (temporary memory). Press any key to continue.
- NOTE:** *The "Test Data on DSM" option from the Save Options Menu allows a program to be run in the DSM module's temporary memory (RAM). The contents of RAM are lost whenever power to the DSM module is removed.*
- G. Using a timing light, verify that the engine timing is running at the default timing. If engine timing does match continue with Step 3. If the engine timing does not match, repeat Steps A - F. If repeating these steps does not correct engine timing, contact Waukesha Product Support.
 - H. Once verified, the new TDR value must be saved to ROM. Press [F10] to save the new TDR value. Highlight "Configure DSM Memory" on the next menu and press [Enter]. When the Verification Screen appears press [Y]. Several screens will appear indicating that the data-set is being saved to ROM, permanent memory on the EPROM chip inside the DSM module. Once the data-set has been saved to ROM, a message will state that the DSM memory has been configured to ROM. Press any key to continue.

PROGRAMMING THE DSM SYSTEM FOR A NEW APPLICATION

View/Edit Control Data Values

Engine Family : VHP GAS ENGINE Engine Model : L7042 V-12 # of Cylinders: 12 Primary Fuel : NATURAL GAS PIPELINE QUALITY Secondary Fuel: DIGESTER GAS Comments:		
Timing Disk Reference 26 °BTDC <F3> To Calculate TDR		
D-Lead Position - - ->	Grounded	Open
Most Advanced Timing	10 °BTDC	10 °BTDC
Most Retarded Timing	4 °BTDC	4 °BTDC
Default Timing	8 °BTDC	8 °BTDC
End of Sample Window	30 °ATDC	
Retard 1° Every	1 Knock Sample(s)	
Advance 1° Every	5 No-Knock Sample(s)	
Warm-Up Delay Time	300 Seconds	
Shutdown Delay Time	15 Seconds	

Detonation Level Select	
Sensor 1	2500 mV
Sensor 2	2500 mV
Sensor 3	2500 mV
Sensor 4	2500 mV
Sensor 5	2500 mV
Sensor 6	2500 mV
Sensor 7	2500 mV
Sensor 8	2500 mV
Sensor 9	2500 mV
Sensor 10	2500 mV
Sensor 11	2500 mV
Sensor 12	2500 mV

NOTE: Entries above 2400mV result in a Disabled Sensor.

<F10> to Save <ESC> to Main Menu <F5> to AUTOCAL

Figure 3.10-22. View/Edit Control Data Values Screen

3. The DSM parameters include: default timing values, retard and advance timing values and rates of change, and delay times. To edit any of the values in the data-set, position the cursor in the field for the parameter you want to edit. Then enter the new value.

Refer to Figure 3.10-22 and the correct table while editing the data-set. The values provided in the tables are the recommended data-set parameters for the DSM system. Modifications may be made based on site conditions.

- Table 3.10-1 on page 13 provides the data-set parameters for 8L-AT27GL engines.
- Table 3.10-2 on page 14 provides the data-set parameters for 12V-AT27GL engines.
- Table 3.10-3 on page 14 provides the data-set parameters for 12V-AT25GL engines.
- Table 3.10-4 on page 14 provides the data-set parameters for VHP engines.
- Table 3.10-5 on page 14 provides the data-set parameters for VGF engines.

Listed are definitions of each of the data-set parameters found on the View/Edit Control Data Values Screen.

Comments: Type in any comments regarding DSM programming or revise existing comments. Typically, comments include site, engine number, and date information.

Most Advanced Timing: The maximum advanced timing at which the system will allow the engine to operate. Enter the most advanced timing for the Ignition Module's "D" lead grounded and the most advanced timing for the "D" lead open.

NOTE: "Most Advanced Timing" may not be greater than nameplate timing.

Most Retarded Timing: The minimum timing at which the DSM system will allow a cylinder to retard in order to control detonation. Enter the most retarded timing for the Ignition Module's "D" lead grounded and the most retarded timing for the "D" lead open.

Default Timing: Default timing is the retarded ignition timing imposed by the DSM system when it is not protecting against detonation. The DSM system activates default timing for a cylinder when the cylinder's sensor is disabled, when the sensor fails, and during engine warm-up delay.

PROGRAMMING THE DSM SYSTEM FOR A NEW APPLICATION

End of Sample Window: The end of sample window is a predetermined angle after top dead center (ATDC) in crankshaft degrees at which the DSM system stops looking for detonation.

Retard X° Every Y Knock Sample(s): Allows you to select how fast the timing retards by changing the "X" and "Y" values. When an individual cylinder is in detonation, the timing retards "X" degrees for every "Y" consecutive times detonation is found.

Advance X° Every Y No-Knock Sample(s): Allows you to select how fast the timing advances by changing the "X" and "Y" values. Once an individual cylinder is no longer in detonation, the timing advances "X" degrees for every "Y" consecutive times the cylinder is not found to be detonating.

Warm-Up Delay Time: Allows you to select the amount of delay between the time the engine begins rotating and when the DSM system takes control. While this delay is active, the cylinders are operating at the default timing. The purpose of this delay is to prevent misleading

vibration signals, that may exist during the time the engine is warming up, from being incorrectly construed as "knock" signals. During the Warm-Up Delay Time, the DSM system is not protecting against detonation.

Shutdown Delay Time: Allows you to select the amount of delay between the moment when the cylinder reaches the Most Retarded Timing during detonation and the time the shutdown warning becomes active while still in detonation.

NOTE: Make sure to program the Shutdown Delay Time long enough to avoid unnecessary shutdowns. For example: If engine timing reaches the Maximum Retard limit AND the Shutdown Delay Time is shorter than the Advance Rate, shutdown may occur before the engine is allowed to advance at the programmed Advance Rate.

4. Continue with the next section, "Running The AutoCal Program," to establish detonation threshold so that the DSM system can operate properly.

Table 3.10-1. 8L-AT27GL DSM Data-Set Parameters¹

FUEL	AIR/FUEL RATIO (% EXHAUST O ₂)	DEFAULT TIMING VALUES (°BTDC)	MAX. ADVANCE ² (°BTDC)	MAX. RETARD (°BTDC)	END OF SAMPLE WINDOW	"D" LEAD
Natural Gas	28:1 (9.8)	6°	8°	2°	30°	OPEN
	32:1 (11.4)	18°	20°	8°	30°	GROUNDLED
Field Gas (115 Octane)	32:1 (11.4)	8°	10°	4°	30°	OPEN
Digester Gas	30:1 (10.5)	18°	20°	12°	30°	GROUNDLED
Landfill Gas	30:1 (10.5)	18°	22°	14°	30°	GROUNDLED
FUEL QUALITY:		64 WKI™ AND BELOW			64 WKI™ +	
Retard Rate		4° Every 1 Knock Sample(s)			1° Every 1 Knock Sample(s)	
Advance Rate		1° Every 5 No-Knock Sample(s)			1° Every 5 No-Knock Sample(s)	
Warm-Up Delay Time		300 Second(s)			300 Second(s)	
Shutdown Delay Time		5 Second(s)			15 Second(s)	

NOTE: ¹ The timing values listed apply to engines with the six hole prechamber cups.

² "Max. Advance" should never exceed nameplate timing.

PROGRAMMING THE DSM SYSTEM FOR A NEW APPLICATION

Table 3.10-2. 12V-AT27GL DSM Data-Set Parameters¹

FUEL	AIR/FUEL RATIO (% EXHAUST O ₂)	DEFAULT TIMING VALUES (°BTDC)	MAX. ADVANCE ² (°BTDC)	MAX. RETARD (°BTDC)	END OF SAMPLE WINDOW	"D" LEAD
Natural Gas	28:1 (9.8)	6°	8°	2°	30°	OPEN
	32:1 (11.4)	16°	18°	8°	30°	GROUNDED
Field Gas (115 Octane)	32:1 (11.4)	8°	10°	4°	30°	OPEN
Digester Gas	30:1 (10.5)	16°	18°	10°	30°	GROUNDED
Landfill Gas	30:1 (10.5)	16°	20°	12°	30°	GROUNDED
FUEL QUALITY:		64 WKI™ AND BELOW		64 WKI™ +		
Retard Rate		4° Every 1 Knock Sample(s)		1° Every 1 Knock Sample(s)		
Advance Rate		1° Every 5 No-Knock Sample(s)		1° Every 5 No-Knock Sample(s)		
Warm-Up Delay Time		300 Second(s)		300 Second(s)		
Shutdown Delay Time		5 Second(s)		15 Second(s)		

NOTE: ¹ The timing values listed apply to engines with the six hole prechamber cups.
² "Max. Advance" should never exceed nameplate timing.

Table 3.10-3. 12V-AT25GL DSM Data-Set Parameters

FUEL	AIR/FUEL RATIO (% EXHAUST O ₂)	DEFAULT TIMING VALUES (°BTDC)	MAX. ADVANCE ¹ (°BTDC)	MAX. RETARD (°BTDC)	END OF SAMPLE WINDOW	"D" LEAD
Natural Gas	28:1 (9.8)	8°	10°	4°	30°	OPEN
Digester Gas	28:1 (8.8)	12°	14°	8°	30°	OPEN
Landfill Gas	26:1 (8.8)	15°	17°	11°	30°	GROUNDED
FUEL QUALITY:		64 WKI™ AND BELOW		64 WKI™ +		
Retard Rate		3° Every 1 Knock Sample(s)		1° Every 1 Knock Sample(s)		
Advance Rate		1° Every 5 No-Knock Sample(s)		1° Every 5 No-Knock Sample(s)		
Warm-Up Delay Time		300 Second(s)		300 Second(s)		
Shutdown Delay Time		5 Second(s)		15 Second(s)		

NOTE: ¹ "Max. Advance" should never exceed nameplate timing.

Table 3.10-4. VHP DSM Data-Set Parameters

Most Advanced Timing	Nameplate Timing
Most Retarded Timing	Nameplate Timing - 6°
Default Timing	Nameplate Timing - 2°
End of Sample Window	30°
Retard X° Every Y Knock Sample(s)	Retard 1° Every 1 Sample Propane Only = Retard 3° Every 1 Sample
Advance X° Every Y No-Knock Sample(s)	1° Every 5 Samples
Warm-Up Delay Time	300 Seconds
Shutdown Delay Time	15 Seconds

Table 3.10-5. VGF DSM Data-Set Parameters

Most Advanced Timing	Nameplate Timing
Most Retarded Timing	Nameplate Timing - 6°
Default Timing	Nameplate Timing - 2°
End of Sample Window	30°
Retard X° Every Y Knock Sample(s)	Retard 2° Every 1 Sample Propane Only = Retard 3° Every 1 Sample
Advance X° Every Y No-Knock Sample(s)	1° Every 5 Samples
Warm-Up Delay Time	300 Seconds
Shutdown Delay Time	15 Seconds

PROGRAMMING THE DSM SYSTEM FOR A NEW APPLICATION

RUNNING THE AUTOCAL PROGRAM

The DSM AutoCal program is the automatic calibration of the detonation threshold levels by the DSM Interface Program. The DSM module monitors for detonation using the frequency output of each cylinder with engine mounted knock sensors. These knock sensors must be calibrated or "AutoCaled." During AutoCal, the knock sensors are calibrated so that the DSM system can operate properly.

An AutoCal should be run the first time the DSM is programmed for an engine or whenever a DSM is programmed for a new application. Additionally, the DSM system must be re-AutoCaled using the DSM Interface Program and a PC after doing any removal, repair, or replacement of engine cylinder heads, cylinder liners, cylinder gaskets, pistons, or knock sensors. This calibration **MUST BE** done using the AutoCal program as explained in this section.

CAUTION The sensors give an output even when the engine is not in detonation. The sensor output increases with load, so the engine must be at its **HIGHEST LOAD** during AutoCal. If the AutoCal program is run while the engine is at a lower load, an increase in load may be mistaken for detonation. The engine must be running at the maximum load and speed anticipated during normal operation.

NOTE: At light loads, engine characteristics are very different than at higher loads. Typically, this results in lower output from the knock sensors which, if low enough, will result in a "lost sensor" error even when the system is working properly. Errors may result at low loads after engine warm up. These errors go away once the engine is fully loaded. If "lost sensor" errors are experienced at low loads and do not correct themselves as the engine is fully loaded, refer to Section 4.00, DSM System Diagnostics And Troubleshooting.

1. Verify that the engine is running at the maximum load and speed anticipated during normal engine operation.

CAUTION Detonation must not be present while running AutoCal. If detonation occurs at any time during the calibration program, the AutoCal results must be discarded and the AutoCal program must be rerun.

2. Detach or copy the applicable AutoCal Worksheet from the back of this manual. The blue AutoCal Worksheet applies to 6, 8, and 12 cylinder engines (see Table 3.10-6 for sample worksheet). The yellow AutoCal Worksheet applies to 16 cylinder engines (see Table 3.10-7 for sample worksheet). Be sure to detach or copy the worksheet applicable to your engine application.

3. Verify that the View/Edit Control Data Values Screen is showing.

Table 3.10-6. AutoCal Worksheet For 6, 8, And 12 Cylinder Engines

SENSOR	SET-POINT "S" COLUMN RESULTS										HIGHEST "S" VALUE
	RUN #	RUN #	RUN #	RUN #	RUN #	RUN #	RUN #	RUN #	RUN #	RUN #	
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											

PROGRAMMING THE DSM SYSTEM FOR A NEW APPLICATION

Table 3.10-7. AutoCal Worksheet For 16 Cylinder Engines

SENSOR PAIRS	SET-POINT "S" COLUMN RESULTS										HIGHEST "S" VALUE
	RUN #	RUN #	RUN #	RUN #	RUN #	RUN #	RUN #	RUN #	RUN #	RUN #	
1 & 2											
3 & 4											
5 & 6											
7 & 8											
9 & 10											
11 & 12											
13 & 14											
15 & 16											

4. To begin AutoCal, press [F5] while viewing the View/Edit Control Data Values Screen. The AutoCal Screen appears. Figure 4.05-3 shows the AutoCal Screen for 6, 8, and 12 cylinder engine applications. Figure 4.05-4 shows the AutoCal Screen for 16 cylinder engine applications.

NOTE: The AutoCal results shown in the figures and tables provided in this manual are for example only. Actual AutoCal values will vary depending on the application.

NOTE: "L" = Low, "M" = Medium, "H" = High, "S" = Set-Point in Figure 3.10-23 and Figure 4.05-4.

5. Verify that the "AutoCal Test Timing" on the AutoCal Screen (see Figure 3.10-23 or Figure 3.10-24) is the same as that fuel's "Most Advanced Timing" (grounded or open, whichever is applicable) on the View/Edit Control Data Values Screen (see Figure 3.10-25). If the "AutoCal Test Timing" is not the same as "Most Advanced Timing," enter the "Most Advanced Timing" on the AutoCal Screen.

NOTE: AutoCal will default to the "D" lead grounded ignition setting which is "Most Advanced Timing." For secondary fuel (or "D" lead open), the AutoCal Screen test timing value may need to be edited as explained in Step 5.

AUTOCAL TEST TIMING

Automatic Calibration of Detonation Sensor Threshold Voltages

AutoCal Test Timing 10 °BTDC

Messages:

AutoCal	L	M	H	S
Sensor 1				
Sensor 2				
Sensor 3				
Sensor 4				
Sensor 5				
Sensor 6				
Sensor 7				
Sensor 8				
Sensor 9				
Sensor 10				
Sensor 11				
Sensor 12				

Engine Timing for Autocal Program. <F10> Accepts, <ESC> Aborts

Figure 3.10-23. AutoCal Screen For 6, 8, And 12 Cylinder Engines

PROGRAMMING THE DSM SYSTEM FOR A NEW APPLICATION

AUTOCAL TEST TIMING Automatic Calibration of Detonation Sensor Threshold Voltages

AutoCal Test Timing 10 °BTDC

Messages:

AutoCal	L	M	H	S
Sensors 1 & 2				
Sensors 3 & 4				
Sensors 5 & 6				
Sensors 7 & 8				
Sensors 9 & 10				
Sensors 11 & 12				
Sensors 13 & 14				
Sensors 15 & 16				

Engine Timing for Autocal Program. <F10> Accepts, <ESC> Aborts

Figure 3.10-24. AutoCal Screen For 16 Cylinder Engines

MOST ADVANCED TIMING View/Edit Control Data Values

Engine Family V-12 GAS ENGINE
 Engine Model : L70 V-12
 # of Cylinders : 12
 Primary Fuel : NATURAL GAS PIPELINE QUALITY
 Secondary Fuel : DIESETER GAS
 Comments:

Timing Disk Reference 26 °BTDC
 <F3> To Calculate TDR
 D-Lead Position - - -> Grounded Open
 Most Advanced Timing 10 °BTDC 10 °BTDC
 Most Retarded Timing 4 °BTDC 4 °BTDC
 Default Timing 8 °BTDC 8 °BTDC
 End of Sample Window 30 °ATDC

Retard 1° Every 1 Knock Sample(s)
 Advance 1° Every 5 No-Knock Sample(s)

Warm-Up Delay Time 300 Seconds
 Shutdown Delay Time 15 Seconds

Detonation Level Select

Sensor 1	2500 mV
Sensor 2	2500 mV
Sensor 3	2500 mV
Sensor 4	2500 mV
Sensor 5	2500 mV
Sensor 6	2500 mV
Sensor 7	2500 mV
Sensor 8	2500 mV
Sensor 9	2500 mV
Sensor 10	2500 mV
Sensor 11	2500 mV
Sensor 12	2500 mV

NOTE: Entries above 2400mV result in a Disabled Sensor.

<F10> to Save
<ESC> to Main Menu
<F5> to AUTOCAL

Figure 3.10-25. View/Edit Control Data Values Screen

PROGRAMMING THE DSM SYSTEM FOR A NEW APPLICATION

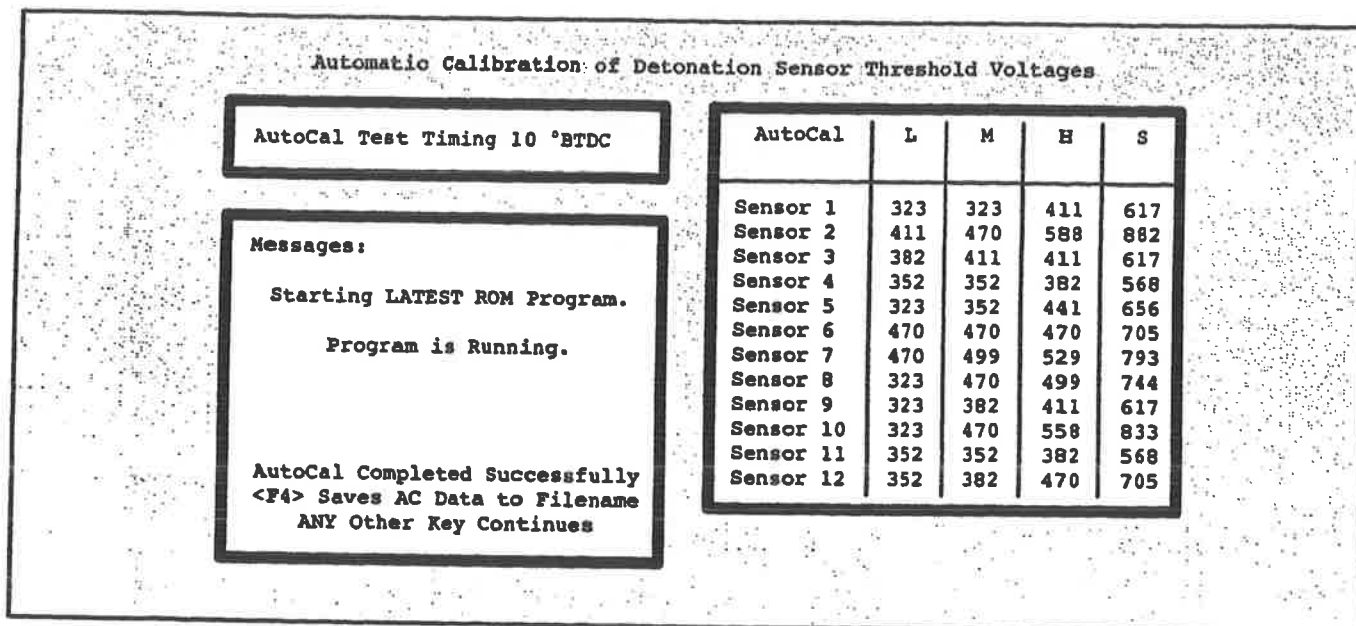


Figure 3.10-26. Completion Of AutoCal Program

6. Press [F10] to accept the "AutoCal Test Timing" value and begin the AutoCal program. Calibration numbers for each sensor will begin appearing in the "S" or Set-Point column. When the calibration process is completed your screen will resemble the screen shown in Figure 3.10-26.

NOTE: If any errors occur during the AutoCal program they will be displayed as LOW, STAL, or HISP in the Set-Point column on the AutoCal Screen. Additionally, an error message will be provided in the "Messages" box on the AutoCal Screen stating, "AutoCal Completed With ERRORS." See Section 4.00, DSM System Diagnostics And Troubleshooting, to correct problem. Once the problem is corrected, rerun AutoCal.

NOTE: If an HISP or STAL error occurs, the AutoCal Program will stop as soon as the error is detected. If a LOW error occurs, the AutoCal program will continue but the AutoCal results on the View/Edit Control Data Values Screen will NOT be updated.

NOTE: To save your AutoCal results to a file, press [F4] after running the AutoCal program. Follow the instructions on the screens that follow. The file will be saved to the drive and directory where the DSM Interface Program is located. This file is NOT retrievable through

the DSM but can be opened outside of the DSM program in Microsoft® Notepad® or a word processing program and then printed. Saving the AutoCal results to a file is NOT a substitute for saving to ROM. Be sure to save the FINAL AutoCal results to ROM as explained in the following section, "Saving Data-Set to ROM."

7. In a "RUN #" column on your AutoCal Worksheet, record the values listed in the "S" or Set-Point column on the AutoCal Screen. For example, the values in the "S" or Set-Point column on the AutoCal Screen in Figure 3.10-26 are recorded in the sample AutoCal Worksheet shown in Table 3.10-8.

NOTE: If you have a portable printer connected to your PC, press the [Print Screen] button for a printout of the AutoCal Screen.

8. Press any key to continue. You will return to the View/Edit Control Data Values Screen. The "S" or Set-Point values just determined during the AutoCal program appears in the "Detonation Level Select" table on the right hand side of the View/Edit Control Data Values Screen (see Figure 3.10-27).

PROGRAMMING THE DSM SYSTEM FOR A NEW APPLICATION

Table 3.10-8. AutoCal Worksheet Example - Run # 1 Results

SENSOR	SET-POINT "S" COLUMN RESULTS										HIGHEST "S" VALUE
	RUN # 1	RUN # ___	RUN # ___	RUN # ___	RUN # ___	RUN # ___	RUN # ___	RUN # ___	RUN # ___	RUN # ___	
1	617										
2	882										
3	617										
4	568										
5	656										
6	705										
7	793										
8	744										
9	617										
10	833										
11	568										
12	705										

NOTE: The AutoCal results shown in the figures and tables provided in this manual are for example only. Actual AutoCal values will vary depending on the application.

View/Edit Control Data Values

<p>Engine Family : VHP GAS ENGINE Engine Model : L7042 V-12 # of Cylinders: 12 Primary Fuel : NATURAL GAS PIPELINE QUALITY Secondary Fuel: DIGESTER GAS Comments:</p> <hr/> <p>Timing Disk Reference 26 °BTDC <F3> To Calculate TDR</p> <p>D-Lead Position - - -> Grounded Open</p> <p>Most Advanced Timing 10 °BTDC 10 °BTDC</p> <p>Most Retarded Timing 4 °BTDC 4 °BTDC</p> <p>Default Timing 8 °BTDC 8 °BTDC</p> <p>End of Sample Window 30 °ATDC</p> <hr/> <p>Retard 1° Every 1 Knock Sample(s)</p> <p>Advance 1° Every 5 No-Knock Sample(s)</p> <hr/> <p>Warm-Up Delay Time 300 Seconds</p> <p>Shutdown Delay Time 15 Seconds</p>	<p style="text-align: center;">Detonation Level Select</p> <table style="width: 100%; border-collapse: collapse;"> <tr><td>Sensor 1</td><td>617</td><td>mV</td></tr> <tr><td>Sensor 2</td><td>882</td><td>mV</td></tr> <tr><td>Sensor 3</td><td>617</td><td>mV</td></tr> <tr><td>Sensor 4</td><td>568</td><td>mV</td></tr> <tr><td>Sensor 5</td><td>656</td><td>mV</td></tr> <tr><td>Sensor 6</td><td>705</td><td>mV</td></tr> <tr><td>Sensor 7</td><td>793</td><td>mV</td></tr> <tr><td>Sensor 8</td><td>744</td><td>mV</td></tr> <tr><td>Sensor 9</td><td>617</td><td>mV</td></tr> <tr><td>Sensor 10</td><td>833</td><td>mV</td></tr> <tr><td>Sensor 11</td><td>568</td><td>mV</td></tr> <tr><td>Sensor 12</td><td>705</td><td>mV</td></tr> </table>	Sensor 1	617	mV	Sensor 2	882	mV	Sensor 3	617	mV	Sensor 4	568	mV	Sensor 5	656	mV	Sensor 6	705	mV	Sensor 7	793	mV	Sensor 8	744	mV	Sensor 9	617	mV	Sensor 10	833	mV	Sensor 11	568	mV	Sensor 12	705	mV
Sensor 1	617	mV																																			
Sensor 2	882	mV																																			
Sensor 3	617	mV																																			
Sensor 4	568	mV																																			
Sensor 5	656	mV																																			
Sensor 6	705	mV																																			
Sensor 7	793	mV																																			
Sensor 8	744	mV																																			
Sensor 9	617	mV																																			
Sensor 10	833	mV																																			
Sensor 11	568	mV																																			
Sensor 12	705	mV																																			

NOTE: Entries above 2400mV result in a Disabled Sensor.

<F10> to Save
<ESC> to Main Menu
<F5> to AUTOCAL

Figure 3.10-27. View/Edit Control Data Values Screen With Preliminary AutoCal Results

PROGRAMMING THE DSM SYSTEM FOR A NEW APPLICATION

9. Rerun the AutoCal program two additional times following Steps 4 - 8. Be sure to record the "S" or Set-Point column results for each AutoCal you run on the AutoCal Worksheet.
10. Press any key to continue. You will return to the View/Edit Control Data Values Screen. The values determined by the last AutoCal program you ran appears in the "Detonation Level Select" table on the right hand side of the View/Edit Control Data Values Screen.
11. If this is a dual fuel application and if possible, change fuels going to the engine and repeat Steps 3 - 10 to run the AutoCal program while running on the secondary fuel and timing. Record all "S" or Set-Point values determined by the AutoCal program for each sensor on the AutoCal Worksheet.
12. After running the AutoCal programs, circle the highest "S" or Set-Point value calibrated during all the AutoCals for each sensor on the worksheet (see Table 3.10-9).
13. Record the circled (highest) "S" or Set-Point value in the "Highest 'S' Value" column on the worksheet (see Table 3.10-9).
14. Compare the "S" or Set-Point values for each sensor recorded in the "Highest 'S' Value" column on your worksheet. If the results determined for each sensor vary by more than 500 from one sensor to another, refer to Table 4.00-4 in Section 4.00, *DSM System Diagnostics And Troubleshooting*. If the values do vary by more than 500 from sensor to sensor it may indicate 1) engine detonation, 2) sensor mounting imperfections, 3) unattached or incorrectly routed wire harnesses and/or ground wiring, or 4) other engine related problems. The troubleshooting table in Section 4.00 provides you with remedies.
15. With the View/Edit Control Data Values Screen showing, position the cursor in the "Detonation Level Select" table on the screen.
16. Enter the highest set-point value calibrated for each sensor in the "Detonation Level Select" table on the View/Edit Control Data Values Screen (see Figure 4.05-8). These values are recorded on your AutoCal Worksheet in the "Highest 'S' Value" column. For example, in Figure 3.10-28, "656" was entered since it was the highest detonation level calibrated for Sensor 1 during all AutoCal programs completed.
17. Continue with the next section, "Saving Data-Set To ROM." **Make sure to complete the next section. Data-sets NOT saved to ROM are lost when power is disconnected from the DSM module.**

PROGRAMMING THE DSM SYSTEM FOR A NEW APPLICATION

Table 3.10-9. AutoCal Worksheet Example - Completed Results

SENSOR	SET-POINT "S" COLUMN RESULTS										HIGHEST "S" VALUE
	RUN # 1	RUN # 2	RUN # 3	RUN # ___	RUN # ___	RUN # ___	RUN # ___	RUN # ___	RUN # ___	RUN # ___	
1	617	617	656								656
2	882	833	793								882
3	617	705	656								705
4	568	568	617								617
5	656	656	705								705
6	705	656	617								705
7	793	744	833								833
8	744	793	793								793
9	617	656	656								656
10	833	793	882								882
11	568	568	617								617
12	705	744	705								744

NOTE: The AutoCal results shown in the figures and tables provided in this manual are for example only. Actual AutoCal values will vary depending on the application.

View/Edit Control Data Values

<p>Engine Family : VHP GAS ENGINE Engine Model : L7042 V-12 # of Cylinders: 12 Primary Fuel : NATURAL GAS PIPELINE QUALITY Secondary Fuel: DIGESTER GAS Comments:</p> <hr/> <p>Timing Disk Reference 26 °BTDC <F3> To Calculate TDR D-Lead Position - - -> Grounded Open Most Advanced Timing 10 °BTDC 10 °BTDC Most Retarded Timing 4 °BTDC 4 °BTDC Default Timing 8 °BTDC 8 °BTDC End of Sample Window 30 °ATDC</p> <hr/> <p>Retard 1° Every 1 Knock Sample(s) Advance 1° Every 5 No-Knock Sample(s)</p> <hr/> <p>Warm-Up Delay Time 300 Seconds Shutdown Delay Time 15 Seconds</p>	<p>Detonation Level Select</p> <table style="width: 100%; border-collapse: collapse;"> <tr><td>Sensor 1</td><td>656 mV</td></tr> <tr><td>Sensor 2</td><td>882 mV</td></tr> <tr><td>Sensor 3</td><td>705 mV</td></tr> <tr><td>Sensor 4</td><td>617 mV</td></tr> <tr><td>Sensor 5</td><td>705 mV</td></tr> <tr><td>Sensor 6</td><td>705 mV</td></tr> <tr><td>Sensor 7</td><td>833 mV</td></tr> <tr><td>Sensor 8</td><td>793 mV</td></tr> <tr><td>Sensor 9</td><td>656 mV</td></tr> <tr><td>Sensor 10</td><td>882 mV</td></tr> <tr><td>Sensor 11</td><td>617 mV</td></tr> <tr><td>Sensor 12</td><td>744 mV</td></tr> </table>	Sensor 1	656 mV	Sensor 2	882 mV	Sensor 3	705 mV	Sensor 4	617 mV	Sensor 5	705 mV	Sensor 6	705 mV	Sensor 7	833 mV	Sensor 8	793 mV	Sensor 9	656 mV	Sensor 10	882 mV	Sensor 11	617 mV	Sensor 12	744 mV
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Sensor 10	882 mV																								
Sensor 11	617 mV																								
Sensor 12	744 mV																								

NOTE: Entries above 2400mV result in a Disabled Sensor.

<F10> to Save <ESC> to Main Menu <F5> to AUTOCAL

Figure 3.10-28. View/Edit Control Data Values Screen With Completed AutoCal Results

PROGRAMMING THE DSM SYSTEM FOR A NEW APPLICATION

SAVING DATA-SET TO ROM

1. Save the edited data-set to ROM (permanent memory) on the EPROM chip in the DSM module. Press [F10] for the Saving Options Menu.
2. Highlight "Configure DSM Memory" on the menu and press [Enter] (see Figure 3.10-29).

NOTE: The "Test Data on DSM" option from the Save Options Menu allows a program to be run in the DSM module's temporary memory (RAM). This may be used for troubleshooting so that the ROM memory space is

preserved. The contents of RAM are lost whenever power to the DSM module is removed.

3. When the Verification Screen appears as shown in Figure 3.10-30, press [Y].

CAUTION Do not disturb the serial cable or interrupt computer power while programming. If the serial cable is disturbed or disconnected during the saving process, the EPROM chip in the DSM module will become corrupted and will need to be replaced.

View/Edit Control Data Values

<p>Engine Family : VHP GAS ENGINE Engine Model : L7042 V-12 # of Cylinders: 12 Primary Fuel : NATURAL Secondary Fuel: DIGESTE Comments:</p> <p>Timing Disk Reference <F3> To Calculate LDR</p> <table style="width: 100%; border-collapse: collapse;"> <tr> <td>D-Lead Position -- --></td> <td>Grounded</td> <td>Open</td> </tr> <tr> <td>Most Advanced Timing</td> <td>10 °BTDC</td> <td>10 °BTDC</td> </tr> <tr> <td>Most Retarded Timing</td> <td>4 °BTDC</td> <td>4 °BTDC</td> </tr> <tr> <td>Default Timing</td> <td>8 °BTDC</td> <td>8 °BTDC</td> </tr> <tr> <td>End of Sample Window</td> <td>30 °ATDC</td> <td></td> </tr> </table> <p>Retard 1° Every 1 Knock Sample(s) Advance 1° Every 5 No-Knock Sample(s)</p> <p>Warm-Up Delay Time 300 Seconds Shutdown Delay Time 15 Seconds</p>	D-Lead Position -- -->	Grounded	Open	Most Advanced Timing	10 °BTDC	10 °BTDC	Most Retarded Timing	4 °BTDC	4 °BTDC	Default Timing	8 °BTDC	8 °BTDC	End of Sample Window	30 °ATDC		<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="2" style="text-align: center;">Detonation Level Select</th> </tr> </thead> <tbody> <tr><td>Sensor 1</td><td>656 mV</td></tr> <tr><td>Sensor 2</td><td>882 mV</td></tr> <tr><td>Sensor 3</td><td>705 mV</td></tr> <tr><td>Sensor 4</td><td>617 mV</td></tr> <tr><td>Sensor 5</td><td>705 mV</td></tr> <tr><td>Sensor 6</td><td>705 mV</td></tr> <tr><td>Sensor 7</td><td>833 mV</td></tr> <tr><td>Sensor 8</td><td>793 mV</td></tr> <tr><td>Sensor 9</td><td>656 mV</td></tr> <tr><td>Sensor 10</td><td>882 mV</td></tr> <tr><td>Sensor 11</td><td>617 mV</td></tr> <tr><td>Sensor 12</td><td>744 mV</td></tr> </tbody> </table> <p style="font-size: small;">NOTE: Entries above 2400mV result in a Disabled Sensor.</p>	Detonation Level Select		Sensor 1	656 mV	Sensor 2	882 mV	Sensor 3	705 mV	Sensor 4	617 mV	Sensor 5	705 mV	Sensor 6	705 mV	Sensor 7	833 mV	Sensor 8	793 mV	Sensor 9	656 mV	Sensor 10	882 mV	Sensor 11	617 mV	Sensor 12	744 mV
D-Lead Position -- -->	Grounded	Open																																								
Most Advanced Timing	10 °BTDC	10 °BTDC																																								
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Sensor 10	882 mV																																									
Sensor 11	617 mV																																									
Sensor 12	744 mV																																									

Save Data to Filename
 Test Data on DSM
Configure DSM Memory
 View Wiring Data

<F10> to Save
<ESC> to Main Menu
<F5> to AUTOCAL

Figure 3.10-29. Saving Options Menu

View/Edit Control Data Values

<p>Engine Family : VHP GAS ENGINE Engine Model : L7042 V-12 # of Cylinders: 12 Primary Fuel : NATURAL GAS PIPELINE QUALITY Secondary Fuel: Comments:</p> <p>Timing Disk Reference <F3></p> <p>D-Lead Position Most Advanced Timing Most Retarded Timing Default Timing End of Sample Window</p> <p>Retard 1° Every Advance 1° Every</p> <p>Warm-Up Delay Time 300 Seconds Shutdown Delay Time 15 Seconds</p>	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="2" style="text-align: center;">Detonation Level Select</th> </tr> </thead> <tbody> <tr><td>1</td><td>656 mV</td></tr> <tr><td>2</td><td>882 mV</td></tr> <tr><td>3</td><td>705 mV</td></tr> <tr><td>4</td><td>617 mV</td></tr> <tr><td>5</td><td>705 mV</td></tr> <tr><td>6</td><td>705 mV</td></tr> <tr><td>7</td><td>833 mV</td></tr> <tr><td>8</td><td>793 mV</td></tr> <tr><td>9</td><td>656 mV</td></tr> <tr><td>10</td><td>882 mV</td></tr> <tr><td>11</td><td>617 mV</td></tr> <tr><td>12</td><td>744 mV</td></tr> </tbody> </table> <p style="font-size: small;">NOTE: Entries above 2400mV result in a Disabled Sensor.</p>	Detonation Level Select		1	656 mV	2	882 mV	3	705 mV	4	617 mV	5	705 mV	6	705 mV	7	833 mV	8	793 mV	9	656 mV	10	882 mV	11	617 mV	12	744 mV
Detonation Level Select																											
1	656 mV																										
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4	617 mV																										
5	705 mV																										
6	705 mV																										
7	833 mV																										
8	793 mV																										
9	656 mV																										
10	882 mV																										
11	617 mV																										
12	744 mV																										

OK to Store New Values?

Yes
No esc

<F10> to Save
<ESC> to Main Menu
<F5> to AUTOCAL

Figure 3.10-30. Verification Screen

PROGRAMMING THE DSM SYSTEM FOR A NEW APPLICATION

4. Several screens will appear indicating that the data-set is being saved to ROM, permanent memory on the EPROM chip inside the DSM module. Once the data-set has been saved to ROM, the message shown in Figure 3.10-31 appears.

NOTE: The DSM allows 25 saves to ROM. Once ROM has been fully configured, the EPROM chip in the DSM module must be replaced to permit further saves to permanent memory.

5. Press any key to continue and the View/Edit Control Data Values Screen appears (see Figure 3.10-32).

NOTE: Make copies of your data-set for future reference. If a printer is connected to your PC, press [Print Screen] on the keyboard.

View/Edit Control Data Values

Engine Family : VHP GAS ENGINE Engine Model : L7042 V-12 # of Cylinders: 12 Primary Fuel : Secondary Fuel: Comments:	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="2" style="text-align: center;">Detonation Level Select</th> </tr> </thead> <tbody> <tr><td style="text-align: center;">1</td><td style="text-align: right;">656 mV</td></tr> <tr><td style="text-align: center;">2</td><td style="text-align: right;">882 mV</td></tr> <tr><td style="text-align: center;">3</td><td style="text-align: right;">705 mV</td></tr> <tr><td style="text-align: center;">4</td><td style="text-align: right;">617 mV</td></tr> <tr><td style="text-align: center;">5</td><td style="text-align: right;">705 mV</td></tr> <tr><td style="text-align: center;">6</td><td style="text-align: right;">705 mV</td></tr> <tr><td style="text-align: center;">7</td><td style="text-align: right;">833 mV</td></tr> <tr><td style="text-align: center;">8</td><td style="text-align: right;">793 mV</td></tr> <tr><td style="text-align: center;">9</td><td style="text-align: right;">656 mV</td></tr> <tr><td style="text-align: center;">10</td><td style="text-align: right;">882 mV</td></tr> <tr><td style="text-align: center;">11</td><td style="text-align: right;">617 mV</td></tr> <tr><td style="text-align: center;">12</td><td style="text-align: right;">744 mV</td></tr> </tbody> </table>	Detonation Level Select		1	656 mV	2	882 mV	3	705 mV	4	617 mV	5	705 mV	6	705 mV	7	833 mV	8	793 mV	9	656 mV	10	882 mV	11	617 mV	12	744 mV
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7	833 mV																										
8	793 mV																										
9	656 mV																										
10	882 mV																										
11	617 mV																										
12	744 mV																										
Starting ROM3 Program DSM Memory has been Configured. Program Is Running. Press ANY KEY to Continue																											
Timing Disk Reference <F3> D-Lead Position Most Advanced Timing Most Retarded Timing Default Timing End of Sample Window	Retard 1° Every Advance 1° Every 5 No-Knock Sample(s)																										
Warm-Up Delay Time 300 Seconds Shutdown Delay Time 15 Seconds																											

<F10> to Save
<ESC> to Main Menu
<F5> to AUTOCAL

Figure 3.10-31. Verification Screen Of Save To ROM

View/Edit Control Data Values

Engine Family : VHP GAS ENGINE Engine Model : L7042 V-12 # of Cylinders: 12 Primary Fuel : NATURAL GAS PIPELINE QUALITY Secondary Fuel: DIGESTER GAS Comments:	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="2" style="text-align: center;">Detonation Level Select</th> </tr> </thead> <tbody> <tr><td style="text-align: center;">Sensor 1</td><td style="text-align: right;">656 mV</td></tr> <tr><td style="text-align: center;">Sensor 2</td><td style="text-align: right;">882 mV</td></tr> <tr><td style="text-align: center;">Sensor 3</td><td style="text-align: right;">705 mV</td></tr> <tr><td style="text-align: center;">Sensor 4</td><td style="text-align: right;">617 mV</td></tr> <tr><td style="text-align: center;">Sensor 5</td><td style="text-align: right;">705 mV</td></tr> <tr><td style="text-align: center;">Sensor 6</td><td style="text-align: right;">705 mV</td></tr> <tr><td style="text-align: center;">Sensor 7</td><td style="text-align: right;">833 mV</td></tr> <tr><td style="text-align: center;">Sensor 8</td><td style="text-align: right;">793 mV</td></tr> <tr><td style="text-align: center;">Sensor 9</td><td style="text-align: right;">656 mV</td></tr> <tr><td style="text-align: center;">Sensor 10</td><td style="text-align: right;">882 mV</td></tr> <tr><td style="text-align: center;">Sensor 11</td><td style="text-align: right;">617 mV</td></tr> <tr><td style="text-align: center;">Sensor 12</td><td style="text-align: right;">744 mV</td></tr> </tbody> </table>	Detonation Level Select		Sensor 1	656 mV	Sensor 2	882 mV	Sensor 3	705 mV	Sensor 4	617 mV	Sensor 5	705 mV	Sensor 6	705 mV	Sensor 7	833 mV	Sensor 8	793 mV	Sensor 9	656 mV	Sensor 10	882 mV	Sensor 11	617 mV	Sensor 12	744 mV
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Sensor 10	882 mV																										
Sensor 11	617 mV																										
Sensor 12	744 mV																										
Timing Disk Reference 26 °BTDC <F3> To Calculate TDR D-Lead Position - - -> Grounded Open																											
Most Advanced Timing 10 °BTDC 10 °BTDC Most Retarded Timing 4 °BTDC 4 °BTDC Default Timing 8 °BTDC 8 °BTDC End of Sample Window 30 °ATDC																											
Retard 1° Every 1 Knock Sample(s) Advance 1° Every 5 No-Knock Sample(s)																											
Warm-Up Delay Time 300 Seconds Shutdown Delay Time 15 Seconds																											

<F10> to Save
<ESC> to Main Menu
<F5> to AUTOCAL

Figure 3.10-32. View/Edit Control Data Values Screen

PROGRAMMING THE DSM SYSTEM FOR A NEW APPLICATION

SAVING DATA-SET TO DISK

Data-sets are assigned filenames and saved on disk so the user can retain the data-set for future reference. Each time a new program is saved to ROM, the previous program can no longer be retrieved. The only way to keep track of old data-sets is to save to disk.

NOTE: When saving to disk, the data-set will be saved to the drive and directory where the DSM Interface Program is located.

1. Save this program to disk by pressing [F10] (see Figure 3.10-33).
2. Highlight "Save Data to Filename" from the menu and press [Enter].
3. Enter a filename according to the following procedure (see Figure 3.10-34). Read all three steps prior to saving the file to the disk.
 - A. Locate the engine's serial number on the name-plate.
 - B. If the engine has a "C-" number, remove the "C-" and the "/" from the number.

Example: C-10768/01 would give a root file name of "1076801". If the engine does not have a "C-" number use all six digits in the serial number for the filename.

- C. The first time the configuration is saved to the disk add an "A" to the end. This is to indicate that this is the first save of this configuration. If changes are made to the configuration, save the next file with the same numerical information and change the suffix letter to "B". Continue in this manner for each revision to the file.

Once eight characters have been entered, the file will automatically be saved to the PC disk where the DSM program resides. If the filename is less than eight characters, press [Enter] to save.

4. Press [ESC] to return to the Main Menu.
5. If the data-set for your engine has been saved to ROM and a file on disk, confirm the exit to the Main Menu by pressing [Y] (see Figure 3.10-35) and the Main Menu appears. If you have not saved the data-set to ROM (permanent memory), press [N] and refer to "Saving Data-Set To ROM" in this section.

View/Edit Control Data Values

Engine Family : VHP GAS ENGINE	
Engine Model : L7042 V-12	
# of Cylinders : 12	
Primary Fuel : NATURAL	
Secondary Fuel: DIGESTED	
Comments:	
Timing Disk Reference	
<F3> To Calculate ROM	
D-Lead Position - - ->	Grounded Open
Most Advanced Timing	10 °BTDC 10 °BTDC
Most Retarded Timing	4 °BTDC 4 °BTDC
Default Timing	8 °BTDC 8 °BTDC
End of Sample Window	30 °ATDC
Retard 1° Every	1 Knock Sample(s)
Advance 1° Every	5 No-Knock Sample(s)
Warm-Up Delay Time	300 Seconds
Shutdown Delay Time	15 Seconds

Save Data to Filename
Test Data on DSM
Configure DSM Memory
View Wiring Data

Detonation Level Select		
Sensor 1	656	mV
Sensor 2	882	mV
Sensor 3	705	mV
Sensor 4	617	mV
Sensor 5	705	mV
Sensor 6	705	mV
Sensor 7	833	mV
Sensor 8	793	mV
Sensor 9	656	mV
Sensor 10	882	mV
Sensor 11	617	mV
Sensor 12	744	mV

NOTE: Entries above 2400mV result in a Disabled Sensor.

<F10> to Save <ESC> to Main Menu <F5> to AUTOCAL

Figure 3.10-33. Saving Options Menu

PROGRAMMING THE DSM SYSTEM FOR A NEW APPLICATION

View/Edit Control Data Values

<p>Engine Family : VHP GAS ENGINE Engine Model : L7042 V-12 # of Cylinders: 12 Primary Fuel : Secondary Fuel: Comments:</p> <p>Timing Disk Refe <F3></p> <p>D-Lead Position Most Advanced T Most Retarded T Default Timing End of Sample W</p> <p>Retard 1° Eve Advance 1° Every 5 No-Knock Sample(s)</p> <p>Warm-Up Delay Time 300 Seconds Shutdown Delay Time 15 Seconds</p>	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="2" style="text-align: center;">Detonation Level Select</th> </tr> </thead> <tbody> <tr><td>r 1</td><td>656 mV</td></tr> <tr><td>r 2</td><td>882 mV</td></tr> <tr><td>r 3</td><td>705 mV</td></tr> <tr><td>r 4</td><td>617 mV</td></tr> <tr><td>r 5</td><td>705 mV</td></tr> <tr><td>r 6</td><td>705 mV</td></tr> <tr><td>r 7</td><td>833 mV</td></tr> <tr><td>r 8</td><td>793 mV</td></tr> <tr><td>r 9</td><td>656 mV</td></tr> <tr><td>r 10</td><td>882 mV</td></tr> <tr><td>r 11</td><td>617 mV</td></tr> <tr><td>r 12</td><td>744 mV</td></tr> </tbody> </table> <p style="font-size: small;">NOTE: Entries above 2400mV result in a Disabled Sensor.</p>	Detonation Level Select		r 1	656 mV	r 2	882 mV	r 3	705 mV	r 4	617 mV	r 5	705 mV	r 6	705 mV	r 7	833 mV	r 8	793 mV	r 9	656 mV	r 10	882 mV	r 11	617 mV	r 12	744 mV
Detonation Level Select																											
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r 7	833 mV																										
r 8	793 mV																										
r 9	656 mV																										
r 10	882 mV																										
r 11	617 mV																										
r 12	744 mV																										

Save Choices to Disk

Input DataFile Name

<F10> to Save <ESC> to Main Menu <F5> to AUTOCAL

Figure 3.10-34. Entering Filename Of Data-Set

View/Edit Control Data Values

<p>Engine Family : VHP GAS ENGINE Engine Model : L7042 V-12 # of Cylinders: 12 Primary Fuel : Secondary Fuel: Comments:</p> <p>Timing Disk Refe <F3></p> <p>D-Lead Position Most Advanced T Most Retarded T Default Timing End of Sample W</p> <p>Retard 1° Eve Advance 1° Every 5 No-Knock Sample(s)</p> <p>Warm-Up Delay Time 300 Seconds Shutdown Delay Time 15 Seconds</p>	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="2" style="text-align: center;">Detonation Level Select</th> </tr> </thead> <tbody> <tr><td>r 1</td><td>656 mV</td></tr> <tr><td>r 2</td><td>882 mV</td></tr> <tr><td>r 3</td><td>705 mV</td></tr> <tr><td>r 4</td><td>617 mV</td></tr> <tr><td>r 5</td><td>705 mV</td></tr> <tr><td>r 6</td><td>705 mV</td></tr> <tr><td>r 7</td><td>833 mV</td></tr> <tr><td>r 8</td><td>793 mV</td></tr> <tr><td>r 9</td><td>656 mV</td></tr> <tr><td>r 10</td><td>882 mV</td></tr> <tr><td>r 11</td><td>617 mV</td></tr> <tr><td>r 12</td><td>744 mV</td></tr> </tbody> </table> <p style="font-size: small;">NOTE: Entries above 2400mV result in a Disabled Sensor.</p>	Detonation Level Select		r 1	656 mV	r 2	882 mV	r 3	705 mV	r 4	617 mV	r 5	705 mV	r 6	705 mV	r 7	833 mV	r 8	793 mV	r 9	656 mV	r 10	882 mV	r 11	617 mV	r 12	744 mV
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r 7	833 mV																										
r 8	793 mV																										
r 9	656 mV																										
r 10	882 mV																										
r 11	617 mV																										
r 12	744 mV																										

Exit to Main Menu

Changes Will be Lost if
 you Have Not Saved Them.

Do You REALLY Want to EXIT?

Yes

No esc

<F10> to Save <ESC> to Main Menu <F5> to AUTOCAL

Figure 3.10-35. Confirmation Of Exit

PROGRAMMING THE DSM SYSTEM FOR A NEW APPLICATION

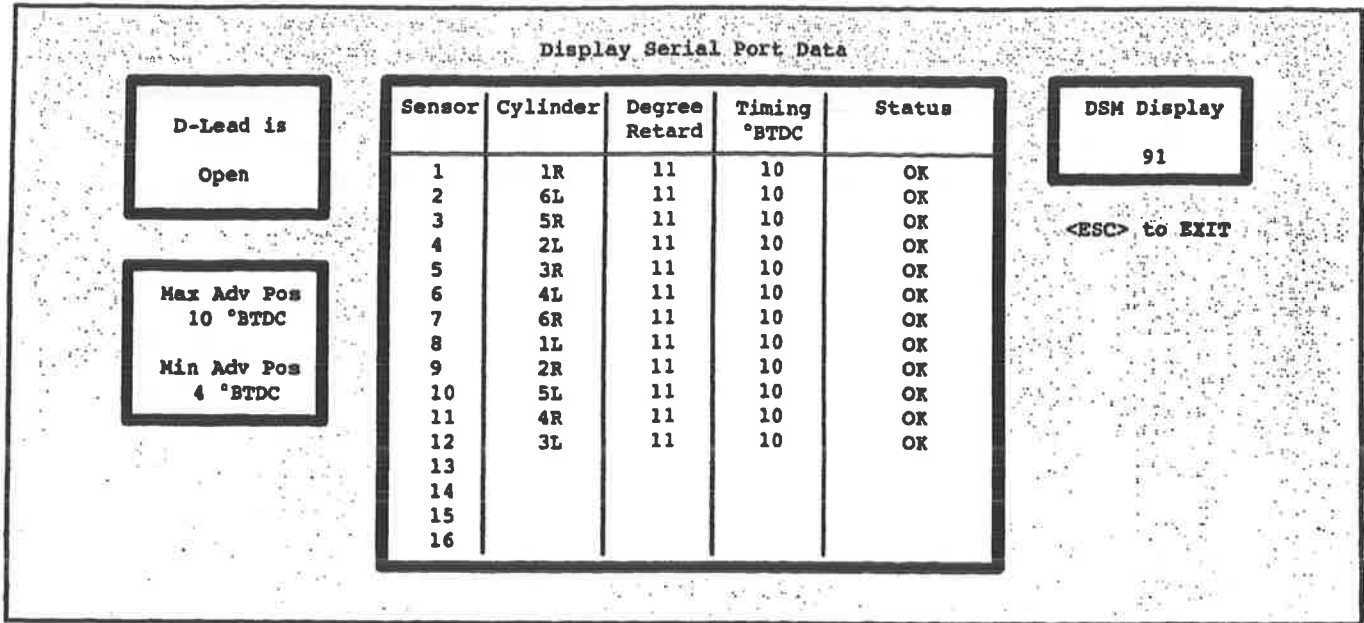


Figure 3.10-36. Display Serial Port Data Screen

POST-PROGRAMMING CHECKS

After the engine has been successfully started, the engine timing verified, and the AutoCal program completed, you need to complete a check of the system to verify that the DSM system is working properly.

Several programming checks must be completed. The procedures that follow take you step-by-step through the programming checks. Make copies of your data-set or save your data-set to a file for future reference.

CHECK 1: CHECKING FOR PROPER SENSOR CONNECTION

Viewing Display Serial Port Data Screen

1. Highlight "View Serial Link" on the Main Menu and press [Enter] (see Figure 3.10-37). The Display Serial Port Data Screen appears (see Figure 3.10-36). Information such as engine timing will vary depending on the application.

NOTE: If the engine is not running and the "D" lead is switched on the CEC Ignition Module (Models 811, 1211, 1611), the "D" lead status will not update immediately on the Display Serial Port Data Screen. The engine must rotate before the status of the "D" lead is updated.

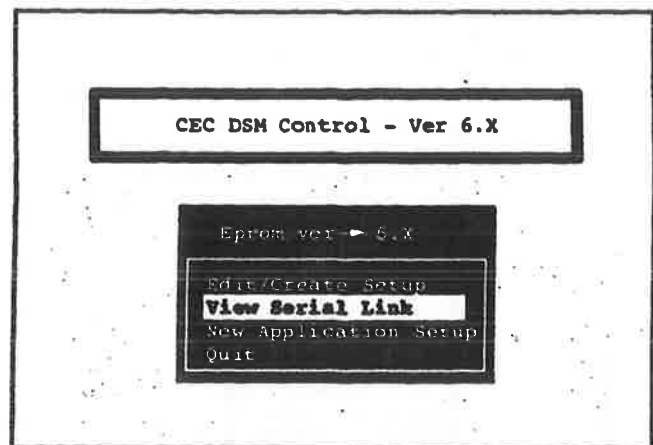


Figure 3.10-37. DSM Interface Program Main Menu

The following information can be obtained from the Display Serial Port Data Screen (see Figure 3.10-36):

- Status of "D" lead
- Programmed limits for minimum and maximum timing
- Current sensor status and timing information
- LCD, alarm, and shutdown status
- Error messages appear on the right side of the screen and flash

This makes the Display Serial Port Data Screen in the View Serial Link option from the Main Menu useful for troubleshooting and checking proper sensor connection.

PROGRAMMING THE DSM SYSTEM FOR A NEW APPLICATION

Checking Individual Sensors On 6, 8, And 12 Cylinder Engines

The "Sensor #" corresponds to the cylinder's position in the firing order. Use the following procedure to check proper sensor connection.

CAUTION Make sure the engine is at full load during this check. At light loads, engine characteristics are very different than at higher loads. Typically, this results in lower output from the knock sensors which, if low enough, will result in a "lost sensor" error even when the system is working properly. Errors may result at low loads after engine warm up. These errors go away once the engine is fully loaded.

NOTE: If "lost sensor" errors are experienced at low loads and do not correct themselves as the engine is fully loaded, refer to Section 4.00, DSM System Diagnostics And Troubleshooting.

1. Access the Display Serial Port Data Screen by selecting "View Serial Link" from the DSM program's Main Menu.
2. Disconnect a plastic connector from a sensor.
3. On the Display Serial Port Data Screen, verify that "Sensor Low" appears in the "Status" column of the

disconnected sensor (see Figure 3.10-38). This may take up to 3 minutes to appear.

NOTE: If a bad or disconnected sensor is detected, the DSM module also displays a message on the LCD display inside the DSM module.

NOTE: After removing the plastic connector from a cylinder, use a timing light and verify that the timing has been retarded to the default you set. If it has not, refer to Section 4.00, DSM System Diagnostics And Troubleshooting.

Step 3 is important because during normal operation you want the DSM system to retard the timing of a cylinder to the default value if a sensor goes bad or a wire is broken. The DSM system will retard the timing to the default timing value when a sensor goes bad or a wire is broken since the DSM system is not protecting that cylinder.

4. Reconnect the plastic connector. The sensor status will change from "Sensor Low" to "OK" in less than 3 minutes.
5. Repeat Steps 2 - 4 until all sensor connections have been checked. This checking process should take approximately 10 minutes for each sensor.
6. Press [ESC] to return to the Main Menu.

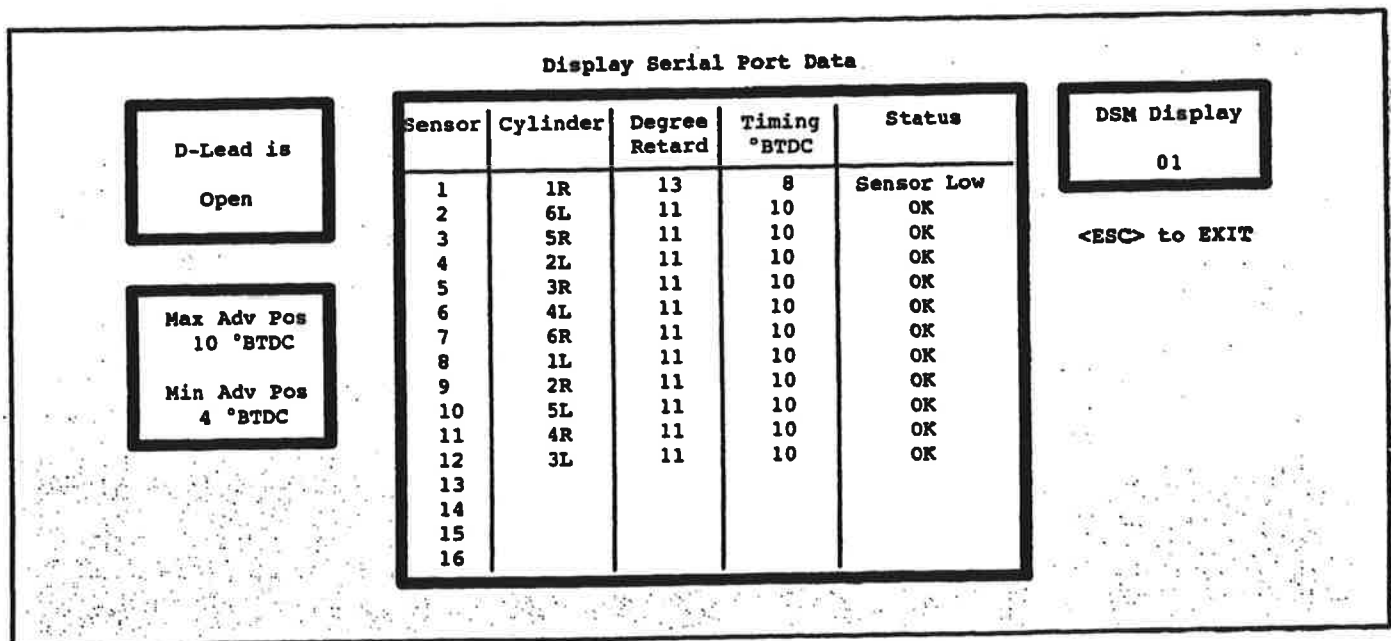


Figure 3.10-38. Display Serial Port Data Screen With Low Sensor

PROGRAMMING THE DSM SYSTEM FOR A NEW APPLICATION

Performing Lost Sensor Check Test On 16 Cylinder Engines

The 16 cylinder DSM system checks for detonation in cylinder pairs and not individually (like the 6, 8, and 12 cylinder engines). Because of cylinder pairs, the DSM system does not automatically display lost sensor alarms on the Display Serial Port Data Screen. To display lost sensors, a lost sensor check must be performed. Complete the steps in this section to perform a lost sensor check for 16 cylinder engines.

A test for lost sensors on 16 cylinder engines should be performed whenever the safety controls and alarms are tested on the engine.

CAUTION Make sure the engine is at full load during this check. At light loads, engine characteristics are very different than at higher loads. Typically, this results in lower output from the knock sensors which, if low enough, will result in a "lost sensor" error even when the system is working properly. Errors may result at low loads after engine warm up. These errors go away once the engine is fully loaded.

NOTE: If "lost sensor" errors are experienced at low loads and do not correct themselves as the engine is fully loaded, refer to Section 4.00, DSM System Diagnostics And Troubleshooting.

1. Access the Display Serial Port Data Screen (see Figure 3.10-40) by selecting "View Serial Link" from the DSM program's Main Menu. Although sensor

status is displayed in the "Status" column, a sensor check must be manually completed to indicate a bad or disconnected sensor on the Display Serial Port Data Screen. A bad or disconnected sensor will be indicated on the Display Serial Port Data Screen during Steps 3 and 5 that follow.

NOTE: If a bad or disconnected sensor is detected, the DSM module also displays a message on the LCD display inside the DSM module.

2. Press the SENSOR CHECK button on the DSM filter once, the red Right Bank LED on the DSM filter will be illuminated (see Figure 3.10-39).

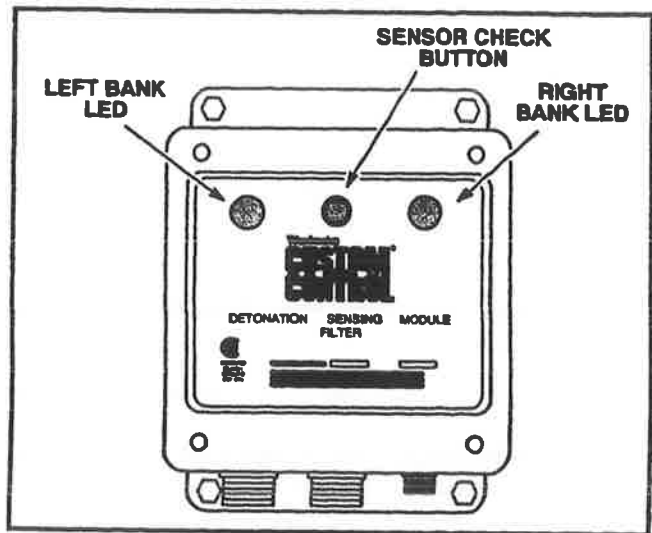


Figure 3.10-39. DSM Filter For 16 Cylinder Engines

Display Serial Port Data

Sensor	Cylinder	Degree Retard	Timing °BTDC	Status
1	1L	11	10	OK
2	3R	11	10	OK
3	3L	14	7	OK
4	7R	14	7	OK
5	7L	12	9	OK
6	5R	12	9	OK
7	5L	11	10	OK
8	8R	11	10	OK
9	8L	13	8	OK
10	6R	13	8	OK
11	6L	11	10	OK
12	2R	11	10	OK
13	2L	11	10	OK
14	4R	11	10	OK
15	4L	12	9	OK
16	1R	12	9	OK

D-Lead is
Open

Max Adv Pos
10 °BTDC

Min Adv Pos
4 °BTDC

DSM Display
91

<ESC> to EXIT

Figure 3.10-40. Display Serial Port Data Screen

PROGRAMMING THE DSM SYSTEM FOR A NEW APPLICATION

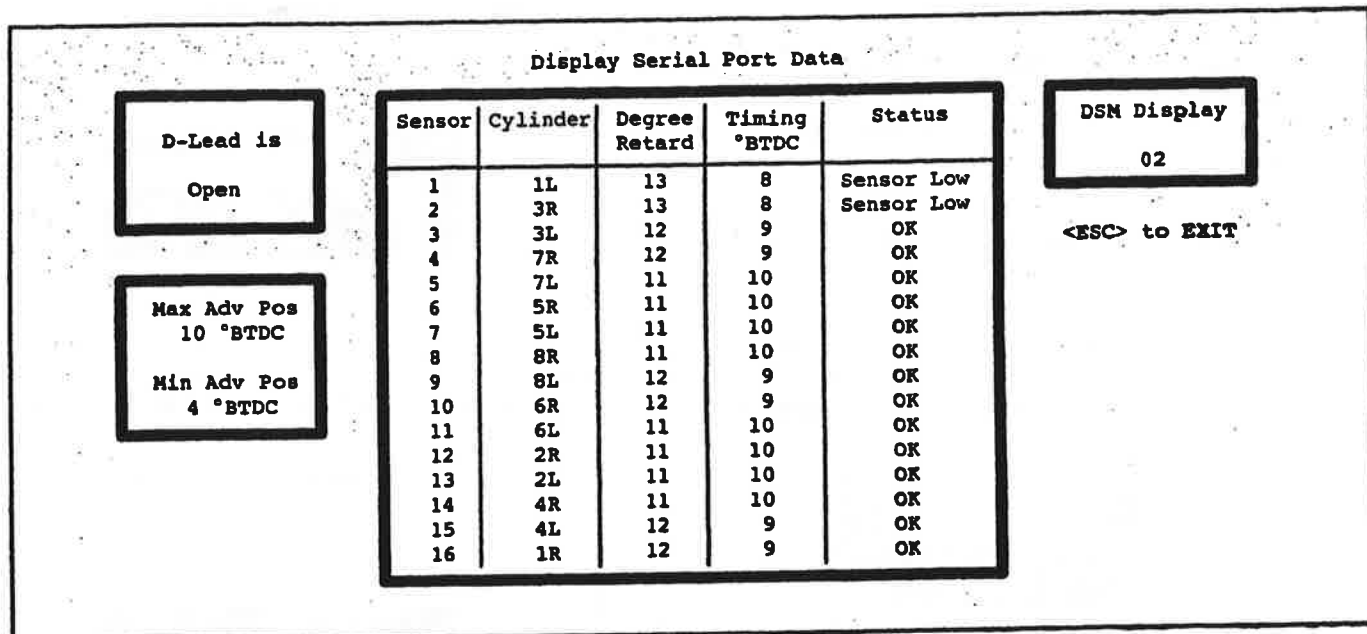


Figure 3.10-41. Display Serial Port Data Screen

3. If there are any bad or disconnected sensors on the right bank of the engine, the status shown on the Display Serial Port Data Screen will change from "OK" to "Sensor Low" for both cylinders in the pair within three minutes (see Figure 3.10-41).

4. After three minutes, press the SENSOR CHECK button again to perform the sensor test on the left bank of the engine.

5. If there are any bad or disconnected sensors on the left bank of the engine, the status shown on the Display Serial Port Data Screen will change from "OK" to "Sensor Low" for both cylinders in the pair within three minutes.

6. After three minutes, press the SENSOR CHECK button again to exit the lost sensor check test. The LEDs will turn off.

NOTE: The DSM system will automatically exit the "sensor check" mode after five minutes and the LEDs will turn off, returning the DSM system to normal operation.

7. Perform a sensor check whenever the safety controls and alarms are tested on the engine.

Individual sensor connections can be checked on the engine by disconnecting a sensor and running the lost sensor check. A disconnected sensor signal for a cylinder pair will appear on the Display Serial Data Port Screen. The status on the Display Serial Port Data Screen will indicate which "cylinder pair" has a low signal and the RIGHT BANK or LEFT BANK LED on the DSM filter will determine which bank has the low signal.

PROGRAMMING THE DSM SYSTEM FOR A NEW APPLICATION

Viewing Wiring Data

The "Sensor #" corresponds to the cylinder's position in the firing order. This information can be obtained from the DSM Interface Program using the following procedure.

1. Highlight "Edit/Create Setup" from the Main Menu and press [Enter] (see Figure 3.10-42).

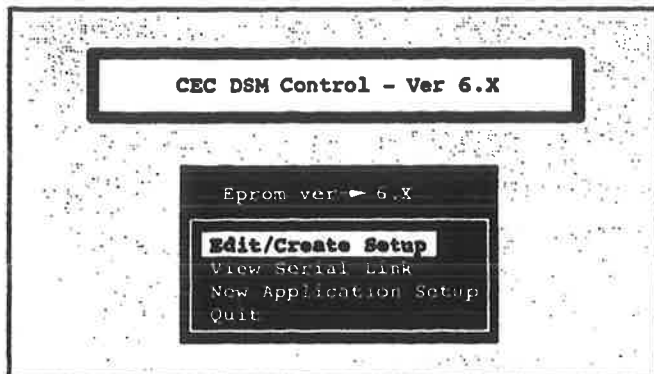


Figure 3.10-42. DSM Interface Program Main Menu

2. Highlight "Retrieve from DSM" on the next menu and press [Enter] (see Figure 3.10-43).

3. Press [F10] when the View/Edit Control Data Values Screen appears.

4. Highlight "View Wiring Data" and press [Enter] (see Figure 3.10-44).

5. The Display Wiring Data Screen appears (see Figure 3.10-45). Record the wiring data for future reference or print-out a copy of the screen if a printer is available.



Figure 3.10-43. Selecting Next Menu Choice

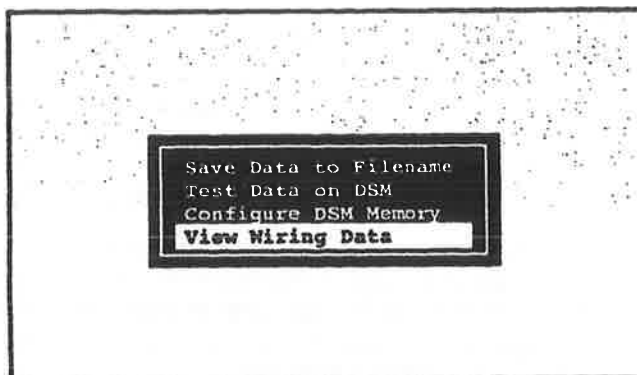


Figure 3.10-44. Selecting Next Menu Choice

6. Press [Esc] and return to the View/Edit Control Data Screen.

7. Press [Esc] to return to the Main Menu.

8. Continue with Check 2: Confirming DSM System Configuration.

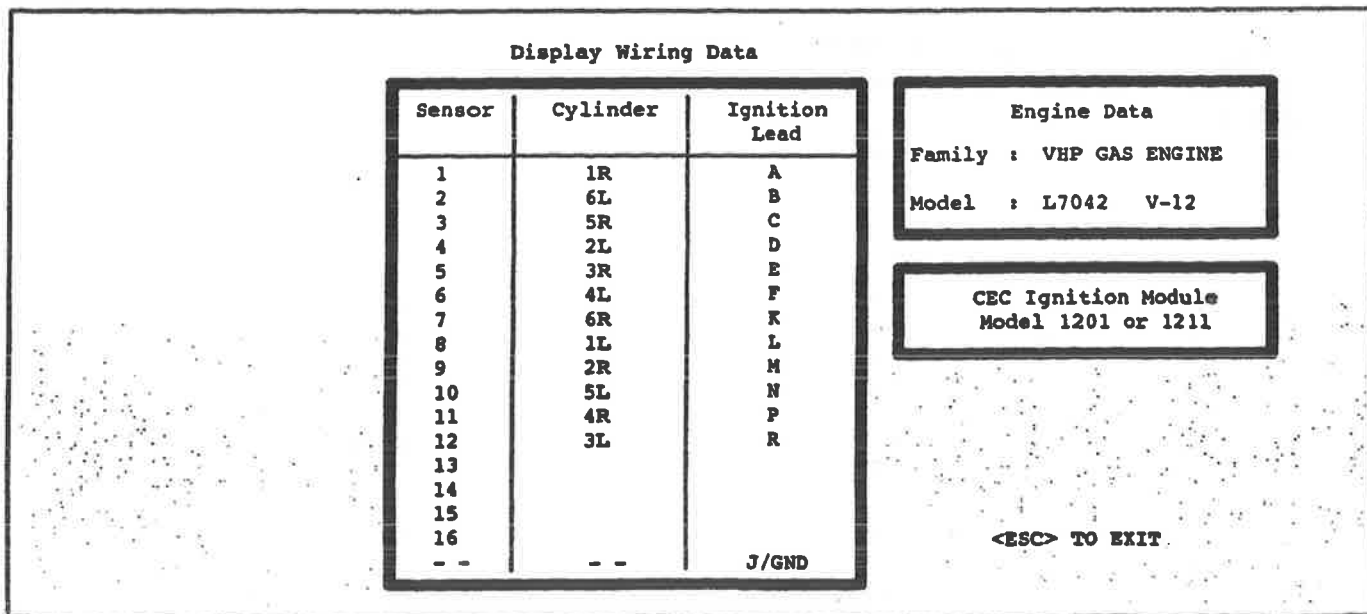


Figure 3.10-45. Display Wiring Data Screen

CHECK 2: CONFIRMING DSM SYSTEM CONFIGURATION

Use the following procedure to confirm that the DSM module has been configured with the latest data-set.

NOTE: If the current data-set has not been saved to a filename, save it before continuing using the procedure in the section "Saving Data-Set To Disk" in this section.

1. Highlight "Quit" on the Main Menu and press [Enter] (see Figure 3.10-46).

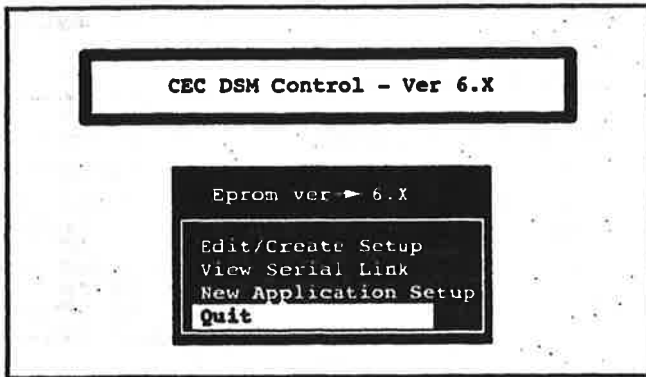


Figure 3.10-46. DSM Interface Program Main Menu

2. Press "Y" to confirm that the program is to be exited.

CAUTION Perform the proceeding steps exactly as stated. A small amount of voltage is supplied to the DSM module from the Ignition Module through the harness. This voltage could corrupt the EPROM chip in the DSM module if the harness is not disconnected first.

NOTE: When the DSM module is disconnected from the Ignition Module, the engine timing will be determined by the switch positions on the Ignition Module.

3. Disconnect the DSM module from the Ignition Module. Remove the "DSM to ignition" harness from the 14 pin connector on the side of the Ignition Module.
4. Disconnect power from the DSM module for 15 minutes.
5. Restore power to the DSM module.

6. Start the DSM Interface Program on your PC.

NOTE: For information on installing and/or accessing the DSM Interface Program, refer to the white card at the back of this manual which holds the 3-1/2" diskette for installation and accessing instructions.

7. The Communications Menu appears on the screen after the Software Identification Screen (see Figure 3.10-47 and Figure 3.10-48). A black dot is located in a circle next to "1" which indicates that the selected communications port on your computer is port 1. Press [Enter] to select communications port 1. If the DB-9 cable is connected to a different port on your PC, use the arrow keys on the keyboard to select the corresponding port from the Communications Menu and press [Enter] (typically: port 1 is correct).

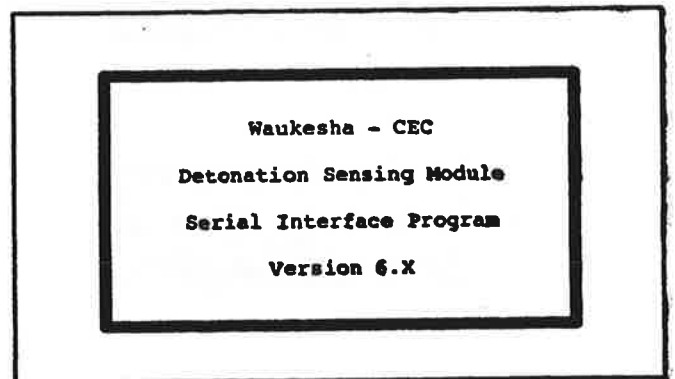


Figure 3.10-47. Software Version Identification

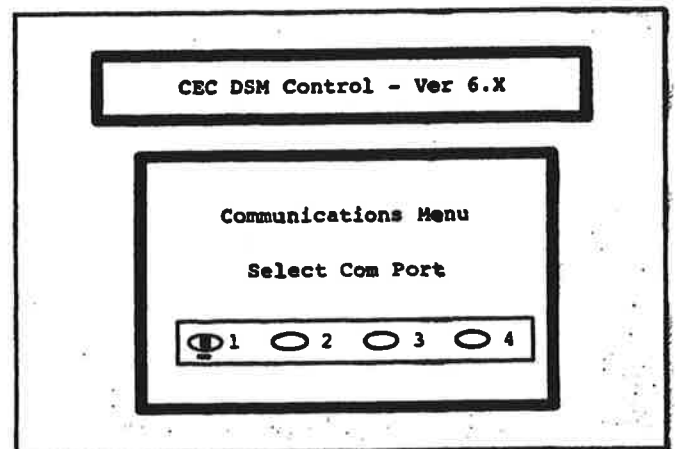


Figure 3.10-48. Communications Menu

PROGRAMMING THE DSM SYSTEM FOR A NEW APPLICATION

8. The Main Menu will now appear (see Figure 3.10-49). Highlight "Edit/Create Setup" and press [Enter].

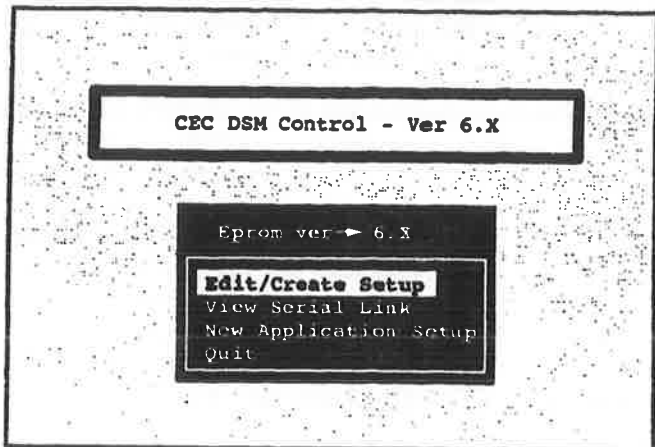


Figure 3.10-49. DSM Interface Program Main Menu

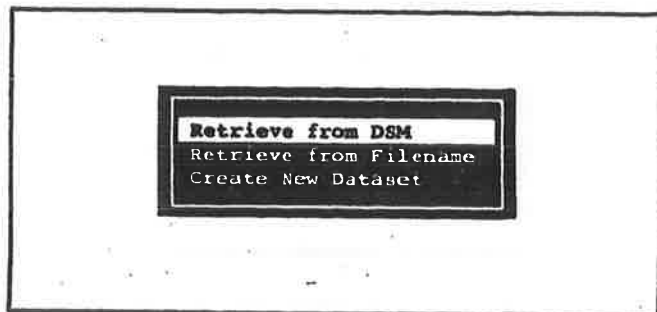


Figure 3.10-50. Selecting Next Menu Choice

9. Highlight "Retrieve from DSM" from the Edit/Create Setup Menu and press [Enter] (see Figure 3.10-50).

10. The program will be retrieved from the DSM. The View/Edit Control Data Values Screen will appear on the screen (see Figure 3.10-51). Verify that these are the values that were entered earlier. If the correct data does not appear, check to see that the serial cable is not faulty and that the power to the DSM module is within specification. Refer to Section 2.10, *DSM System Power, Alarm, And Ground Connections*, for correct power specifications. Retrieve the correct data-set from disk and attempt a second "store." If difficulty continues, refer to Section 4.00, *DSM System Diagnostics And Troubleshooting*.

NOTE: Programs saved to the EPROM chip will be retained even if power to the DSM module is interrupted. Programs saved to RAM will be lost when power to the DSM module is disconnected. The DSM module will not allow the DSM Interface Program to be exited while a program is running in RAM. If you attempt to leave the DSM Interface Program without saving the evaluation data to ROM, a warning will be displayed. You must verify that it is OK to restart the last ROM program.

11. Reconnect the DSM module to the Ignition Module.

12. Press [Esc] to return to the Main Menu.

View/Edit Control Data Values

Engine Family : VHP GAS ENGINE Engine Model : L7042 V-12 # of Cylinders : 12 Primary Fuel : NATURAL GAS PIPELINE QUALITY Secondary Fuel : DIGESTER GAS Comments:		<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="2">Detonation Level Select</th> </tr> </thead> <tbody> <tr><td>Sensor 1</td><td>656 mV</td></tr> <tr><td>Sensor 2</td><td>882 mV</td></tr> <tr><td>Sensor 3</td><td>705 mV</td></tr> <tr><td>Sensor 4</td><td>617 mV</td></tr> <tr><td>Sensor 5</td><td>705 mV</td></tr> <tr><td>Sensor 6</td><td>705 mV</td></tr> <tr><td>Sensor 7</td><td>833 mV</td></tr> <tr><td>Sensor 8</td><td>793 mV</td></tr> <tr><td>Sensor 9</td><td>656 mV</td></tr> <tr><td>Sensor 10</td><td>882 mV</td></tr> <tr><td>Sensor 11</td><td>617 mV</td></tr> <tr><td>Sensor 12</td><td>744 mV</td></tr> </tbody> </table> <p>NOTE: Entries above 2400mV result in a Disabled Sensor.</p>	Detonation Level Select		Sensor 1	656 mV	Sensor 2	882 mV	Sensor 3	705 mV	Sensor 4	617 mV	Sensor 5	705 mV	Sensor 6	705 mV	Sensor 7	833 mV	Sensor 8	793 mV	Sensor 9	656 mV	Sensor 10	882 mV	Sensor 11	617 mV	Sensor 12	744 mV
Detonation Level Select																												
Sensor 1	656 mV																											
Sensor 2	882 mV																											
Sensor 3	705 mV																											
Sensor 4	617 mV																											
Sensor 5	705 mV																											
Sensor 6	705 mV																											
Sensor 7	833 mV																											
Sensor 8	793 mV																											
Sensor 9	656 mV																											
Sensor 10	882 mV																											
Sensor 11	617 mV																											
Sensor 12	744 mV																											
Timing Disk Reference 26 °BTDC <F3> To Calculate TDR D-Lead Position - - -> Grounded Open Most Advanced Timing 10 °BTDC 10 °BTDC Most Retarded Timing 4 °BTDC 4 °BTDC Default Timing 8 °BTDC 8 °BTDC End of Sample Window 30 °ATDC																												
Retard 1° Every 1 Knock Sample(s) Advance 1° Every 5 No-Knock Sample(s)																												
Warm-Up Delay Time 300 Seconds Shutdown Delay Time 15 Seconds																												

<F10> to Save <ESC> to Main Menu <F5> to AUTOCAL

Figure 3.10-51. View/Edit Control Data Values Screen

SECTION 3.15

DSM COMPUTER SCREEN AND DATA RETRIEVAL

SCREEN AND DATA RETRIEVAL

Once a DSM module is programmed for an engine, computer screens can be retrieved to view engine performance. The DSM Interface Program allows you to retrieve saved data-sets, change settings, and view engine performance. Section 3.15 explains the steps necessary to view data-sets and computer screens. **No programming or editing procedures are included in this section.** Data-sets can be retrieved from the DSM module EPROM chip or saved DSM data-set files.

Section 3.05, *Editing An Existing DSM Data-Set*, explains the steps required to edit an existing DSM data-set. The data-set that is edited following the procedures in this section is engine specific. Complete all the programming steps provided in this section.

Section 3.10, *Programming The DSM System For A New Application*, explains the programming steps and post-programming checks to be completed in retrofit applications or whenever a DSM module is removed from one engine and installed on another engine model. By completing the programming steps in this section, any existing data-set is overwritten and an entirely new data-set is programmed.

NOTE: If the internally mounted LCD inside the DSM module reads "99" (no data), the DSM module is sensing that a new EPROM chip is installed and no data-set exists. You will need to complete the programming steps in Section 3.10, *Programming The DSM System For A New Application*.

DSM PROGRAM STARTUP FOR SCREEN AND DATA RETRIEVAL

NOTE: If any of the alarm or shutdown LEDs come on any time during DSM system operation, see Section 4.00, *DSM System Diagnostics And Troubleshooting*.

1. To access the DSM Interface Program, connect a standard DB-9 serial cable (male to female) to the communications port (labeled P1A) within the DSM module. This is the communications port on the right (see Figure 3.15-1). Connect the other end of the cable to the PC's communications port. Typically, this is port 1 (also referred to as COM 1, serial A, or serial 1).

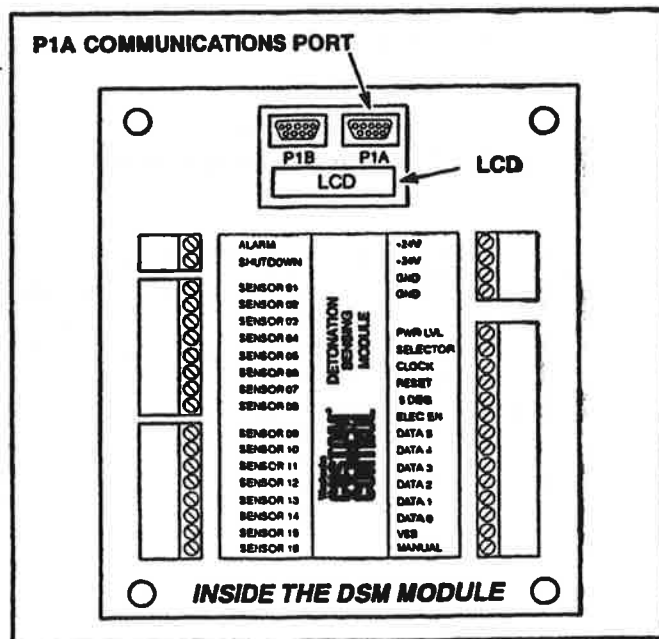


Figure 3.15-1. DB-9 Serial Cable Connection Inside DSM Module

DSM COMPUTER SCREEN AND DATA RETRIEVAL

2. Start the DSM Interface Program on your PC.

NOTE: For information on installing and/or accessing the DSM Interface Program, refer to the white card at the back of this manual which holds the 3-1/2" diskette for installation and accessing instructions.

NOTE: This manual assumes you are already familiar with basic MS-DOS commands for viewing directories, copying files, and other MS-DOS concepts. If you need more information on these subjects, refer to a MS-DOS instruction manual.

3. Once the DSM Interface Program is open, the screen shown in Figure 3.15-2 appears. The bottom line of this screen indicates what software version of the DSM program you are using.

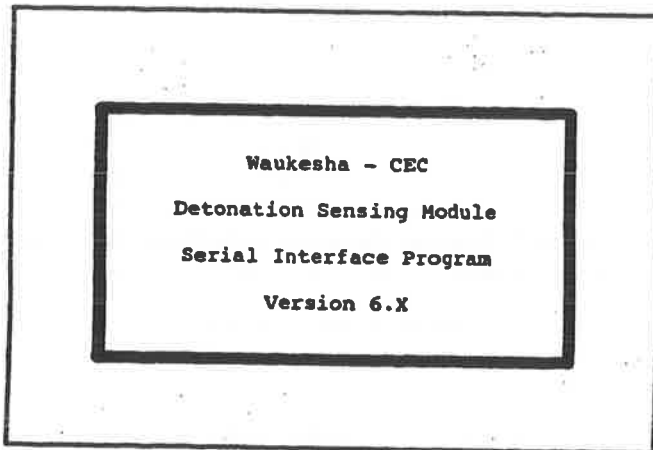


Figure 3.15-2. Software Version Identification

CAUTION Verify that the DB-9 serial cable is securely connected to the appropriate computer port. If the serial cable is disturbed or disconnected during the saving process, the EPROM chip in the DSM module will become corrupted and will need to be replaced.

4. Automatically the Communications Menu appears (see Figure 3.15-3). A black dot is located in a circle next to "1" which indicates that the selected communications port on your computer is port 1. Press [Enter] to select communications port 1. If the DB-9 cable is connected to a different port on your PC, use the arrow keys on the keyboard to select the corresponding port from the Communications Menu and press [Enter] (typically: port 1 is correct).

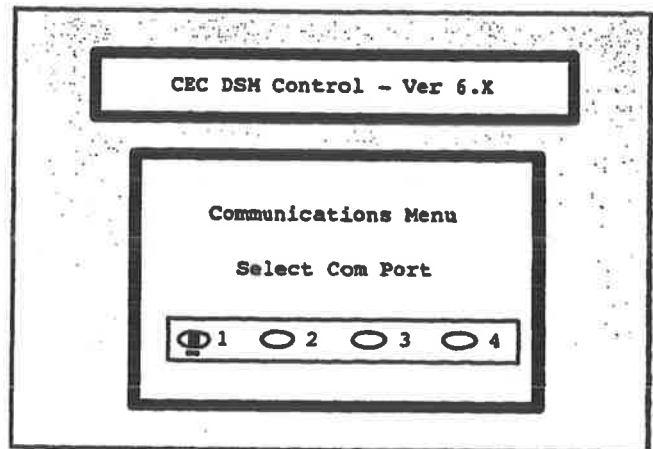


Figure 3.15-3. Communications Menu

5. The DSM Interface Program's Main Menu appears showing various program options available (see Figure 3.15-4).

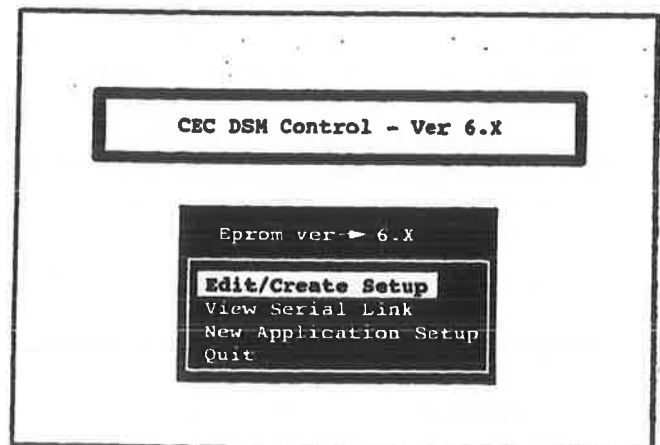


Figure 3.15-4. DSM Interface Program Main Menu

RETRIEVING A SAVED DATA-SET

1. With the DSM Interface Program's Main Menu showing on your screen, highlight "Edit/Create Setup" and press [Enter] (see Figure 3.15-10).

NOTE: For information on installing and/or accessing the DSM Interface Program, refer to the white card at the back of this manual which holds the 3-1/2" diskette for installation and accessing instructions.

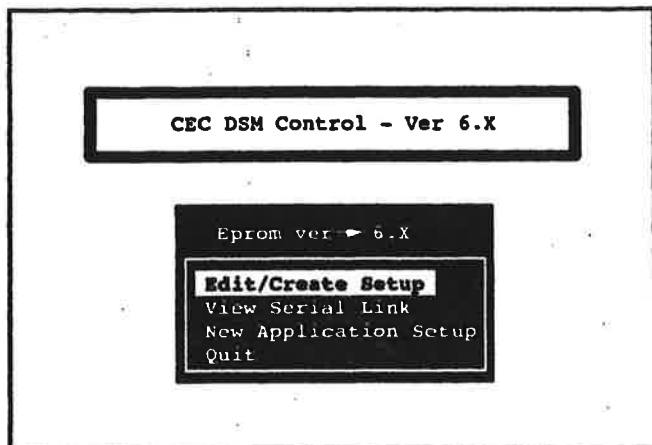


Figure 3.15-10. DSM Interface Program Main Menu

NOTE: If you want to save an opened file to ROM (permanent memory), refer to Section 3.05, Editing An Existing Data-Set.



Figure 3.15-11. Edit/Create Setup Menu

2. On the next menu highlight "Retrieve from Filename" and press [Enter] (see Figure 3.15-11).

3. Highlight the file name (serial number) you want to open and press [Enter] (see Figure 3.15-12). The information that is shown on the View/Edit Control Data Values Screen is information that has been saved in a file and not what is stored on the DSM module's EPROM chip (permanent memory) (see Figure 3.15-13).

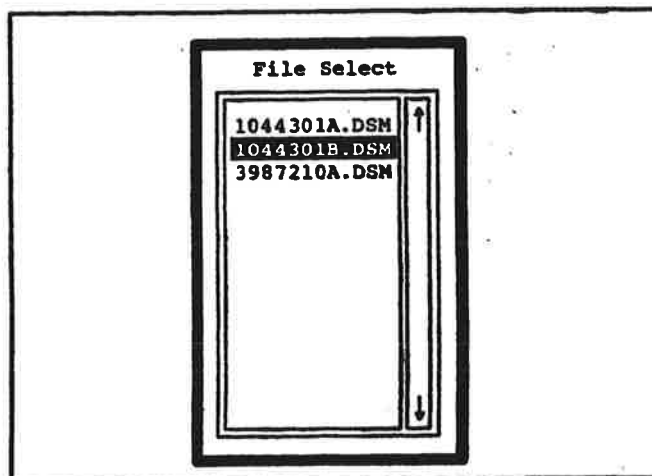


Figure 3.15-12. Selecting File Name Of Saved Data-Set

View/Edit Control Data Values			
Engine Family : VHP GAS ENGINE Engine Model : L7042 V-12 # of Cylinders: 12 Primary Fuel : NATURAL GAS PIPELINE QUALITY Secondary Fuel: DIGESTER GAS Comments:			
Timing Disk Reference 26 °BTDC <F3> To Calculate TDR			
D-Lead Position - - ->	Grounded	Open	
Most Advanced Timing	10 °BTDC	10 °BTDC	
Most Retarded Timing	4 °BTDC	4 °BTDC	
Default Timing	8 °BTDC	8 °BTDC	
End of Sample Window	30 °ATDC		
Retard 1°	Every 1	Knock Sample(s)	
Advance 1°	Every 5	No-Knock Sample(s)	
Warm-Up Delay Time	300	Seconds	
Shutdown Delay Time	15	Seconds	

Detonation Level Select	
Sensor 1	529 mV
Sensor 2	441 mV
Sensor 3	441 mV
Sensor 4	392 mV
Sensor 5	656 mV
Sensor 6	480 mV
Sensor 7	459 mV
Sensor 8	534 mV
Sensor 9	391 mV
Sensor 10	492 mV
Sensor 11	355 mV
Sensor 12	624 mV

NOTE: Entries above 2400mV result in a Disabled Sensor.
 <F5> to AUTOCAL

<F10> to Save <ESC> to Main Menu

Figure 3.15-13. View/Edit Control Data Values Screen

DSM COMPUTER SCREEN AND DATA RETRIEVAL

CONTENTS

**SECTION 4.00 - DSM SYSTEM DIAGNOSTICS
AND TROUBLESHOOTING**

SECTION 4.05 - RUNNING THE DSM AUTOCAL PROGRAM

**SECTION 4.10 - LOST SENSOR CHECK ON
16 CYLINDER ENGINES**

SECTION 4.15 - EPROM CHIP REPLACEMENT

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SECTION 4.00

DSM SYSTEM DIAGNOSTICS AND TROUBLESHOOTING

DIAGNOSTICS

DSM SYSTEM DIAGNOSTICS

This section is provided to determine diagnostic codes of the DSM system, as well as, possible corrective actions that may remedy diagnostic problems.

Inside the DSM module is a liquid crystal display (LCD) that gives a numerical read-out on what is happening within the DSM system (see Figure 4.00-1). The LCD continually shows the current status of the DSM system through diagnostic codes.

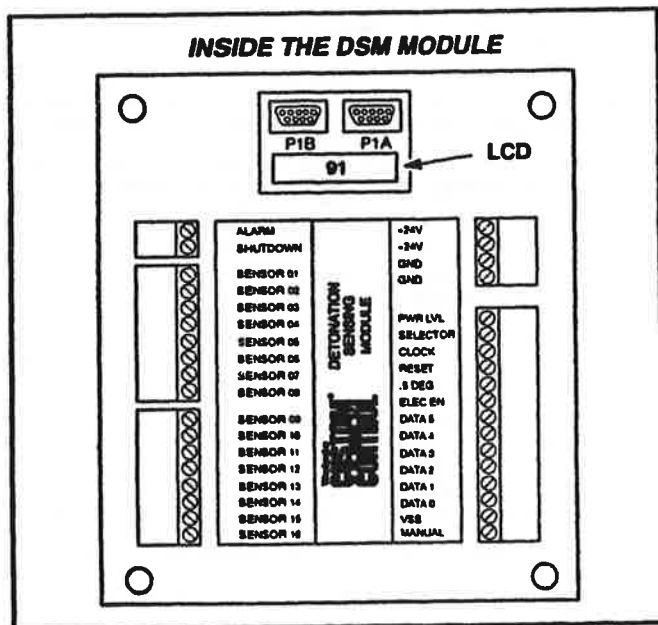


Figure 4.00-1. Detonation Sensing Module LCD

DSM system diagnostics are handled with three light emitting diodes (LEDs) on the front of the DSM module (see Figure 4.00-2).

- The green "Power" LED is lit any time power is applied to the DSM module.

- The yellow "Alarm" LED is lit when power is applied to the DSM and the engine is not running (not due to shutdown mode). The "Alarm" LED lights any time a sensor output is lost or disconnected (6, 8, and 12 cylinder engines). Additionally, the alarm LED lights when the timing is retarded to the most retarded limit (uncontrollable detonation). The alarm LED flashes when the shutdown delay expires and detonation is still present.

NOTE: For 16 cylinder engines a sensor test must be performed to detect a lost sensor. The lost sensor check procedure is explained in Section 4.10, Lost Sensor Check Test For 16 Cylinder Engines. A test for lost sensors should be performed whenever the safety controls and alarms are tested on the engine.

- The red "Shutdown" LED illuminates when the DSM system has reached the most retarded timing, the shutdown delay has timed out, and the engine is still in detonation.

If the "Alarm" (yellow) or "Shutdown" (red) LED is lit on the front panel of the DSM module, refer to the LCD inside the DSM module for the diagnostic code.

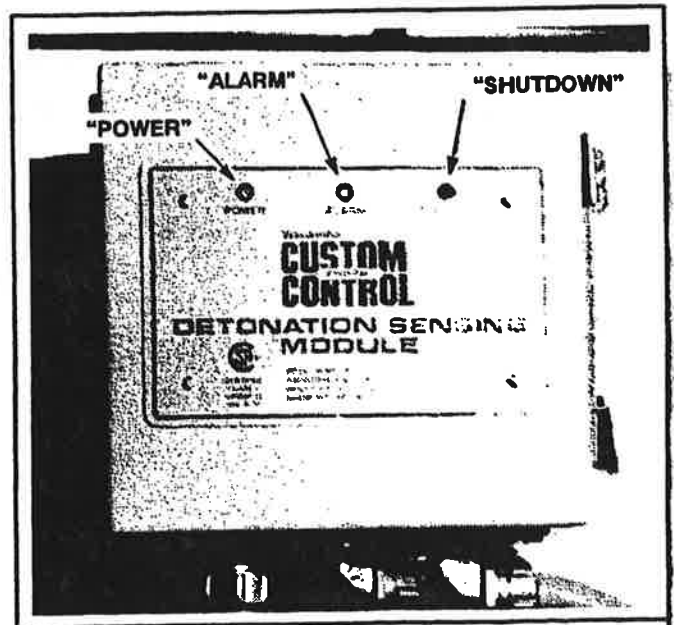


Figure 4.00-2. Detonation Sensing Module Front Panel

DSM SYSTEM DIAGNOSTICS AND TROUBLESHOOTING

The following diagnostic tables are provided to assist you in diagnosing the DSM system.

- Table 4.00-1 provides a description of the DSM system's diagnostic codes.
- Table 4.00-2 provides a description of the condition the DSM system is sensing based on the diagnostic code.
- Table 4.00-3 provides troubleshooting suggestions to remedy the situation.

CAUTION Do not mishandle or drop a DSM knock sensor if a sensor is removed. Improper handling of the sensor could result in permanent damage to the sensor crystal.

CAUTION Do not overtighten sensor. Over-tightening will cause sensor damage.

NOTE: To install a sensor, the sensor must be free of oil and torqued to a value of 20 - 25 ft-lb (27 - 35 N·m). The mounting surface must be flat, smooth (RMS 125), and be perpendicular within 0.008" (1/2 degree).

CAUTION After doing any removal, repair, or replacement of engine cylinder heads, cylinder head gaskets, cylinder liners, pistons, or knock sensors, the DSM system must be AutoCal'd using the DSM Terminal Program and a personal computer. Disregarding this information could result in product damage.

NOTE: Refer to Section 4.05, Running The DSM AutoCal Program.

Table 4.00-1. Description Of Diagnostic LCD Codes

OPERATIONAL CODES		
Code	Status	Description of Condition
Blank	No Power	The DSM module is not powered, system not operating.
(00)	Loss of Rotation	DSM module has sensed that the engine has stopped running.
(75)	Shutdown Active	Uncontrolled detonation present, shutdown output activated by the DSM module.
(90)	Ready to Start	DSM module is waiting for engine to be started.
(81)	Error Present	Sensor error code detected by DSM module. Sensor error for Maximum Retard or failed sensor will follow.
(91)	Normal Operation	The DSM system is running properly. Detonation is being controlled and no errors are present.
(95)	Warm-up Cycle	Warm-up delay time has not elapsed, therefore, engine is running at default timing.
PGM (PROGRAM) INTERRUPT CODES		
Code	Status	Description of Condition
(66)	Configuration Error	Configuration data or application problem if present. (Example: DSM module has been programmed for the wrong engine.)
(86)	Executing AutoCal	DSM module is establishing detonation threshold.
(97)	Serial Transfer	DSM module is communicating with the PC through serial cable.
(99)	No data	The DSM module has not yet been programmed and should not be connected to the Ignition Module while this code is active.
SENSOR CODES		
Code	Status	Description of Condition
(01-16)	Failed Sensor	The DSM module no longer senses a signal from the filter.
(21-36)	Maximum Retard	The cylinder timing for the corresponding sensor has been retarded to its most retarded timing.
(41-56)	Disabled Sensor	The DSM module has been programmed to not control the timing on the corresponding sensor. The cylinder is at default timing.

DSM SYSTEM DIAGNOSTICS AND TROUBLESHOOTING

Table 4.00-2. DSM LCD Message Display Diagnostic Codes

LCD CODE	LED LIGHTS	DESCRIPTION OF CONDITIONS	IGNITION TIMING IN USE
—	— — —	No Power: System Not Operating	CEC Ignition Switch Timing
—	G Y R	No Program: System Has Power But Is Not Executing Code	CEC Ignition Switch Timing
00	G Y -	No Rotation: Engine Stopped Running	CEC Ignition Switch Timing
01	G Y -	Sensor #1: Failed Diagnostic Test	Cylinder Default Timing
02	G Y -	Sensor #2: Failed Diagnostic Test	Cylinder Default Timing
03	G Y -	Sensor #3: Failed Diagnostic Test	Cylinder Default Timing
04	G Y -	Sensor #4: Failed Diagnostic Test	Cylinder Default Timing
05	G Y -	Sensor #5: Failed Diagnostic Test	Cylinder Default Timing
06	G Y -	Sensor #6: Failed Diagnostic Test	Cylinder Default Timing
07	G Y -	Sensor #7: Failed Diagnostic Test	Cylinder Default Timing
08	G Y -	Sensor #8: Failed Diagnostic Test	Cylinder Default Timing
09	G Y -	Sensor #9: Failed Diagnostic Test	Cylinder Default Timing
10	G Y -	Sensor #10: Failed Diagnostic Test	Cylinder Default Timing
11	G Y -	Sensor #11: Failed Diagnostic Test	Cylinder Default Timing
12	G Y -	Sensor #12: Failed Diagnostic Test	Cylinder Default Timing
13	G Y -	Sensor #13: Failed Diagnostic Test	Cylinder Default Timing
14	G Y -	Sensor #14: Failed Diagnostic Test	Cylinder Default Timing
15	G Y -	Sensor #15: Failed Diagnostic Test	Cylinder Default Timing
16	G Y -	Sensor #16: Failed Diagnostic Test	Cylinder Default Timing
21	G Y -	Sensor #1: Uncontrolled Detonation	Cylinder Maximum Retard
22	G Y -	Sensor #2: Uncontrolled Detonation	Cylinder Maximum Retard
23	G Y -	Sensor #3: Uncontrolled Detonation	Cylinder Maximum Retard
24	G Y -	Sensor #4: Uncontrolled Detonation	Cylinder Maximum Retard
25	G Y -	Sensor #5: Uncontrolled Detonation	Cylinder Maximum Retard
26	G Y -	Sensor #6: Uncontrolled Detonation	Cylinder Maximum Retard
27	G Y -	Sensor #7: Uncontrolled Detonation	Cylinder Maximum Retard
28	G Y -	Sensor #8: Uncontrolled Detonation	Cylinder Maximum Retard
29	G Y -	Sensor #9: Uncontrolled Detonation	Cylinder Maximum Retard
30	G Y -	Sensor #10: Uncontrolled Detonation	Cylinder Maximum Retard
31	G Y -	Sensor #11: Uncontrolled Detonation	Cylinder Maximum Retard
32	G Y -	Sensor #12: Uncontrolled Detonation	Cylinder Maximum Retard
33	G Y -	Sensor #13: Uncontrolled Detonation	Cylinder Maximum Retard
34	G Y -	Sensor #14: Uncontrolled Detonation	Cylinder Maximum Retard
35	G Y -	Sensor #15: Uncontrolled Detonation	Cylinder Maximum Retard
36	G Y -	Sensor #16: Uncontrolled Detonation	Cylinder Maximum Retard
41	G - -	Sensor #1: Automatic Timing Control Disabled	Cylinder Default Timing
42	G - -	Sensor #2: Automatic Timing Control Disabled	Cylinder Default Timing
43	G - -	Sensor #3: Automatic Timing Control Disabled	Cylinder Default Timing
44	G - -	Sensor #4: Automatic Timing Control Disabled	Cylinder Default Timing

(Continued)

DSM SYSTEM DIAGNOSTICS AND TROUBLESHOOTING

LCD CODE	LED LIGHTS	DESCRIPTION OF CONDITIONS	IGNITION TIMING IN USE
45	G - -	Sensor #5: Automatic Timing Control Disabled	Cylinder Default Timing
46	G - -	Sensor #6: Automatic Timing Control Disabled	Cylinder Default Timing
47	G - -	Sensor #7: Automatic Timing Control Disabled	Cylinder Default Timing
48	G - -	Sensor #8: Automatic Timing Control Disabled	Cylinder Default Timing
49	G - -	Sensor #9: Automatic Timing Control Disabled	Cylinder Default Timing
50	G - -	Sensor #10: Automatic Timing Control Disabled	Cylinder Default Timing
51	G - -	Sensor #11: Automatic Timing Control Disabled	Cylinder Default Timing
52	G - -	Sensor #12: Automatic Timing Control Disabled	Cylinder Default Timing
53	G - -	Sensor #13: Automatic Timing Control Disabled	Cylinder Default Timing
54	G - -	Sensor #14: Automatic Timing Control Disabled	Cylinder Default Timing
55	G - -	Sensor #15: Automatic Timing Control Disabled	Cylinder Default Timing
56	G - -	Sensor #16: Automatic Timing Control Disabled	Cylinder Default Timing
66	G Y -	Sample Error: Configuration Data or Application Problem	Cylinder Default Timing
75	G y R	Shutdown: Uncontrolled Detonation Present Shutdown Activated	Timing Control
	G Y -	Shutdown: Engine Has Stopped Running Due to Detonation/Shutdown	Cylinder Default Timing
81	G Y -	System Error: Some Cylinders Are OK-Wait for Sensor Error Code	Timing Control
86	G - -	AutoCal: Executing AutoCal Routine	AutoCal Timing
90	G - -	System OK: Ready and Waiting for Engine to Start	Cylinder Default Timing
91	G - -	System OK: Normal Operation	Timing Control
95	G - -	System OK: Delaying Engine Warm-Up	Cylinder Default Timing
97	G - -	Serial Mode: Communication Transfer Mode	Last Active Timing
99	G Y -	No Data: Configuration Data Must Be Down Loaded	30° Retard from Timing Disk Reference Angle

NOTE: The diagnostic codes given in the LCD READ-OUT column are shown on the LCD inside the DSM module. Letters in the LED STATUS column represent the LED lights on the DSM module's front panel that are lit under the given condition: G = Green/Power, Y = Yellow/Alarm, y = Yellow/Alarm Flashing, R = Red/Shutdown

DSM SYSTEM DIAGNOSTICS AND TROUBLESHOOTING

Table 4.00-3. DSM Diagnostic Codes Troubleshooting

IF DIAGNOSTIC CODE ON LED DISPLAY READS:	THEN
Code 00 (No Rotation)	<ul style="list-style-type: none"> a. Engine is not running. b. Ignition Module has lost power. c. "DSM to Ignition" harness is disconnected.
Codes 1 - 16 (Failed Diagnostic Test)	<ul style="list-style-type: none"> a. Verify that the engine is running at the maximum load and speed anticipated during normal engine operation. A faulty sensor code may be activated at low engine loads after warmup. At light loads, engine characteristics are very different than at higher loads. Typically, this results in lower output from the knock sensors which, if low enough, will result in a "lost sensor" error even when the system is working properly. Errors may result at low loads after engine warmup. These errors go away once the engine is fully loaded. b. Check wiring from sensor to DSM for damage. Check that all ground wires ("sensor to DSM" harness and DSM filter grounds) are attached properly. Refer to Chapter 2 <i>Detonation Sensing Module Installation</i>. Repair/replace wiring as required. Once problem is corrected, rerun AutoCal. (Refer to Section 4.05 <i>Running The DSM AutoCal Program</i>.) c. Check Spark plug for misfiring. Replace as required. d. Check admission valves in cylinder head for correct operation. Replace or clean as required. e. Replace sensor. (Refer to Section 2.00 <i>Mounting DSM System Components "Mounting The Knock Sensors"</i>. Rerun AutoCal. (Refer to Section 4.05 <i>Running The DSM AutoCal Program</i>.)
Codes 21 - 36 (Uncontrolled Detonation)	<ul style="list-style-type: none"> a. Shutdown engine. b. Determine if any "hot" or unprocessed gas has gone through the engine that could cause detonation damage. Refer to "Detonation Theory" in Section 1.10 <i>Description Of Operation</i> for detonation theory and a list of detonation promoters/reducers. c. Check gas/air supply. d. Borescope the cylinder to check for detonation damage. e. Review programmed AutoCal values. If calibrated detonation levels vary more than 500 from sensor to sensor, refer to Table 4.00-4, DSM System Troubleshooting.
Codes 41 - 56 (Automatic Timing Control Disabled)	<ul style="list-style-type: none"> a. The sensor was disabled through the DSM Interface Program. Entries above 2400 mV in the Detonation Level Select table on the View/Edit Control Data Values Screen result in a disabled sensor. An AutoCal program must be run to obtain the detonation levels for your application. (Refer to Section 4.05 <i>Running The DSM AutoCal Program</i>.) b. If all sensors are disabled, the installed EPROM chip may never have been programmed. New EPROM chips are configured to keep the sensors and/or controls disabled until AutoCal values are programmed and saved to ROM. It is possible that AutoCal values were not successfully saved to ROM. Run the AutoCal program and save values to ROM. (Refer to Section 4.05 <i>Running The DSM AutoCal Program</i>.)
Code 81 (System Error)	<ul style="list-style-type: none"> a. Sensor error code detected by DSM module. Read the LCD inside the DSM until the sensor error for Maximum Retard or failed sensor is displayed. Or view the Display Serial Port Data Screen using the DSM Interface Program and PC to see status of all the sensors.
All Other Codes	<ul style="list-style-type: none"> a. See Table 4.00-2 for code description and Table 4.00-4 for DSM system troubleshooting.

NOTE: If these diagnostic troubleshooting suggestions do not remedy the problem, refer to Table 4.00-4, "DSM System Troubleshooting."

DSM SYSTEM DIAGNOSTICS AND TROUBLESHOOTING

TROUBLESHOOTING

Table 4.00-4 is provided to assist the user in determining the possible causes of unsatisfactory system operation, as well as point out the corrective action that may be undertaken to remedy the problem.

If problems persist, contact your local Waukesha Engine Distributor or Waukesha Engine Product Support for assistance.

Troubleshooting the DSM can involve some disassembly of circuit board pairs, removal and replacement of multi-pin components (chips), and other work of similar nature. Only "qualified technicians" should undertake these activities. Improper handling of circuit boards and electronic components can cause damage that may render them unusable.

NOTE: Table 4.00-4 is only provided as a service to our customers. It should not be viewed as a reflection of Waukesha Engine's actual experience with this product.

NOTE: If you completed the diagnostics in Table 4.00-3, some of the troubleshooting checks listed in Table 4.00-4 may have already been completed.

WARNING

Always use caution when servicing or repairing an engine and installed CEC systems. Engine components or fluids can be extremely hot and can cause severe personal injury or death.

WARNING

Always wear OSHA approved body, sight, hearing, and respiratory system protection. Never wear loose clothing, jewelry, or long hair around an engine. The use of improper attire may result in severe personal injury or death.

Before referring to the troubleshooting procedures in Table 4.00-4, check the DSM LCD inside the DSM module. During normal operation the LCD code displayed inside the DSM module is 91. If any other codes are displayed, complete the diagnostic checks provided in Table 4.00-1 through Table 4.00-3.

Table 4.00-4. DSM System Troubleshooting

SYMPTOM	PROBABLE CAUSE	REMEDY
"COM Port Failed" message is displayed on the PC.	Communications between the PC and the DSM module cannot be established.	<p>a. Check to see that the DB-9 serial cable is connected to the correct communications port on your PC. Verify that the communications port chosen is enabled in the PC system's setup. Verify that the port chosen from the Communications Menu (when beginning the programming procedure) corresponds to the port the DB-9 serial cable is connected to on the PC.</p> <p>b. Verify that the serial cable is connected to the correct communications port (labeled P1A) within the DSM module.</p> <p>c. Replace DB-9 serial cable.</p> <p>d. Verify that the power supply to the DSM module is within specification. Refer to Section 2.10 <i>DSM System Power, Alarm, And Ground Connections</i> "DSM Module Power Connections" for correct power specifications.</p> <p>e. Remove power from the DSM module and disconnect the "DSM to ignition" harness from the 14 pin connector on the side of the Ignition Module. Wait for one minute before repowering and reconnecting the DSM module to the Ignition Module. Restart programming procedure.</p> <p>f. If the problem persists, then replace the EPROM chip inside the DSM module. Refer to Section 4.15 <i>EPROM Chip Replacement</i>.</p>
"Com Device I/O Error Occurred" message is displayed on the PC after trying to program a new application.	Previous version of the DSM Interface Program software (version 5.3c) is being accessed by a PC with a high speed (MHz) processor.	a. Verify that current DSM Interface Software (version 6.X) is being accessed. PCs with a high speed processor may cause communication device input/output errors with the previous version of the DSM Interface Program (version 5.3c). DSM Interface Program, version 6.X, has been upgraded to run on high speed PCs.

(Continued)

DSM SYSTEM DIAGNOSTICS AND TROUBLESHOOTING

SYMPTOM	PROBABLE CAUSE	REMEDY
<p>DSM system loses the program's data-set whenever the power is disconnected.</p>	<p>The data-set created was only stored in RAM using the "Test Data on DSM" selection of the Save Menu. Any program stored in RAM will be lost when the power is disconnected from the DSM module. The "Configure DSM Memory" should be used to save the data to ROM (permanent memory on the EPROM chip).</p>	<p>a. The data-set you created has been lost. If the data-set has been stored to disk it can be retrieved and then saved to the EPROM chip (see Section 3.15 <i>DSM System Computer Screen And Data Retrieval</i> "Retrieving A Saved Data-Set"). If the data was not saved to disk, reprogram the DSM module following the programming steps in Section 3.05 <i>Editing An Existing DSM Data-Set</i> and save the data-set to ROM (permanent memory).</p> <p>b. Check power supply to the DSM module during save to ROM to verify power supply continues to meet specification. Refer to Section 2.10 <i>DSM System Power, Alarm, And Ground Connections</i> "DSM Module Power Connections" for correct power specifications. If power supply does not continue to meet specification, correct power supply. Resave data-set and during the save re-verify power supply continues to be within specification.</p> <p>c. If the problem persists, replace the EPROM chip inside the DSM module. Refer to Section 4.15 <i>EPROM Chip Replacement</i>.</p>
<p>The DSM module cannot be programmed.</p>	<p>The EPROM chip may have been damaged.</p>	<p>a. Verify that the power supply to the DSM module and DSM filter is within specification. Refer to Section 2.10 <i>DSM System Power, Alarm, And Ground Connections</i> "DSM Module Power Connections" for correct power specifications.</p> <p>b. Check to see that the DB-9 serial cable is connected to the correct communications port on your PC. Verify that the communications port chosen is enabled in the PC system's setup. Verify that the port chosen from the Communications Menu (when beginning the programming procedure) corresponds to the port the DB-9 serial cable is connected to on the PC.</p> <p>c. Verify that the serial cable is connected to the correct communications port (labeled P1A) within the DSM module.</p> <p>d. Replace DB-9 serial cable.</p> <p>e. Check that all wire harnesses and ground wires are attached and routed properly. Refer to Chapter 2 <i>Detonation Sensing Module Installation</i>.</p> <p>f. Check if the EPROM chip has the maximum allowed 25 saves. The screen will indicate the ROM location (or number of saves already made to the EPROM chip) when you retrieve a data-set from ROM or enter the View Serial Link Screen. For example: When you choose "Edit/Create Setup" from the Main Menu and then "Retrieve from DSM," the screen will indicate whether the data-set is in RAM or ROM; and if in ROM, from which ROM location. A message like "Data Source is ROM 5" indicates that there are 20 saves still available to ROM. If the EPROM chip is full (25 saves), replace the EPROM chip inside the DSM module. Refer to Section 4.15 <i>EPROM Chip Replacement</i>.</p> <p>g. Verify that current DSM Interface Software (version 6.X) is being accessed. PCs with a high speed processor may cause communication device input/output errors with the previous version of the DSM Interface Program (version 5.3c). DSM Interface Program, version 6.X, has been upgraded to run on high speed PCs (speeds greater than 100 Mhz).</p> <p>h. If the problem persists, replace the EPROM chip inside the DSM module. Refer to Section 4.15 <i>EPROM Chip Replacement</i>.</p>

(Continued)

DSM SYSTEM DIAGNOSTICS AND TROUBLESHOOTING

SYMPTOM	PROBABLE CAUSE	REMEDY
<p>Unable to run the AutoCal program.</p>	<p>1) Communications problem between the PC and the DSM module.</p> <p>2) Previous version of the DSM Interface Program software (version 5.3c) is being accessed by a PC.</p>	<p>a. Retry running the AutoCal Program.</p> <p>b. Check to see that the DB-9 serial cable is connected to the correct communications port on your PC. Verify that the communications port chosen is enabled in the PC system's setup. Verify that the port chosen from the Communications Menu (when beginning the programming procedure) corresponds to the port the DB-9 serial cable is connected to on the PC.</p> <p>c. Verify that the serial cable is connected to the correct communications port (labeled P1A) within the DSM module.</p> <p>c. Replace DB-9 serial cable. Retry running the AutoCal Program.</p> <p>d. Check that all wire harnesses and ground wires are attached and routed properly. Refer to Chapter 2 <i>Detonation Sensing Module Installation</i>. Rerun AutoCal. (Refer to Section 4.05 <i>Running The DSM AutoCal Program</i>.)</p> <p>e. Verify that current DSM Interface Software (version 6.X) is being accessed. PCs with a high speed processor (speeds greater than 100 Mhz) may cause communication device input/output errors with the previous version of the DSM Interface Program (version 5.3c). DSM Interface Program, version 6.X, has been upgraded to run on high speed PCs.</p>
<p>Calibrated detonation levels determined from the AutoCal program vary by more than 500 from sensor to sensor.</p>	<p>1) Sensor mounting surface imperfections.</p> <p>2) Wire harnesses and/or ground wiring are not attached or routed properly.</p> <p>3) Engine is in detonation.</p> <p>4) Other engine related problems.</p>	<p>a. Verify that the sensors are mounted and installed properly. Sensor MUST have full-face contact with mounting surface. Imperfections in the surface that the sensor mounts against can cause higher sensor output. The sensors must be torqued to the correct specification. Refer to Section 2.00 <i>Mounting DSM System Components "Mounting The Knock Sensors"</i>. Rerun AutoCal. (Refer to Section 4.05 <i>Running The DSM AutoCal Program</i>.)</p> <p>b. Check that all wire harnesses and ground wires are attached and routed properly. Refer to Chapter 2 <i>Detonation Sensing Module Installation</i>. Rerun AutoCal. (Refer to Section 4.05 <i>Running The DSM AutoCal Program</i>.)</p> <p>c. Verify that the power supply to the DSM module and DSM filter is within specification. Refer to Section 2.10 <i>DSM System Power, Alarm, And Ground Connections "DSM Module Power Connections"</i> for correct power specifications.</p> <p>CAUTION Detonation must not be present while running AutoCal. If detonation occurs at any time during the calibration program, the AutoCal results must be discarded and the AutoCal program must be rerun.</p> <p>d. Determine if the engine is in detonation. Change timing by backing off 2 degrees from the current timing setting. Rerun AutoCal. If after backing off the timing by 2 degrees the AutoCal results are within the acceptable 500 range it may indicate inaudible detonation is occurring. Check the following:</p> <ol style="list-style-type: none"> 1. Check engine timing, the air/fuel ratio, and load. 2. Check for any conditions that may cause detonation such as a change in fuel quality. Refer to "Detonation Theory" in Section 1.10 <i>Description Of Operation</i> for detonation theory and a list of detonation promoters/reducers. 3. Borescope the engine to look for signs of detonation or signs of general engine wear. <p>Once the engine is not detonating, rerun AutoCal. (Refer to Section 4.05 <i>Running The DSM AutoCal Program</i>.)</p> <p>e. Check other possible engine problems such as: valves hitting liners, valves hitting piston, main bearings, cylinder head torque, piston cooling jets, etc.</p> <p>f. Replace the sensor and rerun AutoCal. (Refer to Section 4.05 <i>Running The DSM AutoCal Program</i>.)</p>

(Continued)

DSM SYSTEM DIAGNOSTICS AND TROUBLESHOOTING

SYMPTOM	PROBABLE CAUSE	REMEDY
A LOW error (low setpoint) occurs during the AutoCal program and is displayed in the Set-Point column of the Auto-Cal Screen.	The AutoCal value determined is considered too low.	<p>a. Verify that the engine is running at the maximum load and speed anticipated during normal engine operation.</p> <p>CAUTION The sensors give an output even when the engine is not in detonation. The sensor output increases with load, so the engine must be at its highest load during AutoCal. If the AutoCal program is run while the engine is at a lower load, an increase in load may be mistaken for detonation. The engine must be running at the maximum load and speed anticipated during normal operation.</p> <p>b. Check that all wire harnesses and ground wires are attached and routed properly. Verify that the "DSM to Ignition" harness is connected. Refer to Chapter 2 <i>Detonation Sensing Module Installation</i>. Rerun AutoCal. (Refer to Section 4.05 <i>Running The DSM AutoCal Program</i>.)</p> <p>c. Replace the sensor and rerun AutoCal. (Refer to Section 4.05 <i>Running The DSM AutoCal Program</i>.)</p>
A STAL error (stall error) occurs during the AutoCal program and is displayed in the Set-Point column of the Auto-Cal Screen.	During AutoCal, the DSM system senses the engine is not running.	<p>a. Verify engine rotation.</p> <p>b. Check that the "DSM to ignition" harness is connected and routed properly. Refer to Chapter 2 <i>Detonation Sensing Module Installation</i>. Rerun AutoCal. (Refer to Section 4.05 <i>Running The DSM AutoCal Program</i>.)</p>
An HISP error (high setpoint error) occurs during the Auto-Cal program and is displayed in the Set-Point column of the AutoCal Screen.	The AutoCal value is higher than the maximum 2400 mV value.	<p>a. Determine if the engine is in detonation. Once the engine is not detonating, rerun AutoCal. (Refer to "Detonation Theory" in Section 1.10 <i>Description Of Operation</i> for detonation theory and a list of detonation promoters/reducers.) (Refer to Section 4.05 <i>Running The DSM AutoCal Program</i>.)</p> <p>b. Check that all wire harnesses and ground wires are attached and routed properly. Refer to Chapter 2 <i>Detonation Sensing Module Installation</i>. Rerun AutoCal. (Refer to Section 4.05 <i>Running The DSM AutoCal Program</i>.)</p> <p>c. Verify that the sensors are mounted and installed properly. Sensor MUST have full-face contact with mounting surface. Imperfections in the surface that the sensor mounts to can cause higher sensor output. The sensors must be torqued to the correct specification. Refer to Section 2.00 <i>Mounting DSM System Components "Mounting The Knock Sensors"</i>. Rerun AutoCal. (Refer to Section 4.05 <i>Running The DSM AutoCal Program</i>.)</p> <p>d. Check other possible engine problems such as: valves hitting liners, valves hitting piston, main bearings, cylinder head torque, piston cooling jets, etc.</p> <p>e. Replace the sensor and rerun AutoCal. (Refer to Section 4.05 <i>Running The DSM AutoCal Program</i>.)</p>
The Display Serial Port Data Screen (View Serial Link) is showing the incorrect "D" lead status.	When the engine is not running and the "D" lead is switched on the CEC Ignition Module (Models 811, 1211, 1611), the "D" lead status does not immediately update.	<p>a. If the engine is not running and the "D" lead is switched on the CEC Ignition Module (Models 811, 1211, 1611), the "D" lead status will not update immediately on the Display Serial Port Data Screen. The engine must rotate before the status of the "D" lead is updated on the screen.</p> <p>b. If the "D" lead status is not updated on the Display Serial Port Data Screen after the engine is started, contact Waukesha Product Support.</p>
When more than one sensor indicates "Low Sensor" on the Display Serial Port Data Screen, the status on the PC display will continue to read "Low Sensor" even though cylinder is at max. advanced timing.	Error is corrected for some but not all sensors displaying "Low Sensor."	<p>a. The status column will not clear the fault "Low Sensor" and change the indication to OK for any of the cylinders until all of the cylinder sensors are corrected. The status can be updated by exiting and then re-entering the View Serial Link Data Screen. DSM system is functioning correctly, the only error will be on the PC display.</p>

(Continued)

DSM SYSTEM DIAGNOSTICS AND TROUBLESHOOTING

SYMPTOM	PROBABLE CAUSE	REMEDY
Unable to retrieve data.	1) Defective or improperly connected DB-9 serial cable. 2) Corrupt EPROM chip.	a. Check to see that the DB-9 serial cable is connected to the correct communications port on your PC. Verify that the communications port chosen is enabled in the PC system's setup. Verify that the port chosen from the Communications Menu (when beginning the programming procedure) corresponds to the port the DB-9 serial cable is connected to on the PC. b. Verify that the serial cable is connected to the correct communications port (labeled P1A) within the DSM module. c. Replace DB-9 serial cable. d. Remove power from the DSM module by disconnecting all terminal blocks inside the module for 1 minute. Reconnect and try to retrieve data. e. If the problem persists, then replace the EPROM chip inside the DSM module. Refer to Section 4.15 <i>EPROM Chip Replacement</i> .
The DSM system continually reduces ignition timing and/or displays the shutdown error when detonation is not present.	Some sensors are exceeding the detonation threshold settings for each individual cylinder.	a. Find out if the engine has been overhauled recently. If so, rerun AutoCal. (Refer to Section 4.05 <i>Running The DSM AutoCal Program</i> .) Whenever major power cylinder components are removed, switched, or replaced, AutoCal must be rerun. b. Verify that the sensors are installed properly. Sensor MUST have full-face contact with mounting surface. Imperfections in the surface that the sensor mounts to can cause higher sensor output. Refer to Section 2.00 <i>Mounting DSM System Components "Mounting The Knock Sensors"</i> . Rerun AutoCal. (Refer to Section 4.05 <i>Running The DSM AutoCal Program</i> .) c. Check that all wire harnesses and ground wires are attached and routed properly. Refer to Chapter 2 <i>Detonation Sensing Module Installation</i> . Rerun AutoCal. (Refer to Section 4.05 <i>Running The DSM AutoCal Program</i> .) d. Check other possible engine problems such as: valves hitting liners, valves hitting piston, main bearings, cylinder head torque, piston cooling jets, etc. e. If this condition only occurs at low load, a load sensing feature may be required. Contact Waukesha Product Support for assistance.
Engine timing does not agree with the program values.	Timing Disk Reference has been programmed incorrectly.	a. Timing Disk Reference (TDR) must be recalculated. Refer to Section 3.05 <i>Editing An Existing DSM Data-Set</i> .
Shutdown warning lights are on and the DSM LCD displays Code 91 (System OK: Normal Operation).	Alarm and/or shutdown connections are not wired or routed properly.	a. Check that alarm and shutdown connections are wired and routed properly. The alarm and shutdown terminals are sinking devices. Refer to "Alarm And Shutdown Connections" in Section 2.10 <i>DSM System Power, Alarm, And Ground Connections</i> .
After the DSM module is powered up, the green power LED lights up, but the LCD inside the DSM module is blank and the DSM does not function.	1) Input voltages are insufficient. 2) DSM module was powered up with Ignition Module connected. 3) EPROM chip is corrupt.	a. Verify that the power supply to the DSM module is within specification. Refer to Section 2.10 <i>DSM System Power, Alarm, And Ground Connections "DSM Module Power Connections"</i> for correct power specifications. b. Disconnect the "DSM to ignition" harness from the DSM module. Turn off power to DSM module. Reapply power to DSM module. Connect PC and retrieve data-set from DSM module. c. If the problem persists, replace the EPROM chip inside the DSM module. Refer to Section 4.15 <i>EPROM Chip Replacement</i> .
When power to DSM system is removed, the engine stops running.	Ignition Module negative power path is through the DSM.	a. Check the Ignition Module's negative power connections and wiring. Refer to <i>Custom Engine Control[®] Ignition Module Installation, Operation, And Maintenance Manual</i> Form 6253 or Form 6272 (Models 811, 1211, 1611). b. Replace Ignition Module.
The DSM system does not detect a lost sensor.	Electrical noise is being seen by the DSM system.	a. Check that all wire harnesses and ground wires are attached and routed properly. Refer to Chapter 2 <i>Detonation Sensing Module Installation</i> . Rerun AutoCal. (Refer to Section 4.05 <i>Running The DSM AutoCal Program</i> .)

NOTE: If these troubleshooting suggestions do not remedy the problem, please contact Waukesha Engine Product Support.

SECTION 4.05

RUNNING THE DSM AUTOCAL PROGRAM

RUNNING THE AUTOCAL PROGRAM

The DSM AutoCal program is the automatic calibration of the detonation threshold levels by the DSM Interface Program. The DSM module monitors for detonation using the frequency output of each cylinder with engine mounted knock sensors. These knock sensors must be calibrated or "AutoCaled." During AutoCal, the knock sensors are calibrated so that the DSM system can operate properly.

An AutoCal should be run the first time the DSM is programmed for an engine or whenever a DSM is programmed for a new application. Additionally, the DSM system must be re-AutoCaled using the DSM Interface Program and a PC after doing any removal, repair, or replacement of engine cylinder heads, cylinder liners, cylinder gaskets, pistons, or knock sensors. This calibration **MUST BE** done using the AutoCal program as explained in this section.

CAUTION Detonation must not be present while running AutoCal. If detonation occurs at any time during the calibration program, the AutoCal results must be discarded and the AutoCal program must be rerun.

CAUTION The sensors give an output even when the engine is not in detonation. The sensor output increases with load, so the engine must be at its **HIGHEST LOAD** during AutoCal. If the AutoCal program is run while the engine is at a lower load, an increase in load may be mistaken for detonation. The engine must be running at the maximum load and speed anticipated during normal operation.

NOTE: At light loads, engine characteristics are very different than at higher loads. Typically, this results in lower output from the knock sensors which, if low enough, will result in a "lost sensor" error even when the system is working properly. Errors may result at low loads after engine warm up. These errors go away once the engine is fully loaded. If "lost sensor" errors are experienced at low loads and do not correct themselves as the engine is fully loaded, refer to Section 4.00, DSM System Diagnostics And Troubleshooting.

1. Verify that the engine is running at the maximum load and speed anticipated during normal engine operation.
2. With the DSM Interface Program's Main Menu showing on your screen, highlight "Edit/Create Setup" and press [Enter] (see Figure 4.05-1).

NOTE: For information on installing and/or accessing the DSM Interface Program, refer to the white card at the back of this manual which holds the 3-1/2" diskette for installation and accessing instructions.

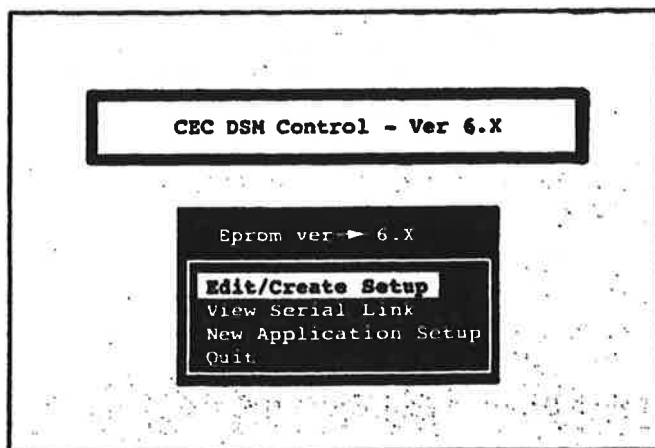


Figure 4.05-1. DSM Interface Program Main Menu

RUNNING THE DSM AUTOCAL PROGRAM

3. On the Edit/Create Setup Menu, highlight "Retrieve from DSM" from this menu and press [Enter].

4. Several screens will appear indicating that the data is being retrieved from the DSM module. Then the View/Edit Control Data Values Screen appears (see Figure 4.05-2). This screen shows the data-set parameters. The information shown on the screen is stored in the DSM.

5. Detach or copy the applicable AutoCal Worksheet from the back of this manual. The blue AutoCal Worksheet applies to 6, 8, and 12 cylinder engines (see Table 4.05-1 for sample worksheet). The yellow AutoCal Worksheet applies to 16 cylinder engines (see Table 4.05-2 for sample worksheet). Be sure to detach or copy the worksheet applicable to your engine application.

View/Edit Control Data Values

<p>Engine Family : VHP GAS ENGINE Engine Model : L7042 V-12 # of Cylinders: 12 Primary Fuel : NATURAL GAS PIPELINE QUALITY Secondary Fuel: DIGESTER GAS Comments:</p> <hr/> <p>Timing Disk Reference 26 °BTDC <F3> To Calculate TDR</p> <p>D-Lead Position - - -> Grounded Open</p> <p>Most Advanced Timing 10 °BTDC 10 °BTDC</p> <p>Most Retarded Timing 4 °BTDC 4 °BTDC</p> <p>Default Timing 8 °BTDC 8 °BTDC</p> <p>End of Sample Window 30 °ATDC</p> <hr/> <p>Retard 1° Every 1 Knock Sample(s) Advance 1° Every 5 No-Knock Sample(s)</p> <hr/> <p>Warm-Up Delay Time 300 Seconds Shutdown Delay Time 15 Seconds</p>	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="2" style="text-align: center;">Detonation Level Select</th> </tr> </thead> <tbody> <tr><td>Sensor 1</td><td style="text-align: right;">833 mV</td></tr> <tr><td>Sensor 2</td><td style="text-align: right;">744 mV</td></tr> <tr><td>Sensor 3</td><td style="text-align: right;">705 mV</td></tr> <tr><td>Sensor 4</td><td style="text-align: right;">617 mV</td></tr> <tr><td>Sensor 5</td><td style="text-align: right;">744 mV</td></tr> <tr><td>Sensor 6</td><td style="text-align: right;">833 mV</td></tr> <tr><td>Sensor 7</td><td style="text-align: right;">833 mV</td></tr> <tr><td>Sensor 8</td><td style="text-align: right;">793 mV</td></tr> <tr><td>Sensor 9</td><td style="text-align: right;">656 mV</td></tr> <tr><td>Sensor 10</td><td style="text-align: right;">882 mV</td></tr> <tr><td>Sensor 11</td><td style="text-align: right;">705 mV</td></tr> <tr><td>Sensor 12</td><td style="text-align: right;">793 mV</td></tr> </tbody> </table> <p style="font-size: small; margin-top: 5px;">NOTE: Entries above 2400mV result in a Disabled Sensor.</p>	Detonation Level Select		Sensor 1	833 mV	Sensor 2	744 mV	Sensor 3	705 mV	Sensor 4	617 mV	Sensor 5	744 mV	Sensor 6	833 mV	Sensor 7	833 mV	Sensor 8	793 mV	Sensor 9	656 mV	Sensor 10	882 mV	Sensor 11	705 mV	Sensor 12	793 mV
Detonation Level Select																											
Sensor 1	833 mV																										
Sensor 2	744 mV																										
Sensor 3	705 mV																										
Sensor 4	617 mV																										
Sensor 5	744 mV																										
Sensor 6	833 mV																										
Sensor 7	833 mV																										
Sensor 8	793 mV																										
Sensor 9	656 mV																										
Sensor 10	882 mV																										
Sensor 11	705 mV																										
Sensor 12	793 mV																										

<F10> to Save <ESC> to Main Menu <F5> to AUTOCAL

Figure 4.05-2. View/Edit Control Data Values Screen

Table 4.05-1. AutoCal Worksheet For 6, 8, And 12 Cylinder Engines

SENSOR	SET-POINT "S" COLUMN RESULTS										HIGHEST "S" VALUE
	RUN #	RUN #	RUN #	RUN #	RUN #	RUN #	RUN #	RUN #	RUN #	RUN #	
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											

Table 4.05-2. AutoCal Worksheet For 16 Cylinder Engines

SENSOR PAIRS	SET-POINT "S" COLUMN RESULTS										HIGHEST "S" VALUE
	RUN #	RUN #	RUN #	RUN #	RUN #	RUN #	RUN #	RUN #	RUN #	RUN #	
1 & 2											
3 & 4											
5 & 6											
7 & 8											
9 & 10											
11 & 12											
13 & 14											
15 & 16											

6. To begin AutoCal, press [F5] while viewing the View/Edit Control Data Values Screen. The AutoCal Screen appears. Figure 4.05-3 shows the AutoCal Screen for 6, 8, and 12 cylinder engine applications. Figure 4.05-4 shows the AutoCal Screen for 16 cylinder engine applications.

NOTE: The AutoCal results shown in the figures and tables provided in this manual are for example only. Actual AutoCal values will vary depending on the application.

NOTE: "L" = Low, "M" = Medium, "H" = High, "S" = Set-Point in Figure 4.05-3 and Figure 4.05-4.

AUTOCAL TEST TIMING

Automatic Calibration of Detonation Sensor Threshold Voltages

AutoCal Test Timing 10 °BTDC

Messages:

AutoCal	L	M	H	S
Sensor 1				
Sensor 2				
Sensor 3				
Sensor 4				
Sensor 5				
Sensor 6				
Sensor 7				
Sensor 8				
Sensor 9				
Sensor 10				
Sensor 11				
Sensor 12				

Engine Timing for Autocal Program. <F10> Accepts, <ESC> Aborts

Figure 4.05-3. AutoCal Screen For 6, 8, And 12 Cylinder Engines

RUNNING THE DSM AUTOCAL PROGRAM

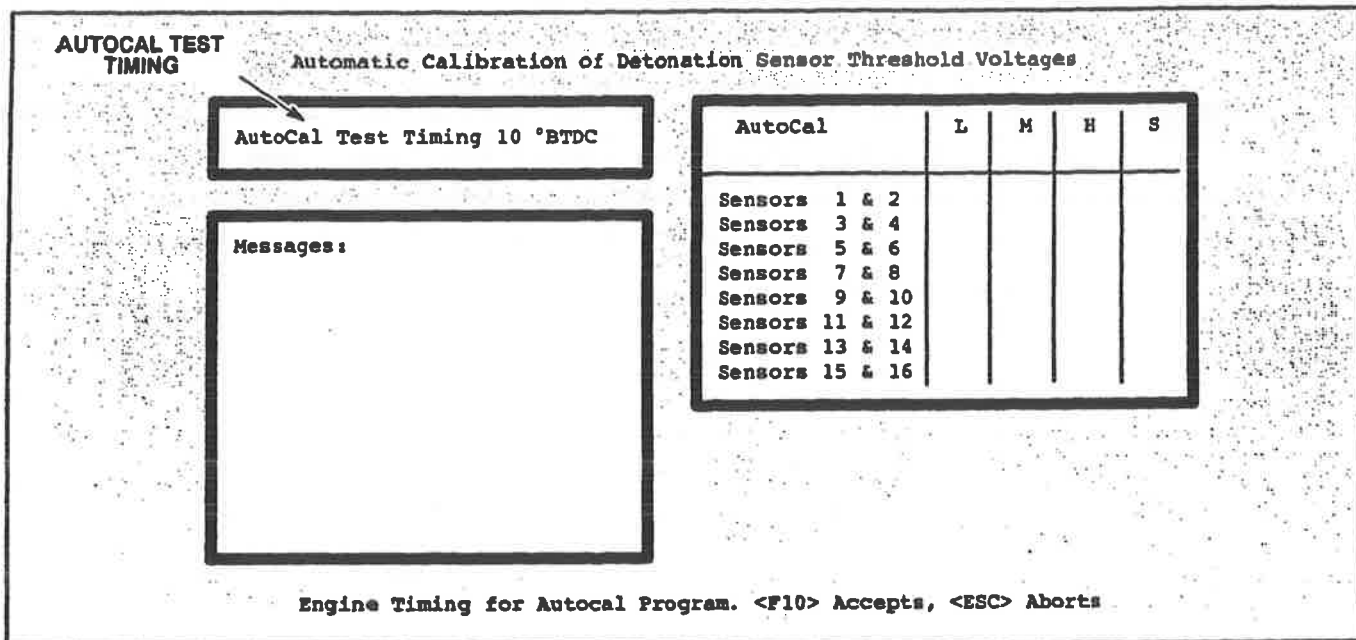


Figure 4.05-4. AutoCal Screen For 16 Cylinder Engines

7. Verify that the "AutoCal Test Timing" on the AutoCal Screen (see Figure 4.05-3 or Figure 4.05-4) is the same as that fuel's "Most Advanced Timing" (grounded or open, whichever is applicable) on the View/Edit Control Data Values Screen (see Figure 4.05-5). If the "AutoCal Test Timing" is not the same as "Most Advanced Timing," enter the "Most Advanced Timing" on the AutoCal Screen.

NOTE: AutoCal will default to the "D" lead grounded ignition setting which is "Most Advanced Timing." For secondary fuel (or "D" lead open), the AutoCal Screen test timing value may need to be edited as explained in Step 7.

8. Press [F10] to accept the "AutoCal Test Timing" value and begin AutoCal. Calibration numbers for each sensor will begin appearing in the "S" or Set-Point column. When the calibration process is completed your screen will resemble the screen shown in Figure 4.05-6.

NOTE: If any errors occur during the AutoCal program they will be displayed as LOW, STAL, or HISP in the

Set-Point column on the AutoCal Screen. Additionally, an error message will be provided in the "Messages" box on the AutoCal Screen stating, "AutoCal Completed With ERRORS." See Section 4.00, DSM System Diagnostics And Troubleshooting, to correct problem. Once the problem is corrected, rerun AutoCal.

NOTE: If an HISP or STAL error occurs, the AutoCal Program will stop as soon as the error is detected. If a LOW error occurs, the AutoCal program will continue but the AutoCal results on the View/Edit Control Data Values Screen will NOT be updated.

NOTE: To save your AutoCal results to a file, press [F4] after running the AutoCal program. Follow the instructions on the screens that follow. The file will be saved to the drive and directory where the DSM Interface Program is located. This file is NOT retrievable through the DSM but can be opened outside of the DSM program in Microsoft® Notepad® or a word processing program and then printed. Saving the AutoCal results to a file is NOT a substitute for saving to ROM. Be sure to save the AutoCal results to ROM.

MOST ADVANCED TIMING View/Edit Control Data Values

Engine Family : V-12 GAS ENGINE Engine Model : L7000 V-12 # of Cylinders: 12 Primary Fuel : NATURAL GAS PIPELINE QUALITY Secondary Fuel: DIESTER GAS Comments:	
Timing Disk Reference	26 °BTDC
<F3> To Calculate TDR	
D-Lead Position - - ->	Grounded Open
Most Advanced Timing	10 °BTDC 10 °BTDC
Most Retarded Timing	4 °BTDC 4 °BTDC
Default Timing	8 °BTDC 8 °BTDC
End of Sample Window	30 °ATDC
Retard 1° Every	1 Knock Sample(s)
Advance 1° Every	5 No-Knock Sample(s)
Warm-Up Delay Time	300 Seconds
Shutdown Delay Time	15 Seconds

Detonation Level Select

Sensor 1	833 mV
Sensor 2	744 mV
Sensor 3	705 mV
Sensor 4	617 mV
Sensor 5	744 mV
Sensor 6	833 mV
Sensor 7	833 mV
Sensor 8	793 mV
Sensor 9	656 mV
Sensor 10	882 mV
Sensor 11	705 mV
Sensor 12	793 mV

NOTE: Entries above 2400mV result in a Disabled Sensor.

<F10> to Save <ESC> to Main Menu <F5> to AUTOCAL

Figure 4.05-5. View/Edit Control Data Values Screen

Automatic Calibration of Detonation Sensor Threshold Voltages

AutoCal Test Timing 10 °BTDC

Messages:

Starting LATEST ROM Program.

Program is Running.

AutoCal Completed Successfully
 <F4> Saves AC Data to Filename
 ANY Other Key Continues

AutoCal	L	M	H	S
Sensor 1	323	323	411	617
Sensor 2	411	470	588	882
Sensor 3	382	411	411	617
Sensor 4	352	352	382	568
Sensor 5	323	352	441	656
Sensor 6	470	470	470	705
Sensor 7	470	499	529	793
Sensor 8	323	470	499	744
Sensor 9	323	382	411	617
Sensor 10	323	470	558	833
Sensor 11	352	352	382	568
Sensor 12	352	382	470	705

Figure 4.05-6. Completion Of AutoCal Program

RUNNING THE DSM AUTOCAL PROGRAM

Table 4.05-3. AutoCal Worksheet Example - Run # 1 Results

SENSOR	SET-POINT "S" COLUMN RESULTS										HIGHEST "S" VALUE
	RUN # 1	RUN # ___	RUN # ___	RUN # ___	RUN # ___	RUN # ___	RUN # ___	RUN # ___	RUN # ___	RUN # ___	
1	617										
2	882										
3	617										
4	568										
5	656										
6	705										
7	793										
8	744										
9	617										
10	833										
11	568										
12	705										

NOTE: The AutoCal results shown in the figures and tables provided in this manual are for example only. Actual AutoCal values will vary depending on the application.

View/Edit Control Data Values

Engine Family : VHP GAS ENGINE Engine Model : L7042 V-12 # of Cylinders: 12 Primary Fuel : NATURAL GAS PIPELINE QUALITY Secondary Fuel: DIGESTER GAS Comments:		<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="2">Detonation Level Select</th> </tr> </thead> <tbody> <tr><td>Sensor 1</td><td>617</td></tr> <tr><td>Sensor 2</td><td>882</td></tr> <tr><td>Sensor 3</td><td>617</td></tr> <tr><td>Sensor 4</td><td>568</td></tr> <tr><td>Sensor 5</td><td>656</td></tr> <tr><td>Sensor 6</td><td>705</td></tr> <tr><td>Sensor 7</td><td>793</td></tr> <tr><td>Sensor 8</td><td>744</td></tr> <tr><td>Sensor 9</td><td>617</td></tr> <tr><td>Sensor 10</td><td>833</td></tr> <tr><td>Sensor 11</td><td>568</td></tr> <tr><td>Sensor 12</td><td>705</td></tr> </tbody> </table> <p style="font-size: small;">NOTE: Entries above 2400mV result in a Disabled Sensor.</p>	Detonation Level Select		Sensor 1	617	Sensor 2	882	Sensor 3	617	Sensor 4	568	Sensor 5	656	Sensor 6	705	Sensor 7	793	Sensor 8	744	Sensor 9	617	Sensor 10	833	Sensor 11	568	Sensor 12	705
Detonation Level Select																												
Sensor 1	617																											
Sensor 2	882																											
Sensor 3	617																											
Sensor 4	568																											
Sensor 5	656																											
Sensor 6	705																											
Sensor 7	793																											
Sensor 8	744																											
Sensor 9	617																											
Sensor 10	833																											
Sensor 11	568																											
Sensor 12	705																											
Timing Disk Reference 26 °BTDC <F3> To Calculate TDR D-Lead Position - - -> Grounded Open Most Advanced Timing 10 °BTDC 10 °BTDC Most Retarded Timing 4 °BTDC 4 °BTDC Default Timing 8 °BTDC 8 °BTDC End of Sample Window 30 °ATDC																												
Retard 1° Every 1 Knock Sample(s) Advance 1° Every 5 No-Knock Sample(s)																												
Warm-Up Delay Time 300 Seconds Shutdown Delay Time 15 Seconds																												

<F10> to Save <ESC> to Main Menu <F5> to AUTOCAL

Figure 4.05-7. View/Edit Control Data Values Screen With Preliminary AutoCal Results

9. In a "RUN #" column on your AutoCal Worksheet, record the values listed in the "S" or Set-Point column on the AutoCal Screen. For example, the values in the "S" or Set-Point column on the AutoCal Screen in Figure 4.05-6 are recorded in the sample AutoCal Worksheet shown in Table 4.05-3.

NOTE: If you have a portable printer connected to your PC, press the [Print Screen] button for a printout of the AutoCal Screen.

10. Press any key to continue. You will return to the View/Edit Control Data Values Screen. The "S" or Set-Point values just determined during the AutoCal program appears in the "Detonation Level Select" table on the right hand side of the View/Edit Control Data Values Screen (see Figure 4.05-7).

11. Rerun the AutoCal program two additional times following Steps 6 - 10. Be sure to record the "S" or Set-Point column results for each AutoCal you run on the AutoCal Worksheet.

12. Press any key to continue. You will return to the View/Edit Control Data Values Screen. The values determined by the last AutoCal program you ran appears in the "Detonation Level Select" table on the right hand side of the View/Edit Control Data Values Screen.

13. If this is a dual fuel application and if possible, change fuels going to the engine and repeat Steps 5 - 12 to run the AutoCal program while running on the secondary fuel and timing. Record all "S" or Set-Point values determined by the AutoCal program for each sensor on the AutoCal Worksheet.

14. After running the AutoCal programs, circle the highest "S" or Set-Point value calibrated during all the AutoCals for each sensor on the worksheet (see Table 4.05-4).

15. Record the circled (highest) "S" or Set-Point value in the "Highest 'S' Value" column on the worksheet (see Table 4.05-4).

16. Compare the "S" or Set-Point values for each sensor recorded in the "Highest 'S' Value" column on your worksheet. If the results determined for each sensor vary by more than 500 from one sensor to another, refer to Table 4.00-4 in Section 4.00, *DSM System Diagnostics And Troubleshooting*. If the values do vary by more than 500 from sensor to sensor it may indicate 1) engine detonation, 2) sensor mounting imperfections, 3) unattached or incorrectly routed wire harnesses and/or ground wiring, or 4) other engine related problems. The troubleshooting table in Section 4.00 provides you with remedies.

17. With the View/Edit Control Data Values Screen showing, position the cursor in the first field of the "Detonation Level Select" table on the screen.

18. Enter the highest set-point value calibrated for each sensor (see Figure 4.05-8). These values are recorded on your AutoCal Worksheet in the "Highest 'S' Value" column. For example, in Figure 4.05-8, "656" was entered since it was the highest detonation level calibrated for Sensor 1 during all AutoCal programs completed.

19. Once all the set-point values are entered in the "Detonation Level Select" table, the edited data-set must be saved to ROM. Press [F10] to save the edited data-set. Highlight "Configure DSM Memory" on the next menu and press [Enter]. When the Verification Screen appears press [Y]. Several screens will appear indicating that the data-set is being saved to ROM, permanent memory on the EPROM chip inside the DSM module. Once the data-set has been saved to ROM, a message will state that the DSM memory has been configured to ROM. Press any key to continue.

RUNNING THE DSM AUTOCAL PROGRAM

Table 4.05-4. AutoCal Worksheet Example - Completed Results

SENSOR	SET-POINT "S" COLUMN RESULTS										HIGHEST "S" VALUE
	RUN # 1	RUN # 2	RUN # 3	RUN # 4	RUN # 5	RUN #	RUN #	RUN #	RUN #	RUN #	
1	617	617	656								656
2	882	833	793								882
3	617	705	656								705
4	568	568	617								617
5	656	656	705								705
6	705	656	617								705
7	793	744	833								833
8	744	793	793								793
9	617	656	656								656
10	833	793	882								882
11	568	568	617								617
12	705	744	705								744

NOTE: The AutoCal results shown in the figures and tables provided in this manual are for example only. Actual AutoCal values will vary depending on the application.

View/Edit Control Data Values

Engine Family : VHP GAS ENGINE
 Engine Model : L7042 V-12
 # of Cylinders: 12
 Primary Fuel : NATURAL GAS PIPELINE QUALITY
 Secondary Fuel: DIGESTER GAS
 Comments:

Timing Disk Reference 26 °BTDC
 <F3> To Calculate TDR
 D-Lead Position - - -> Grounded Open
 Most Advanced Timing 10 °BTDC 10 °BTDC
 Most Retarded Timing 4 °BTDC 4 °BTDC
 Default Timing 8 °BTDC 8 °BTDC
 End of Sample Window 30 °ATDC

Retard 1° Every 1 Knock Sample(s)
 Advance 1° Every 5 No-Knock Sample(s)

Warm-Up Delay Time 300 Seconds
 Shutdown Delay Time 15 Seconds

Detonation
Level Select

Sensor 1	656 mV
Sensor 2	882 mV
Sensor 3	705 mV
Sensor 4	617 mV
Sensor 5	705 mV
Sensor 6	705 mV
Sensor 7	833 mV
Sensor 8	793 mV
Sensor 9	656 mV
Sensor 10	882 mV
Sensor 11	617 mV
Sensor 12	744 mV

NOTE: Entries above 2400mV result in a Disabled Sensor.

<F10> to Save
<ESC> to Main Menu
<F5> to AUTOCAL

Figure 4.05-8. View/Edit Control Data Values Screen With Completed AutoCal Results

SECTION 4.10

LOST SENSOR CHECK TEST ON 16 CYLINDER ENGINES

PERFORMING LOST SENSOR CHECK TEST ON 16 CYLINDER ENGINES

The 16 cylinder DSM system checks for detonation in cylinder pairs and not individually like 6, 8, and 12 cylinder engines. Because of cylinder pairs, the DSM system does not automatically display lost sensor alarms on the Display Serial Port Data Screen. To display lost sensors, a lost sensor check must be performed. Complete the steps in this section to perform a lost sensor check for 16 cylinder engines.

A TEST FOR LOST SENSORS ON 16 CYLINDER ENGINES SHOULD BE PERFORMED WHENEVER THE SAFETY CONTROLS AND ALARMS ARE TESTED ON THE ENGINE.

CAUTION Make sure the engine is at full load during this check. At light loads, engine characteristics are very different than at higher loads. Typically, this results in lower output from the knock sensors which, if low enough, will result in a "lost sensor" error even when the system is working properly. Errors may result at low loads after engine warmup. These errors go away once the engine is fully loaded.

NOTE: If "lost sensor" errors are experienced at low loads and do not correct themselves as the engine is fully loaded, refer to Section 4.00, DSM System Diagnostics And Troubleshooting.

1. Access the Display Serial Port Data Screen (see Figure 4.10-2) by selecting "View Serial Link" from the DSM program's Main Menu. Although sensor status is displayed in the "Status" column, a sensor check must be manually completed to indicate a bad or disconnected sensor on the Display Serial Port Data Screen. A bad or disconnected sensor will be indicated on the Display Serial Port Data Screen during Steps 3 and 5 that follow.

NOTE: If a bad or disconnected sensor is detected, the DSM module also displays a message on the LCD display inside the DSM module.

2. Press the SENSOR CHECK button on the DSM filter once, the red Right Bank LED on the DSM filter will be illuminated (see Figure 4.10-1).

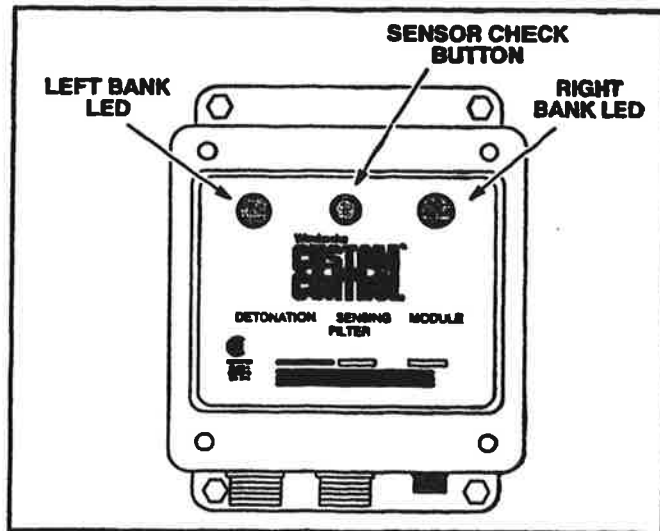


Figure 4.10-1. DSM Filter For 16 Cylinder Engines

CHECKING FOR PROPER SENSOR CONNECTION

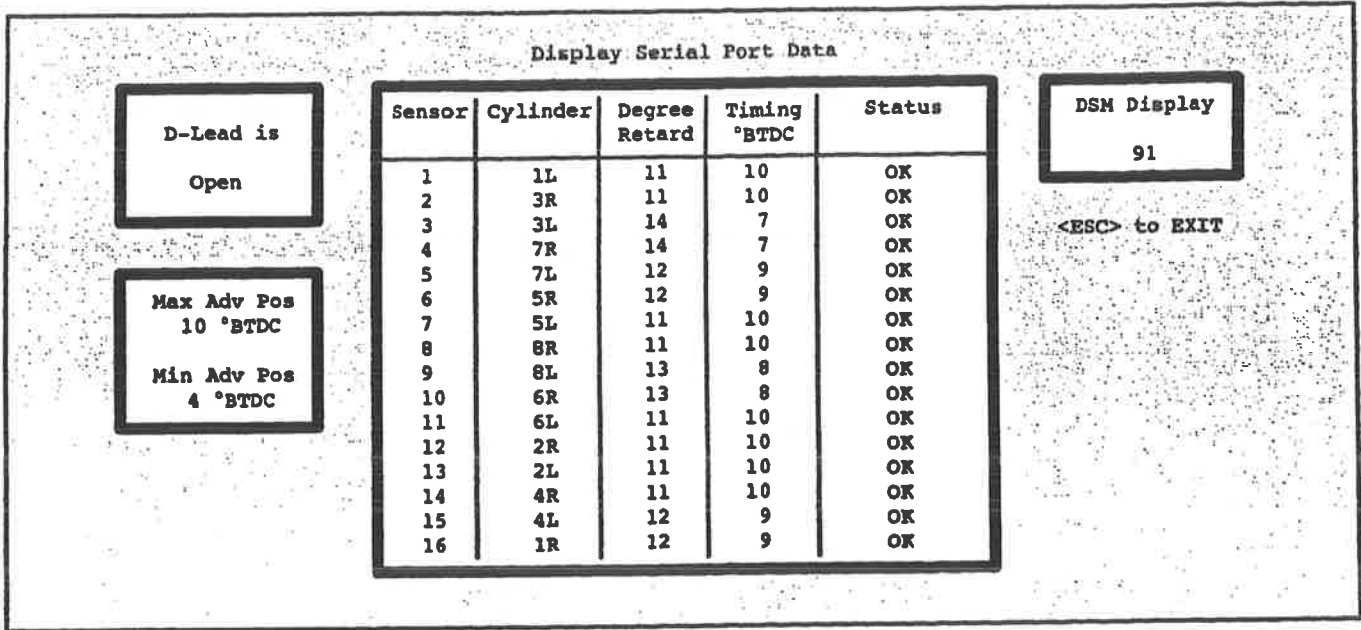


Figure 4.10-2. Display Serial Port Data Screen

3. If there are any bad or disconnected sensors on the right bank of the engine, the status shown on the Display Serial Port Data Screen will change from "OK" to "Sensor Low" for both cylinders in the pair within three minutes (see Figure 4.10-3).

4. After three minutes, press the SENSOR CHECK button again to perform the sensor test on the left bank of the engine.

5. If there are any bad or disconnected sensors on the left bank of the engine, the status shown on the Display Serial Port Data Screen will change from "OK" to

"Sensor Low" for both cylinders in the pair within three minutes.

6. After three minutes, press the SENSOR CHECK button again to exit the lost sensor check test. The LEDs will turn off.

NOTE: The DSM system will automatically exit the "sensor check" mode after 5 minutes and the LEDs will turn off, returning the DSM system to normal operation.

7. Perform a sensor check whenever the safety controls and alarms are tested on the engine.

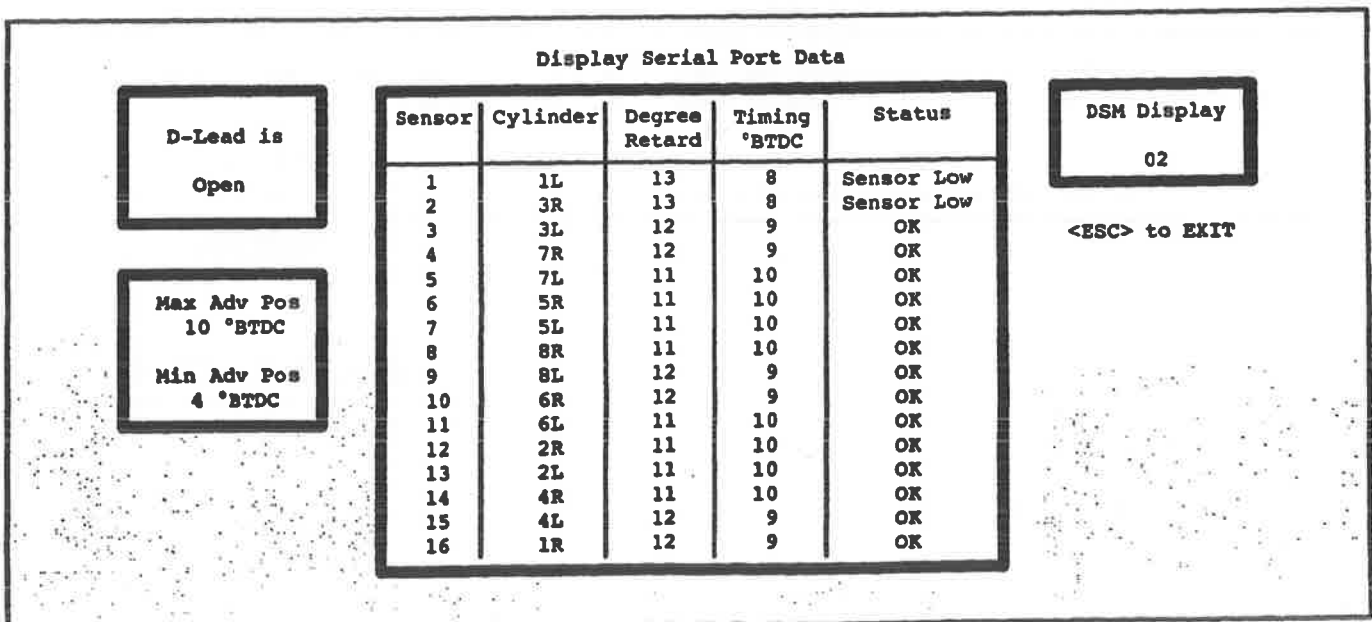


Figure 4.10-3. Display Serial Port Data Screen

SECTION 4.15

EPROM CHIP REPLACEMENT

ABOUT EPROM CHIP REPLACEMENT

Engine parameters and data-sets for your engine are saved on an EPROM chip (ROM, permanent memory) inside the DSM module. Replacement of the EPROM chip is necessary because the EPROM chip is "full" of saved data-sets, the EPROM chip is damaged, or the EPROM chip is to be upgraded (for example: version 5.3c to version 6 series EPROM).

NOTE: For EPROM version 6.X (where X is the revision level), the DSM module allows 25 saves to the EPROM chip. For version 5.3c, the DSM module allows 20 saves to the EPROM chip. Once the EPROM chip has been fully configured, the chip must be replaced.

NOTE: Contact your Waukesha Engine Distributor for EPROM chip part number for replacement.

Damaged or corrupt EPROM chips are referred to several times in the troubleshooting suggestions from Section 4.00. A damaged or corrupt EPROM chip could be caused by any of the following:

- Serial cable became disconnected from DSM module while the program was being saved to the EPROM chip (permanent memory).
- The power to the DSM module was inadequate or excessively "dirty" during EPROM chip save.
- EPROM chip was installed improperly (for example, with indentation notch installed facing the wrong direction or pins not aligned in socket).

Inside the DSM module is a circuit board assembly comprised of two circuit boards. The EPROM chip is located on the bottom circuit board (between the two circuit boards). To replace the EPROM chip it is necessary to remove the circuit board assembly from the DSM module, disassemble the circuit board assembly, and remove the full or damaged EPROM chip. Follow the steps in this section when replacing an EPROM chip.

SAVING DATA-SET TO DISK

To simplify reprogramming of the DSM system after EPROM replacement, save the existing data-set to a file on disk **BEFORE** replacing the EPROM chip. The data-set is assigned a filename and saved on disk so the data-set can be retained for reprogramming when replacing the EPROM chip with the same version chip.

NOTE: If you are upgrading the EPROM chip and DSM Interface Program to the current version (version 6.X), make a printout (or hard copy) of the saved data-set seen on the View/Edit Control Data Values Screen to allow for easy reprogramming. A saved data-set from an earlier version of DSM software cannot be retrieved electronically with the newer DSM software/EPROM chip.

If the existing data-set is already saved to disk or you do not want to save the existing data-set to a disk for reprogramming, continue with the section "Replacing EPROM Chip."

1. With the DSM Interface Program's Main Menu showing on your screen, highlight "Edit/Create Setup" and press [Enter].

NOTE: For information on installing and/or accessing the DSM Interface Program, refer to the white card at the back of this manual which holds the 3-1/2" diskette for installation and accessing instructions.

2. Highlight "Retrieve from DSM" from the next menu and press [Enter]. Several screens will appear indicating that the data is being retrieved from the DSM module. Then the View/Edit Control Data Values Screen appears. This screen shows the engine's saved data-set parameters. The information shown on the screen is stored on the DSM EPROM chip (ROM or permanent memory).

3. Save the existing data-set to disk by pressing [F10] (see Figure 4.15-1).

4. Highlight "Save Data to Filename" from the menu and press [Enter].

EPROM CHIP REPLACEMENT

View/Edit Control Data Values

Engine Family : VHP GAS ENGINE
 Engine Model : L7042 V-12
 # of Cylinders : 12
 Primary Fuel : NATURAL
 Secondary Fuel: DIGESTED
 Comments:

Save Data to Filename
 Test Data on DSM
 Configure DSM Memory
 View Wiring Data

Timing Disk Reference
 <F3> To Calculate IMA

D-Lead Position - - -> Grounded Open
 Most Advanced Timing 10 °BTDC 10 °BTDC
 Most Retarded Timing 4 °BTDC 4 °BTDC
 Default Timing 8 °BTDC 8 °BTDC
 End of Sample Window 30 °ATDC

Retard 1° Every 1 Knock Sample(s)
 Advance 1° Every 5 No-Knock Sample(s)

Warm-Up Delay Time 300 Seconds
 Shutdown Delay Time 15 Seconds

Detonation
Level Select

Sensor 1	656	mV
Sensor 2	882	mV
Sensor 3	705	mV
Sensor 4	617	mV
Sensor 5	705	mV
Sensor 6	705	mV
Sensor 7	833	mV
Sensor 8	793	mV
Sensor 9	656	mV
Sensor 10	882	mV
Sensor 11	617	mV
Sensor 12	744	mV

NOTE: Entries above 2400mV result in a Disabled Sensor.

<F10> to Save <ESC> to Main Menu <F5> to AUTOCAL

Figure 4.15-1. Saving Options Menu

View/Edit Control Data Values

Engine Family : VHP GAS ENGINE
 Engine Model : L7042 V-12
 # of Cylinders : 12
 Primary Fuel :
 Secondary Fuel:
 Comments:

Timing Disk Reference
 <F3>

D-Lead Position
 Most Advanced Timing
 Most Retarded Timing
 Default Timing
 End of Sample Window

Retard 1° Every
 Advance 1° Every 5 No-Knock Sample(s)

Warm-Up Delay Time 300 Seconds
 Shutdown Delay Time 15 Seconds

Detonation
Level Select

r 1	656	mV
r 2	882	mV
r 3	705	mV
r 4	617	mV
r 5	705	mV
r 6	705	mV
r 7	833	mV
r 8	793	mV
r 9	656	mV
r 10	882	mV
r 11	617	mV
r 12	744	mV

NOTE: Entries above 2400mV result in a Disabled Sensor.

Save Choices to Disk

Input DataFile Name

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

<F10> to Save <ESC> to Main Menu <F5> to AUTOCAL

Figure 4.15-2. Entering Filename Of Data-Set

5. Enter a filename according to the following procedure (see Figure 4.15-2). Read all three steps prior to saving the file to the disk.

- A. Locate the engine's serial number on the name-plate.
- B. If the engine has a "C-" number, remove the "C-" and the "/" from the number. Example: C-10768/01 would give a root file name of "1076801". If the engine does not have a "C-" number use all six digits in the serial number for the filename.
- C. The first time the configuration is saved to the disk add an "A" to the end. This is to indicate that

this is the first save of this configuration. If changes are made to the configuration, save the next file with the same numerical information and change the suffix letter to "B". Continue in this manner for each revision to the file.

Once eight characters have been entered, the file will automatically be saved to the computer disk where the DSM program resides. If the filename is less than eight characters, press [Enter] to save.

NOTE: When saving to disk, the data-set will be saved to the drive and directory where the DSM Interface Program is located.

6. Press [ESC] to return to the Main Menu.

REPLACING EPROM CHIP

1. Disconnect the DSM module from the Ignition Module by removing the "DSM to ignition" harness from the 14 pin connector on the side of the Ignition Module.

⚠ WARNING

Disconnect all electrical power supplies before making any connections or servicing any part of the electrical system. Electrical shock can cause severe personal injury or death.

2. Remove power from DSM module
3. Label the white connectors on the left side "T" (top), "M" (middle), "B" (bottom) (see Figure 4.15-3). These wires need to be identified so that reconnections of the wires are made correctly.
4. Disconnect all the wire strips from inside the DSM module including the white wire connectors (see Figure 4.15-3).

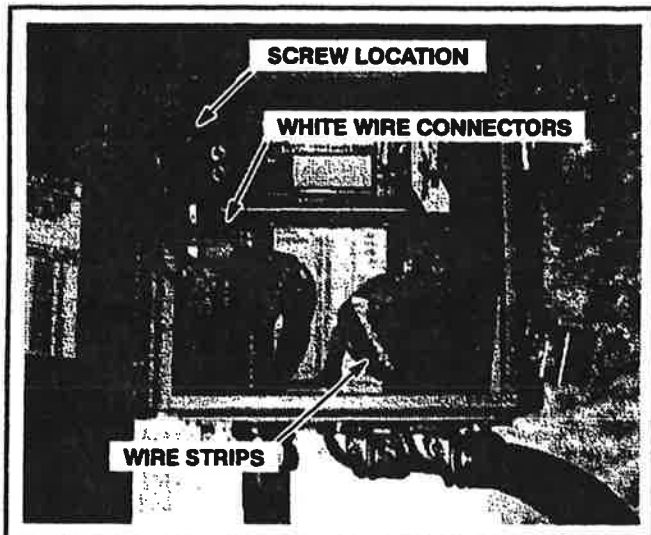


Figure 4.15-3. Disconnecting Wire Strips

5. Remove the four corner screws securing the circuit board assembly to the DSM module.

NOTE: Screws are sealed with Loctite® to prevent loosening under vibration. Be sure to use Loctite® on screws when reinstalling.

6. Carefully remove the circuit board assembly through the front of the DSM module.

NOTE: If you cannot remove the circuit board assembly because the wire connectors are blocking the opening, remove the bottom plate from the DSM module (see Figure 4.15-4). The wires can be pulled out of the module and the circuit board assembly will come out through the front of the DSM module.

7. Remove the three screws from the top circuit board in the order shown in Figure 4.15-5.

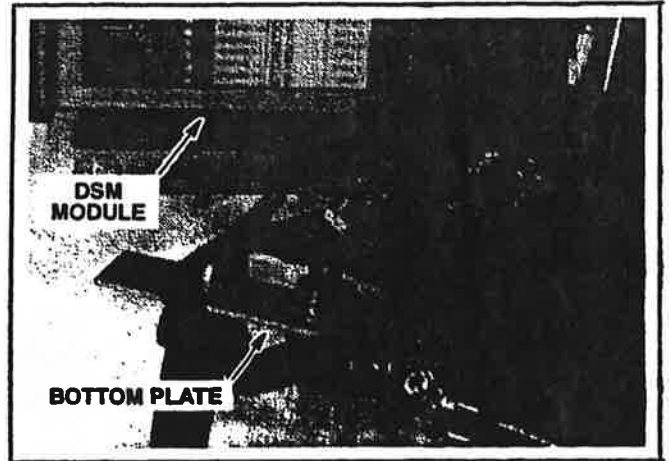


Figure 4.15-4. Removing Bottom Plate Of DSM Module

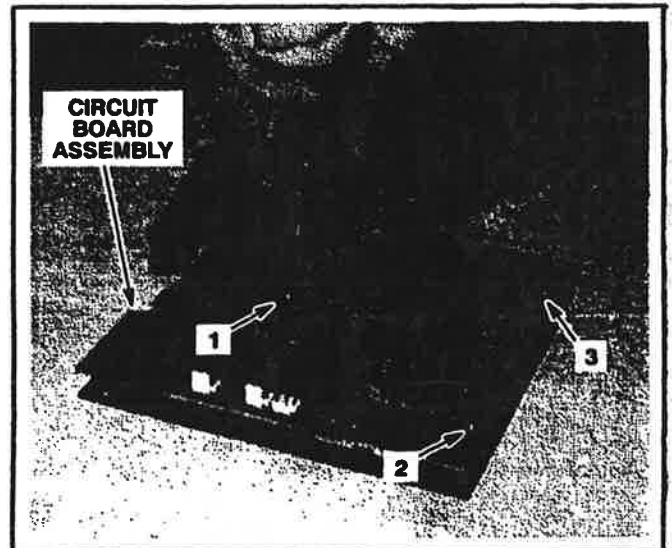


Figure 4.15-5. Removing Screws From Circuit Board Assembly

8. On the right side of the circuit board assembly is a blue connector which holds the two circuit boards together. Using a small flat screwdriver, pry apart the blue connector at the three notches (see Figure 4.15-6).

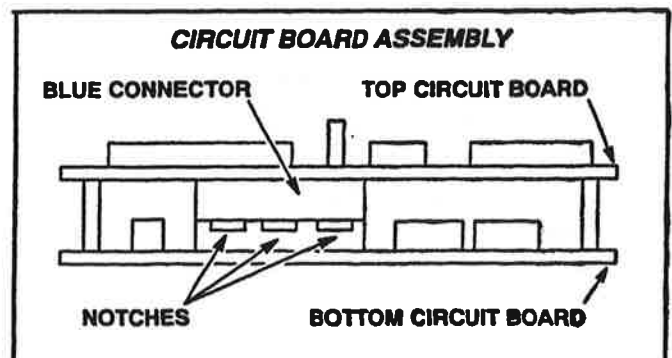


Figure 4.15-6. Disassembling Circuit Board Assembly

EPROM CHIP REPLACEMENT

9. The EPROM chip is located on the upper left side of the bottom circuit board as shown Figure 4.15-7. At the same time, press down the two blue tabs located on both sides of the EPROM chip and the chip will pop off.

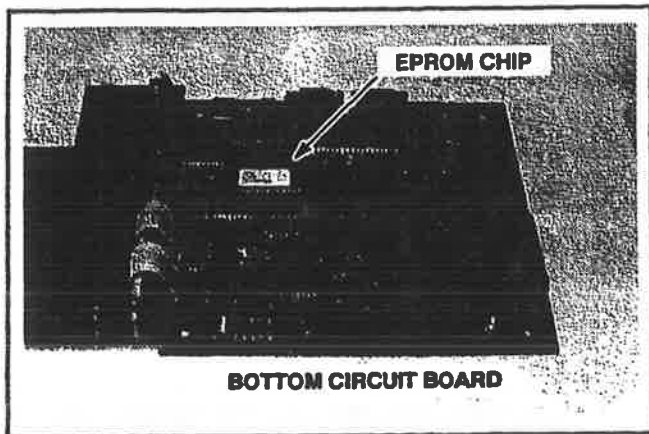


Figure 4.15-7. EPROM Chip Location On Bottom Circuit Board

10. Remove the full/damaged EPROM chip from the circuit board.

11. Carefully place a new EPROM chip in place on the circuit board. Make sure the notched side of the EPROM chip is installed to face toward the right side of the circuit board as shown in Figure 4.15-8 and Figure 4.15-9.

WARNING

The EPROM chip must be installed so the indentation notch on the chip is installed to face toward the right side of the bottom circuit board. Failure to install the EPROM chip correctly will result in a non-functional DSM module and the EPROM chip will need to be replaced.

12. Press the EPROM chip into place making sure that all the pins of the EPROM chip are aligned with the socket. Failure to install the EPROM correctly will result in a non-functional DSM module.

NOTE: If the pins on the new EPROM chip do not align with the socket on the circuit board, press on the side of the pins very carefully until pin alignment allows for installation.

13. After the new EPROM chip is installed, carefully align the top circuit board with the bottom circuit board.

14. Press the circuit boards together so the blue connector on the right sides of the circuit boards snap together.

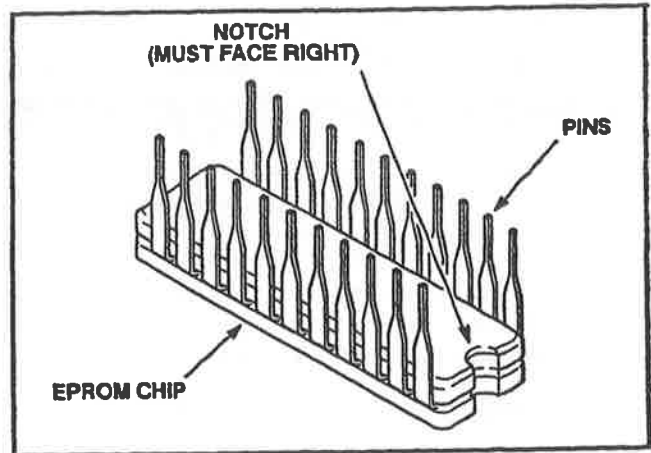


Figure 4.15-8. Correct EPROM Chip Direction

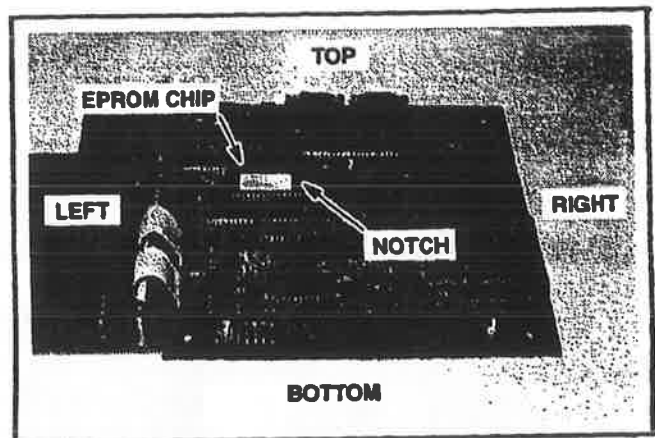


Figure 4.15-9. EPROM Chip Location On Bottom Circuit Board

15. Secure the two circuit boards with the three screws removed in Step 7.

16. Place the circuit board assembly into the DSM module.

17. Secure the circuit board assembly to the DSM module with the four screws removed in Step 5.

18. Reconnect all wire strips and white wire connectors inside the DSM module. Make sure the white connectors are reconnected in the order marked in Step 3.

NOTE: If you had to remove the bottom plate of the DSM module to remove the circuit board assembly, reinstall bottom plate.

19. Reapply power to the DSM module.

REPROGRAMMING THE EPROM CHIP

The EPROM chip just installed will not have a saved data-set. You will need to reprogram the EPROM chip. After reapplying power to the DSM module, the internally mounted LCD display will read "99" (no data). The DSM module is sensing that a new EPROM chip is installed in the DSM module.

- If you want to reprogram the EPROM chip with a completely new data-set, complete the programming steps in Section 3.10, *Programming The DSM System For A New Application*.
- If you have a saved data-set on disk and want to use that information to re-program the EPROM chip, complete the steps in "Retrieving A Saved Data-Set" below.

NOTE: If you are upgrading the EPROM chip and DSM Interface Program from a previous software version (example Version 5.3c) to the current version (version 6.X), you may use the values from a previous data-set to reprogram the DSM system. However, **DO NOT** use AutoCal values from older versions of DSM software when reprogramming a newer version. When upgrading to the current DSM Interface Program software you must rerun the AutoCal program. Refer to Section 4.05 Running The DSM AutoCal Program to run the AutoCal program.

Retrieving A Saved Data-Set

1. With the DSM Interface Program's Main Menu showing on your screen, highlight "Edit/Create Setup" and press [Enter] (see Figure 4.15-10).

NOTE: Verify that the DSM module is disconnected from the Ignition Module before reprogramming the EPROM chip. If the DSM module is not disconnected from the Ignition Module, disconnect the "DSM to ignition" harness from the 14 pin DSM connector on the side of the Ignition Module.

NOTE: For information on installing and/or accessing the DSM Interface Program, refer to the white card at the back of this manual which holds the 3-1/2" diskette for installation and accessing instructions.

2. On the next menu highlight "Retrieve from Filename" and press [Enter] (see Figure 4.15-11).

3. Highlight the file name (serial number) you want to open and press [Enter] (see Figure 4.15-12). The View/Edit Control Data Values Screen appears with the saved data-set information.

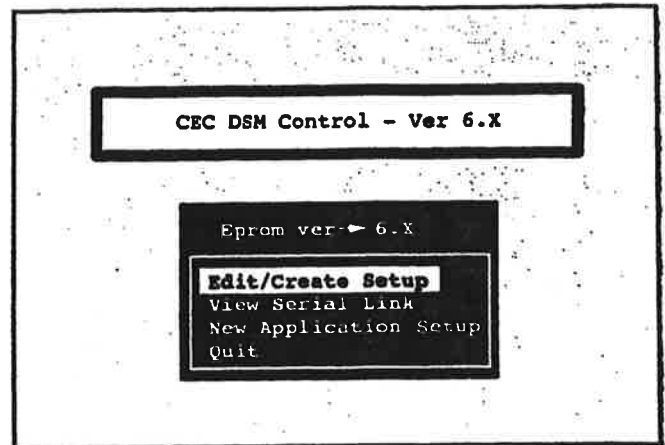


Figure 4.15-10. DSM Interface Program Main Menu

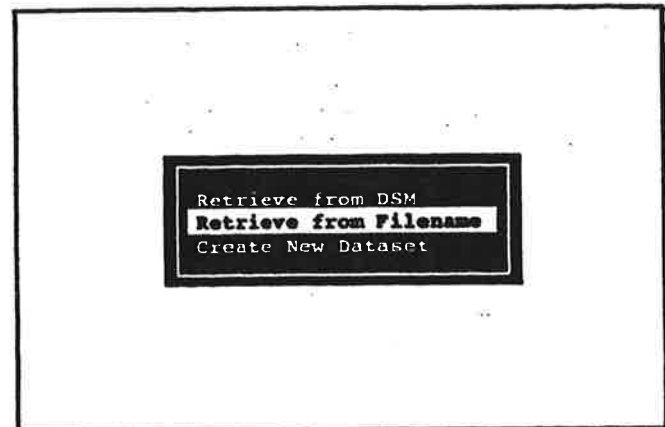


Figure 4.15-11. Edit/Create Setup Menu



Figure 4.15-12. Selecting File Name Of Saved Data-Set

EPROM CHIP REPLACEMENT

4. The information that is shown on the View/Edit Control Data Values Screen has NOT been stored on the DSM module's EPROM chip (permanent memory). Press [F10] to save the loaded data-set to ROM (permanent memory). Highlight "Configure DSM Memory" on the next menu and press [Enter]. When the Verification Screen appears press [Y]. Several screens will appear indicating that the data-set is being saved to ROM, permanent memory on the EPROM chip inside the DSM module. Once the data-set has been saved to ROM, a message will state that the DSM memory has been configured to ROM. Press any key to continue.

5. Reconnect the DSM module to the Ignition Module by threading the "DSM to ignition" harness from the 14 pin connector on the side of the Ignition Module.

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WAUKESHA ENGINE DIVISION, DRESSER INDUSTRIES, INC.
EXPRESS LIMITED WARRANTY FOR CUSTOM ENGINE CONTROLS®

INTRODUCTION

Custom Engine Controls® (CEC) are sold as standard, or as options on new Engines or as Genuine Service Parts, and include the Detonation Sensing Module (DSM), Air Fuel Module (AFM), Turbo Control Management System (TCMS), and Ignition Module (IM), or any other control device identified as a CEC product.

I. TERMS OF EXPRESS LIMITED WARRANTY

Waukesha Engine Division warrants that it will repair or replace, AT ITS ELECTION AND EXPENSE, any CEC installed on an engine, or Enginator®, or product (hereinafter referred to as "Products") manufactured by Waukesha, or purchased as a Genuine Service Part, which proves to have had a defect in material or workmanship.

II. TERM LIMITATIONS OF EXPRESS LIMITED WARRANTY

- A. This coverage shall commence upon initial new Products start-up date or the purchase date, in the case of service parts sales, and shall expire upon the earlier of the following:
1. New Products
 - A. 12 months after the initial new Product start-up date; or
 - B. 24 months after the original shipment date of the covered Products by Waukesha Engine Division.
 2. Genuine Service Parts
 - A. 12 months from the date the CEC is put into service; or
 - B. 18 months from the purchase date.
- B. Notwithstanding the foregoing, Waukesha further warrants that it will repair or replace, AT ITS ELECTION AND EXPENSE, any component of the Waukesha Product damaged as the direct result of a warrantable defect in a CEC product.

III. WAUKESHA'S RESPONSIBILITIES UNDER THE EXPRESS LIMITED WARRANTY

Waukesha shall be responsible for:

- A. The repair or replacement, at Waukesha's election, of covered defective parts and all reasonable labor required regarding a warranted failure during the express limited warranty term. All such labor shall be provided by Waukesha's authorized contractor or distributor.
- B. For the repair of CEC's installed on Products shipped from Waukesha, reasonable and necessary travel and expenses incurred by Waukesha's authorized contractor or distributor.
- C. Replacement of lubricating oil, coolant, filter elements, Waukesha supplied engine components, or other normal maintenance items that are contaminated and/or damaged as a direct result of a warranted failure.

IV. OWNER'S RESPONSIBILITIES UNDER THE EXPRESS LIMITED WARRANTY

Owner shall be responsible for:

- A. The operation and maintenance of the Products within the guidelines established by Waukesha.
- B. Making the Products available to Waukesha or Waukesha's authorized contractors or distributors for any warranty repair, during normal business hours.
- C. All additional costs incurred for premium or overtime labor, should owner request that repairs be made on a premium or overtime schedule.
- D. All costs incurred as the result of removal or reinstallation of the Products as may be required to effect any warranted repair.
- E. All administrative costs and expenses resulting from a warranted failure.
- F. Any costs of transportation, towing, repair facilities, or associated costs.
- G. All travel, mileage, and other related Distributor costs and expenses associated with repair under the terms of the Service Parts Warranty.
- H. All additional labor time in excess of Waukesha's Labor Guide for the warrantable repair.
- I. Loss of revenue and loss of/or damage to real and/or personal property.

V. LIMITATION OF WAUKESHA'S OBLIGATIONS

The obligations of Waukesha under this express limited warranty shall be waived and voided, and Waukesha shall not, thereafter, be responsible for:

- A. Any failure resulting from owner or operator abuse or neglect, including but not by way of limitation, any operation, installation, application, or maintenance practice not in accordance with guidelines or specifications established by Waukesha; or
- B. Any failure resulting from unauthorized modifications or repairs of the Products; or
- C. Any failure resulting from overload, overspeed, overheat, accident, improper storage; or
- D. Failure of owner to promptly provide notice of a claimed defect; or
- E. Failure of Products for which Waukesha did not receive properly completed start-up reports; or
- F. Repairs of a covered failure performed with non-genuine Waukesha parts; or
- G. Repairs of a covered failure performed by non-authorized contractors or distributors; or
- H. Failure to make Products available to Waukesha or its authorized representatives; or
- I. Failure to supply documents such as drawings and specifications relating to the specific application of the Products; or
- J. Improper diagnosis of a Product problem for which a CEC product is replaced.
- K. Failure of Service Parts for which Waukesha did not receive proper documentation concerning the Service Parts purchase date from an Authorized Waukesha Engine Distributor; or
- L. Any failure of a Service Part resulting from misapplication or improper repair procedures; or
- M. Any failure or damage resulting from the improper or extended storage of a Service Part; or
- N. Freight, Customs, Broker Fees, and Import Duties if appropriate documentation is not provided.

VI. APPLICABILITY AND EXPIRATION

The warranties set out above are extended to all owners in the original chain of distribution. The warranties and obligations of Waukesha shall expire and be of no further effect upon the dates of expiration of the applicable warranty periods.

VII. WARRANTY ADMINISTRATION

This warranty is administered exclusively by an Authorized Waukesha Distributor. The invoice for the failed Service Parts must be provided to the Distributor to determine whether the warranty is applicable.

Contact the nearest Authorized Waukesha Distributor for assistance with warranty matters or questions. The location of the nearest Authorized Distributor is available by contacting Waukesha Engine Division at (414) 547-3311.

THE FOREGOING SETS FORTH WAUKESHA'S ONLY OBLIGATIONS AND OWNERS' EXCLUSIVE REMEDY FOR BREACH OF WARRANTY, WHETHER SUCH CLAIMS ARE BASED ON BREACH OF CONTRACT, TORT (INCLUDING NEGLIGENCE AND STRICT LIABILITY), OR OTHER THEORIES, AND THE FOREGOING IS EXPRESSLY IN LIEU OF OTHER WARRANTIES WHATSOEVER EXPRESSED, IMPLIED, AND STATUTORY, INCLUDING WITHOUT LIMITATION, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS.

Notwithstanding the preceding, in no event shall Waukesha be liable for any direct, special, incidental, or consequential damages (whether denominated in contract, tort strict liability, negligence, or other theories) arising out of this Agreement or the use of any Products provided under this Agreement.

Any action arising hereunder or relating hereto, whether based on breach of contract, tort (including negligence and strict liability), or other theories must be commenced within two (2) years after the cause of action accrues or it shall be barred.

All disputes and claims between the parties which may arise out of or in connection with this Contract shall be settled by good faith negotiation between an executive level representative of each party. If the parties are nonetheless unable to reach agreement, such disputes shall be resolved by binding arbitration. The arbitration shall be administered by the American Arbitration Association according to its rules of Commercial Arbitration then in force. The arbitration shall take place in Milwaukee, Wisconsin, before one arbitrator. The language to be used in the arbitration shall be English. The law of Texas shall govern. Judgment upon the award of the arbitrators may be entered in any court of competent jurisdiction.

See Form M-462 for the most current warranty terms. Effective May 1, 1995

AUTOCAL WORKSHEET (6, 8, & 12 CYLINDER ENGINES)

The AutoCal Worksheet is to be used to assist you when programming the DSM module during AutoCal programming. Detach or copy this worksheet when use of the worksheet is required for DSM module programming.

NOTE: This worksheet applies to 6, 8, and 12 cylinder engines. The yellow worksheet applies to 16 cylinder engines. Make sure you use the worksheet that applies to your engine application.

NOTE: Use this worksheet when running the DSM AutoCal Program as described in Section 3.10, Programming The DSM System For A New Application, and Section 4.05, Running The DSM AutoCal Program.

About The AutoCal Program

The DSM AutoCal program is the automatic calibration of the detonation threshold levels by the DSM Interface Program. The DSM module monitors for detonation using the frequency output of each cylinder with engine mounted detonation knock sensors. These knock sensors must be calibrated or "AutoCaled." During AutoCal, the knock sensors are calibrated so that the DSM system can operate properly.

An AutoCal should be run the first time the DSM is programmed for an engine or whenever the DSM is programmed for a new application. Additionally, the DSM system must be re-AutoCaled using the DSM Interface Program and a PC after doing any removal, repair, or replacement of engine cylinder heads,

cylinder liners, cylinder gaskets, pistons, or knock sensors; or when upgrading to a new version of DSM software. This calibration **MUST BE** done using the AutoCal program.

NOTE: If the results recorded in the "Highest 'S' Value" column vary by more than 500 from one sensor to another, refer to Table 4.00-4, "DSM System Troubleshooting", in Section 4.00 of the Detonation Sensing Module Installation, Operation, And Maintenance Manual (Form 6278). If the values do vary by more than 500 from sensor to sensor it may indicate 1) engine detonation, 2) sensor mounting imperfections, 3) unattached or incorrectly routed wire harnesses and/or ground wiring, or 4) other engine related problems.

AutoCal Worksheet For 6, 8, And 12 Cylinder Engines

SENSOR	SET-POINT "S" COLUMN RESULTS										HIGHEST "S" VALUE
	RUN	RUN	RUN	RUN	RUN	RUN	RUN	RUN	RUN	RUN	
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											

DATE: _____

PERFORMED BY: _____

ENGINE SITE/NUMBER: _____

AUTOCAL WORKSHEET (16 CYLINDER ENGINES)

The AutoCal Worksheet is to be used to assist you when programming the DSM module during AutoCal programming. Detach or copy this worksheet when use of the worksheet is required for DSM module programming.

NOTE: This worksheet applies to 16 cylinder engines. The blue worksheet applies to 6, 8, and 12 cylinder engines. Make sure you use the worksheet that applies to your engine application.

NOTE: Use this worksheet when running the DSM AutoCal Program as described in Section 3.10, Programming The DSM System For A New Application, and Section 4.05, Running The DSM AutoCal Program.

About The AutoCal Program

The DSM AutoCal program is the automatic calibration of the detonation threshold levels by the DSM Interface Program. The DSM module monitors for detonation using the frequency output of each cylinder with engine mounted detonation knock sensors. These knock sensors must be calibrated or "AutoCaled." During AutoCal, the knock sensors are calibrated so that the DSM system can operate properly.

An AutoCal should be run the first time the DSM is programmed for an engine or whenever the DSM is programmed for a new application. Additionally, the DSM system must be re-AutoCaled using the DSM Interface Program and a PC after doing any repair or

replacement of engine cylinder heads, cylinder liners, pistons, or knock sensors; or when upgrading to a new version of DSM software. This calibration **MUST BE** done using the AutoCal program.

NOTE: If the results recorded in the "Highest 'S' Value" column vary by more than 500 from one sensor to another, refer to Table 4.00-4, "DSM System Troubleshooting", in Section 4.00 of the Detonation Sensing Module Installation, Operation, And Maintenance Manual (Form 6278). If the values do vary by more than 500 from sensor to sensor it may indicate 1) engine detonation, 2) sensor mounting imperfections, 3) unattached or incorrectly routed wire harnesses and/or ground wiring, or 4) other engine related problems.

AutoCal Worksheet For 16 Cylinder Engines

SENSOR PAIRS	SET-POINT "S" COLUMN RESULTS										HIGHEST "S" VALUE
	RUN #	RUN #	RUN #	RUN #	RUN #	RUN #	RUN #	RUN #	RUN #	RUN #	
1 & 2											
3 & 4											
5 & 6											
7 & 8											
9 & 10											
11 & 12											
13 & 14											
15 & 16											

DATE: _____

PERFORMED BY: _____

ENGINE SITE/NUMBER: _____



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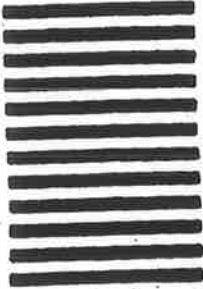
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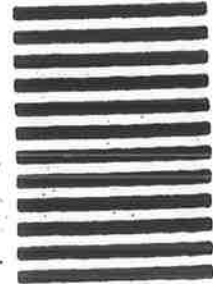
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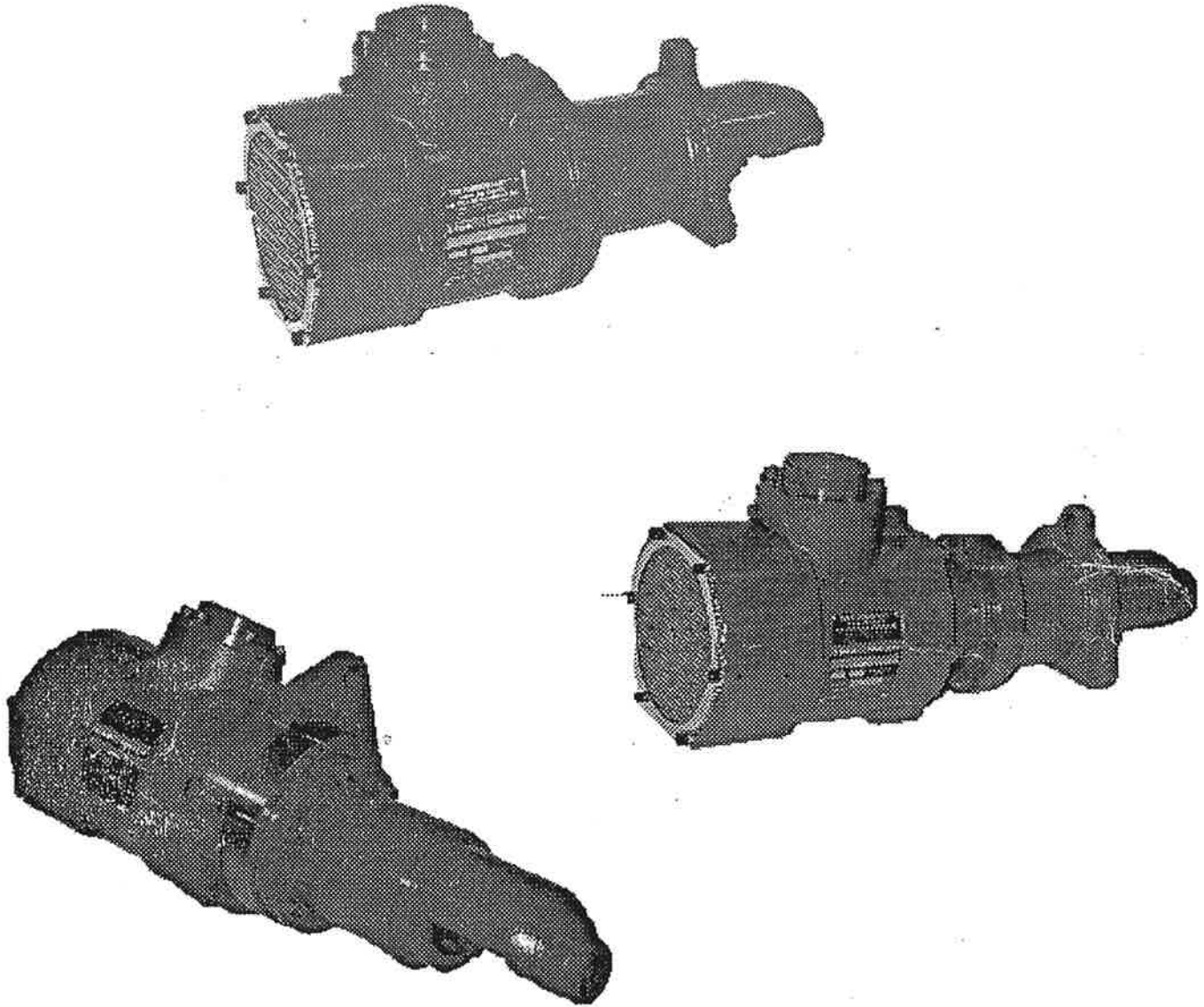


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P.O. BOX 330, FARMSUMERWEG 43, 9900 AH APPINGEDAM, THE NETHERLANDS

STR-227

TDI *TURBOTWIN* Engine Air Starters



INSTALLATION AND OPERATING INSTRUCTIONS
MODELS T112B/T121 T106F/T112F, T112D/T121D

**INSTALLATION & OPERATING MANUAL
FOR
MODELS T106F/T112F, T112B/T121B, T112D/T121D
TURBINE STARTERS**

USE WITH COMPRESSED AIR OR NATURAL GAS

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TDI *TURBOTWIN*

FROM TECH DEVELOPMENT INC

1.0 GENERAL INFORMATION

This manual provides instructions for the installation and operation of the TDI *TURBOTWIN* Starters. If there are questions not answered in this manual, please contact your TDI *TURBOTWIN* distributor or dealer for assistance. See Appendix A for the listing of distributors by state.

The *TURBOTWIN* models are turbine driven starters with an inertially engaged starter drive. Depending on the starter model and engine installation, the *TURBOTWIN* starters have applications ranging from 1000 CID (16 Liters) on diesel engines and up to 20000 CID (320 Liters) on gas engines. The *TURBOTWIN* models are suited to operate within a wide range of inlet pressures and ambient temperatures. Refer to Figure 1 for general specification information. The engine size and parasitic loading will determine the exact minimum pressure that will assure reliable starting.

The *TURBOTWIN* starters are designed for operation with compressed air or natural gas; materials used are compatible with "sour" natural gas and marine environments. Small amounts of foreign matter or liquid in the air stream will not adversely affect *TURBOTWIN* starters. As with all other TDI starters, no lubrication is required in the air supply.

You need to review the rest of this manual before installing your TDI *TURBOTWIN* starter.

Note

Throughout this manual, the term "air" is used to denote the starter drive medium. Unless otherwise stated, "air" means either compressed air or natural gas.

WARNINGS, CAUTIONS AND NOTES

Certain types of information are highlighted in this manual for your attention:

WARNING - used where injury to personnel or damage to the equipment is likely.

CAUTION - used where there is the possibility of damage to the equipment.

NOTE - used to point out special interest information.

1.1 DESCRIPTION

Figures 2, 3, 4 and 5 show the outline of the four basic *TURBOTWIN* models of starters. All models feature three basic subassemblies: a unique two stage turbine motor section, a planetary gearbox section and an inertia drive assembly.

Compressed air or natural gas is used to power the *TURBOTWIN* through the inlet port. The air or gas is expanded through the first nozzle or stators. The high velocity gas impinges on the first stage rotor to yield torque to the gearbox. The gas is further expanded through the second stage stators which impart additional torque to the second stage rotor.

The two stage motor section features greater stall torque than a single stage turbine plus aerodynamic speed control. This aerodynamic speed control helps protect the *TURBOTWIN* starter from damage caused by starter motor over speed. In addition, a steel motor housing module and low-mass rotors provide fail-safe operation.

All *TURBOTWIN*s employ the same basic 7.5:1 ratio planetary gearbox. Reliability and part commonality are designed into all *TURBOTWIN*s. This low gear ratio allows the turbine motor to spin at low speeds for long bearing life. At a typical 3000 rpm pinion speed, the turbine is cruising at a low 22500 rpm.

A simple and reliable inertia drive delivers the torque to the pinion. The pinion is thrown out to engage the engine's ring gear by the turbine motor's acceleration. Lighter weight rotating parts used in the *TURBOTWIN* provide low inertia and even "softer" engagement. In the event of over-pressure, the friction clutch used in every *TURBOTWIN* protects ring gear teeth from static torque overloads. In addition, an inertia engaged starter eliminates the need for complex pre-engagement control plumbing...and is easier to install and maintain than pre-engaged type starters.

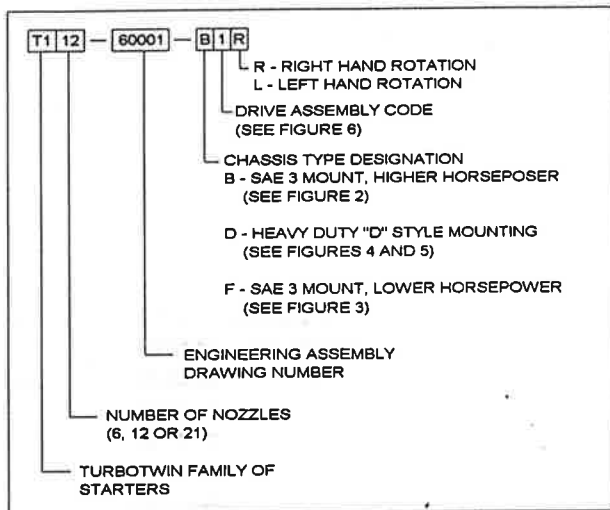
1.2 PRODUCT IDENTIFICATION

Figure 1 lists the available part numbers for the TDI *TURBOTWIN* Starters. The starter nameplate which is pinned to the turbine housing contains the following information: model number, serial number, part number, direction of rotation and the maximum rated operating pressure. An example nameplate is shown in Figure 7.

The model number is a shorthand description of the part number. The part number is described as follows:

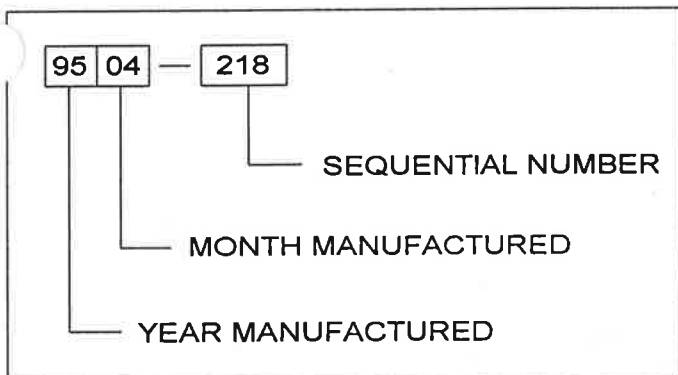
TDI TURBOTWIN

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The direction of rotation is either right hand or left hand rotation as defined by Figure 8. Right Hand rotation is defined as counterclockwise rotation as viewed from the exhaust end of the starter.

The serial number is coded as follows:



The maximum operating pressure is also stamped on the nameplate. The example nameplate shows 150 psig. This pressure is measured at the check port on the starter inlet with the starter in operation.

CAUTION

Exceeding the maximum operating pressure shown on the nameplate may result in drive failure, damage to the starter, damage to the engine or cause personal injury.

The proof pressure is 600 psig and is also shown on the nameplate. This means the turbine housing will not burst when subjected to a static pressure of 600 psig.

Figures 2, 3, 4 and 5 show the installation drawings for the four basic variations of the *TURBOTWIN* Starter.

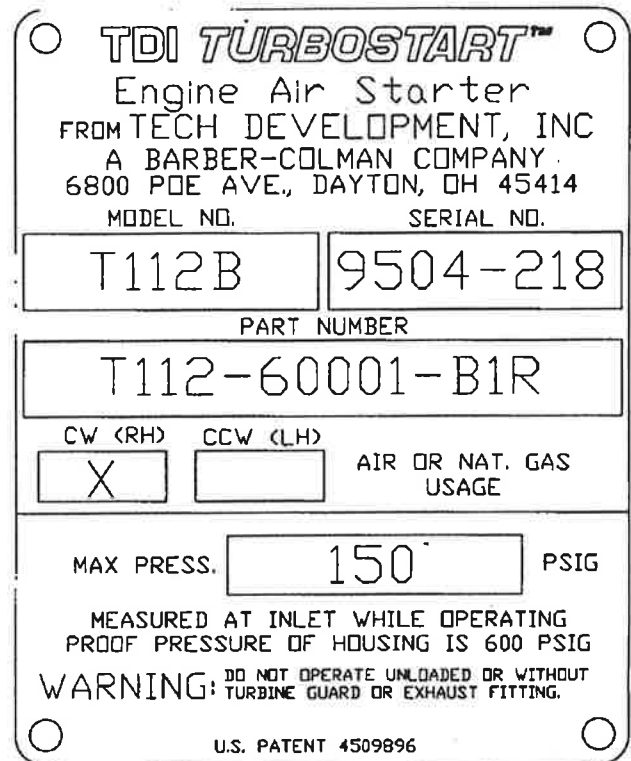


Figure 7. Nameplate

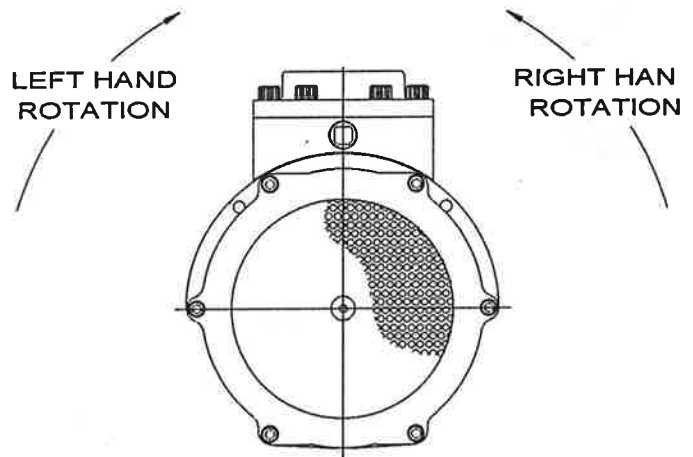


Figure 8. Direction of Rotation as viewed from exhaust end of Starter.

1.3 PHYSICAL CHARACTERISTICS

Figures 2, 3, 4 and 5 show the outlines and package dimensions of the four sizes of *TURBOTWIN* starters.

TDI *TURBOTWIN*

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MODEL NUMBER	PART NUMBER	PRESSURE RANGE (PSIG)	PRESSURE RANGE (BAR)	PINION ROTATION	MAX STALL TORQUE lb-ft	TDI DRIVE NUMBER
T121B	T121-60001-B1R	30 - 90	3.1 - 7.2	RIGHT HAND	300	1-18828
T121B	T121-60001-B2L	30 - 90	3.1 - 7.2	LEFT HAND	300	1-19083
T112B	T112-60001-B1R	60 - 150	5.2 - 11.4	RIGHT HAND	300	1-18828
T112B	T112-60001-B2L	60 - 150	5.2 - 11.4	LEFT HAND	300	1-19083
T106F	T106-60002-F3R	60 - 150	5.2 - 11.4	RIGHT HAND	160	2-22147
T106F	T106-60002-F4L	60 - 150	5.2 - 11.4	LEFT HAND	160	2-22148
T112F	T112-60002-F3R	30 - 90	3.1 - 7.2	RIGHT HAND	160	2-22147
T112F	T112-60002-F4L	30 - 90	3.1 - 7.2	LEFT HAND	160	2-22148
T121D	T121-60003-D1R	30 - 90	3.1 - 7.2	RIGHT HAND	300	1-18828
T121D	T121-60003-D2L	30 - 90	3.1 - 7.2	LEFT HAND	300	1-19083
T112D	T112-60003-D1R	60 - 150	5.2 - 11.4	RIGHT HAND	300	1-18828
T112D	T112-60003-D2L	60 - 150	5.2 - 11.4	LEFT HAND	300	1-19083
T112D	T112-60004-D5R	60 - 150	5.2 - 11.4	RIGHT HAND	300	2-22795
T112D	T112-60004-D6L	60 - 150	5.2 - 11.4	LEFT HAND	300	2-22796
T121D	T121-60004-D5R	30 - 90	3.1 - 7.2	RIGHT HAND	300	2-22795
T121D	T121-60004-D6L	30 - 90	3.1 - 7.2	LEFT HAND	300	2-22796

Figure 1. *TURBOTWIN* Starter Part Number Listing

Figure 2 shows the Models T112B/T121B which are 20.1" long overall and 8.2" in height. This model weighs 54 pounds. The turbine housing diameter is 6.8" which is common to all *TURBOTWIN*S. The rotary inertia of all rotating components is _____ lb-in².

Figure 3 shows the Models T106F/T112F which are 17.4" long overall and 8.2" in height. This model weighs 47 pounds. The turbine housing diameter is 6.8". The rotary inertia of all rotating components is _____ lb-in².

Figure 4 shows the Models T112D/T121D which are 20.1" long overall and 8.4" in height. The mounting flange is 10.2" wide. This model weighs 70 pounds. The turbine housing diameter is 6.8". The rotary inertia of all rotating components is _____ lb-in².

Figure 5 shows the Models T106F/T112F which are 20.4" long overall and 8.4" in height. The mounting flange is 10.2" wide. This model weighs 70 pounds. The turbine housing diameter is 6.8". The rotary inertia of all rotating components is _____ lb-in².

1.4 PERFORMANCE

Graphs of the performance curves are shown in Figures 9 through 12. These graphs feature pinion torque versus pinion speed (rpm) at constant drive air pressures and shaft horsepower versus pinion speed at constant drive air

pressures. Pinion speed is shown on the horizontal axis. The pinion torque is shown along the left edge vertical axis. The shaft horsepower is shown along the right edge vertical axis. Air consumption rates are given for the various drive pressure lines. These performance curves feature air as the drive gas and have open exhaust (standard exhaust guard) which have basically no back pressure.

2.0 INSTALLING THE STARTER

WARNING

Do not operate this starter unless it is properly attached to an engine.

Information on typical *TURBOTWIN* installations is shown in Figures 13 and 14. The components illustrated may vary in shape, but there must at least be an air source, a starter valve or switch and an air piloted relay valve in order to properly install the *TURBOTWIN* starter. Refer to Section 3 for information on TDI accessories.

2.1 GENERAL

Figure 13 shows a typical starter installation using compressed air. The starter is mounted to the SAE 3 engine mounting pad and is secured with three 5/8" bolts on *TURBOTWIN* models T1XXB and T1XXF. Model T1XXD

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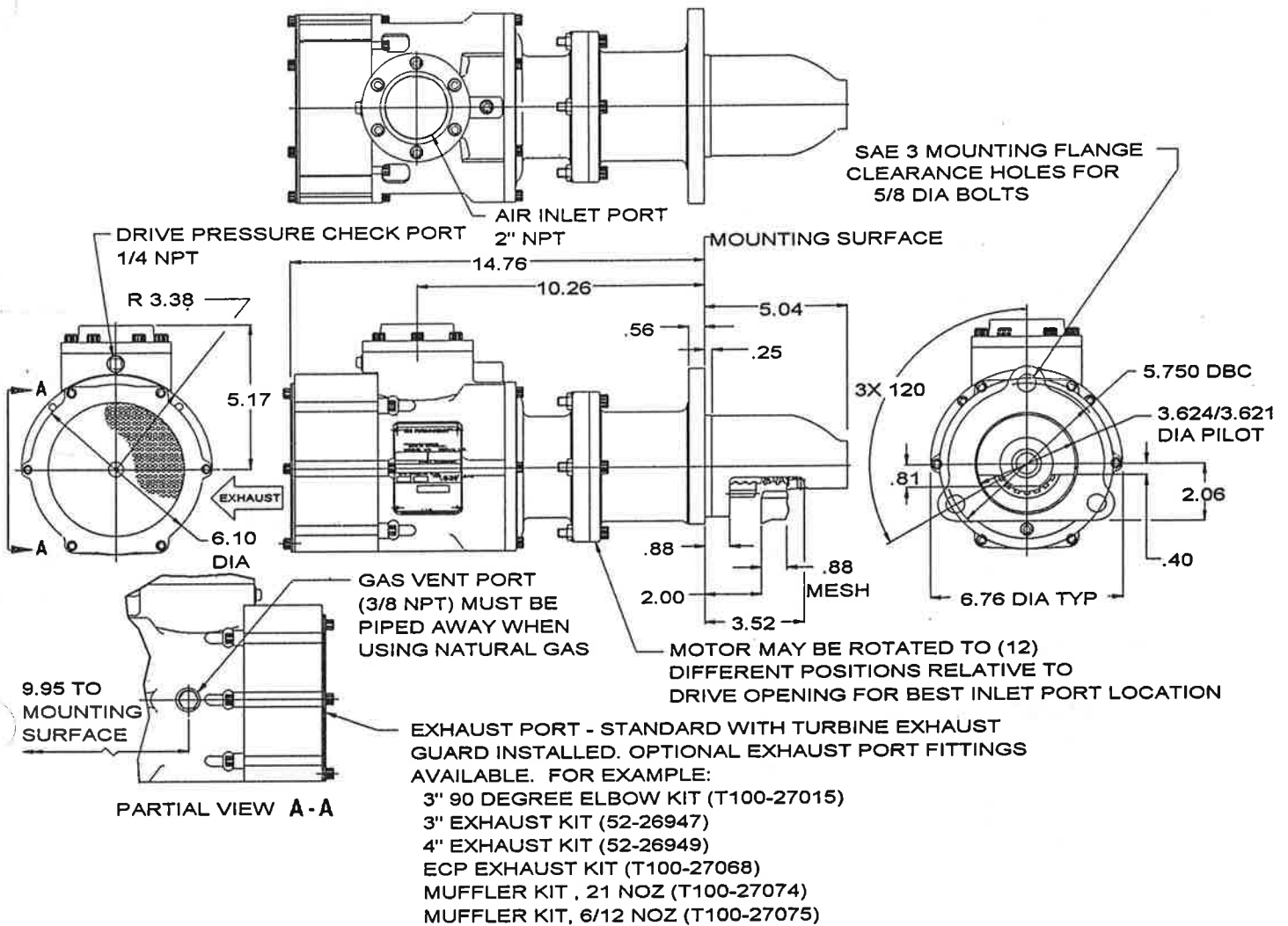


Figure 2. Model T112B/T121B TURBOTWIN

has the heavy-duty "D" style mounting flange which also uses three 5/8" bolts.

The air line to the starter contains a pressure regulator (when necessary) and a manual or remotely controlled valve. All TURBOTWIN starters features a 2" NPT pipe thread on the inlet port.

Most compressed air installations may use the standard exhaust guard. Figure 17 lists the optional exhaust hardware kits. Figure 18 shows illustrations of the various exhaust options.

2.2 ORIENTATION OF THE STARTER

If the factory orientation of the starter's pinion housing assembly, in relation to the inlet port, does not fit your engine installation, these components can easily be re-oriented. Refer to Figures 2, 3, 4 and 5.

All TURBOTWINs have the capability to rotate the inlet port relative to the drive opening for the optimum inlet port location. the number of different positions is 6 to 12 depending on model and application.

The starter should be installed with the inlet valve in a position between horizontal and straight down. Any condensation will be restricted to the air lines, and not in the starter.

CAUTION

All screw threads are treated at the factory with a fastener retention compound. Every screw and tapped hole must be clean and have a drop of Loctite 290 applied to the threads before being reinstalled.

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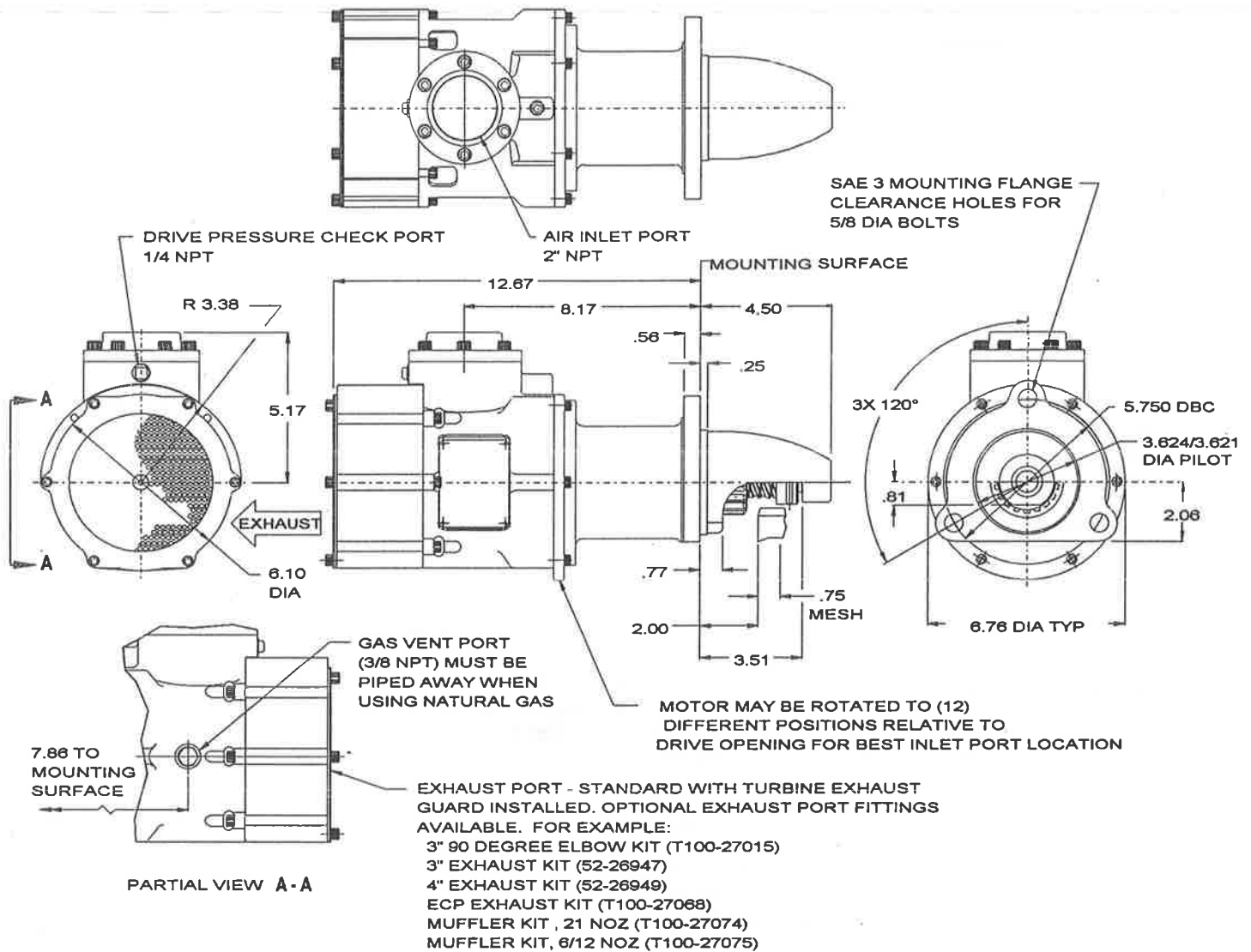


Figure 3. Model T106F/T112F TURBOTWIN

2.2.1 MODELS T112B/T121B

Refer to Figure 2. The drive housing may be rotated to 12 different positions relative to the inlet port. This task should be completed prior to installing the starter on the engine. The following procedure describes how to accomplish this. First, remove the (6) 5/16" X 1.5" long bolts by loosening the (6) nuts. Next, rotate the drive housing without removing it from the starter to the desired position. Clean the bolts and nuts with Loctite Safety Solvent or equivalent. Reinstall the (6) bolts and nuts using Loctite #290 Threadlocker adhesive or equivalent. Torque the bolts and nuts to 25 lb-ft maximum.

2.2.2 MODELS T106F/T112F

Refer to Figure 3. The drive housing may be rotated to 12 different positions relative to the inlet port. This task should be completed prior to installing the starter on the engine. The following procedure describes how to accomplish this. First, remove the (6) 1/4" X .75" long screws which attach the drive housing to the turbine housing. Next, rotate the drive housing without removing it from the starter to the desired position. Clean the screws with Loctite Safety Solvent or equivalent. Reinstall the (6) screws using Loctite #290 Threadlocker adhesive or equivalent. Torque the screws to 10 lb-ft maximum.

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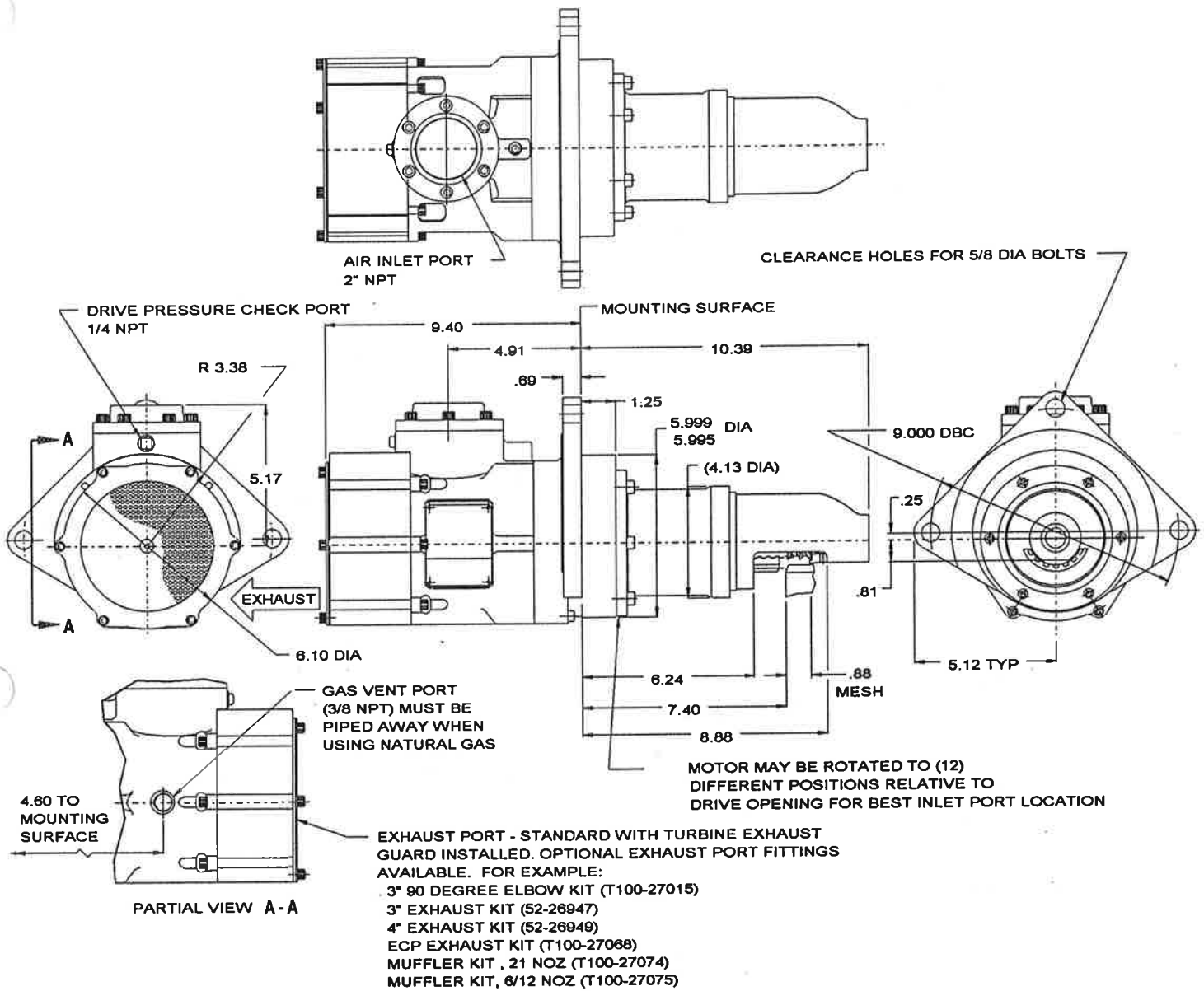


Figure 4. T112D/T121D (Standard Mesh) *TURBOTWIN*

2.2.3 MODELS T112D/T121D

Refer to Figure 4 or 5. The drive housing may be rotated to 12 different positions relative to the inlet port. This task should be completed prior to installing the starter on the engine. The following procedure describes how to accomplish this. First, remove the (6) 5/16" X 1.25" long screws which attach the drive housing to the turbine housing. Next, rotate the drive housing without removing it from the starter to the desired position. Clean the screws with Loctite Safety Solvent or equivalent. Reinstall the (6) screws using Loctite #290 Threadlocker adhesive or equivalent. Torque the screws to 25 lb-ft maximum.

2.3 INERTIA DRIVE ASSEMBLY

The inertia drive assembly consists of a friction clutch pack and the drive pinion which rides on a helical shaft. The pinion is thrown out to engage the engine's ring gear by the turbine motor's acceleration. Lighter weight rotating parts used in the *TURBOTWIN* provide low inertia and even "softer" engagement. In the event of over-pressure, the friction clutch used in every *TURBOTWIN* protects ring gear teeth from static torque overloads.

The torque carrying limit on the friction clutch pack is factory set by the manufacturer. Models T112B/T121B and T112D/T121D are set to 275-300 lb-ft. Models

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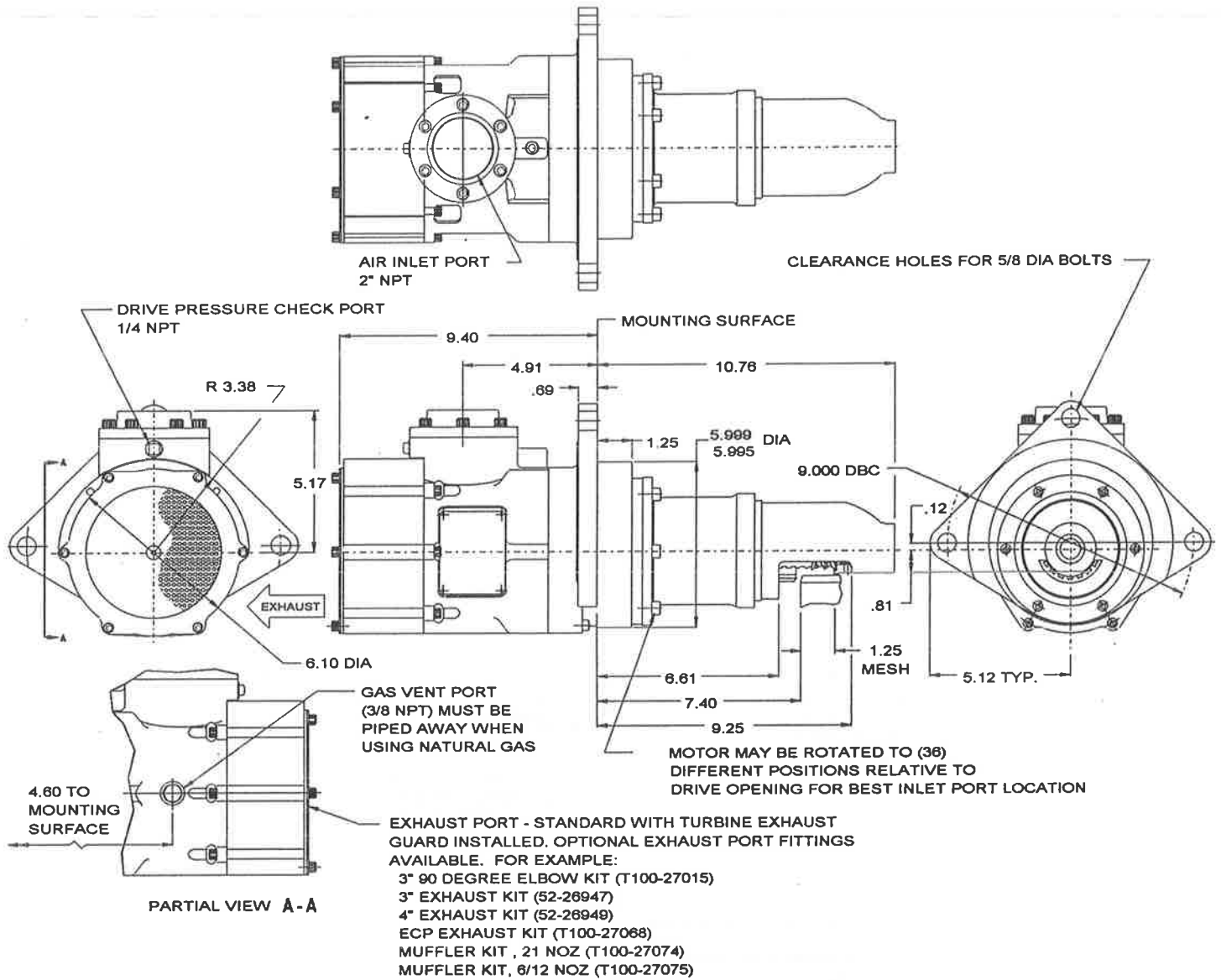


Figure 5. Model T112D/T121D (Long Mesh) TURBOTWIN

BENDIX CODE	TDI PART NUMBER	ROTATION	PITCH	#TEETH/BLANK	PINION PITCH DIA	PRESSURE ANGLE	CLUTCH SET.	LENGTH	TRAVEL	PIN O.D.
1	1-18828	R.H.	6/8	12/12	2.000	20	275-300	8.875	1.062	2.250
2	1-19083	L.H.	6/8	12/12	2.000	20	275-300	8.875	1.062	2.250
3	2-22147	R.H.	6/8	12/11	2.000	20	140-160	7.450	1.000	2.250
4	2-22148	L.H.	6/8	12/11	2.000	20	140-160	7.450	1.000	2.250
5	2-22795	R.H.	6/8	12/12	2.000	20	275-300	9.312	1.4375	2.250
6	2-20927-001	L.H.	6/8	12/12	2.000	20	275-300	9.312	1.4375	2.250

Figure 6. Inertia Drive Assembly Specifications

TDI TURBOTWIN

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T106F/T112F are set to 140-160 lb-ft.

All *TURBOTWIN* starters listed in this manual have a pinion with 6/8 diametral pitch teeth.

The pinion gear data and clutch torque settings are listed in Figure 6.

Backlash is the "free play" between the mesh of two gears. Figure 15 shows the backlash between two gears. Maintaining the proper gear backlash setting allows the gears to mesh smoothly. Proper backlash and alignment allow smooth engagement/disengagement of the pinion gear and loads the tooth face surfaces evenly producing longer gear life. The correct backlash setting for 6/8 diametral pitch gearing used on larger engines is as follows:

Minimum backlash	.015 inch
Maximum backlash	.025 inch

To check the backlash, the pinion will need to be rolled out onto the end of the drive prior to starter installation. This can be accomplished by using a hex drive wrench to rotate the turbine end of the starter while holding the pinion from rotating. The pinion will simply walk to the end of the shaft. An access hole to reach the turbine screw is provided in the turbine standard exhaust guard. The starter must then be installed on the engine. Checking backlash can be accomplished using a dial indicator or a simple blade-type feeler gauge. Because ring gears are not usually perfectly round, it is necessary to check backlash at several (six or more) points around the circumference of the ring gear. Average the highs and lows to allow a setting that is in the range cited above.

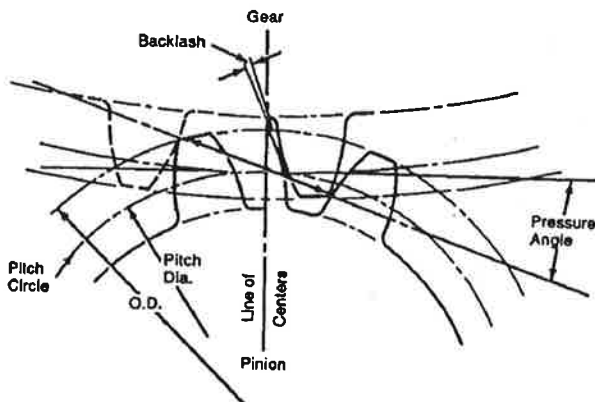


Figure 15. Inertia Drive Pinion Backlash

Setting the correct backlash may involve "shimming" and/or moving the starter bracket(s). An adjustable starter bracket design will simplify this procedure. Always re-check backlash after the installation of a ring gear replacement.

Liberally grease the starter's drive teeth with chassis lube and then mount the *TURBOTWIN* starter on the engine. Tighten all mounting hardware as appropriate. Make sure to use Loctite Threadlocker #290 or equivalent on the starter mounting bolts. Torque the three 5/8" screws to 100 lb-ft.

After mounting the starter to the engine, attach the supply air line to the starter, connect the control air lines and install the solenoid between the ignition switch and air piloted relay valve. See Sections 2.4, 2.5 and 2.6. The following sections describe the connection of the supply line, exhaust piping and optional control lines.

2.4 Supply Line Installation

CAUTION

Be sure to either bleed the pressurized air reservoir and /or safety the air system such as closing all valves prior to installing any starter supply line.

All *TURBOTWIN* starters come standard with a 2" NPT female pipe thread for the inlet connection port. Figures 13 and 14 show typical starter installations. The supply line consists of the line from the air source, a pressure regulator (when necessary), a manual or relay valve, and then the connection to the starter inlet. Hard piping may be used, but a section of flexible tubing should be used right at starter for mobile applications to prevent leaks due to engine vibration.

A turbine driven starter does not require lubrication in the supply air. Therefore, if a vane-type starter motor is being replaced, TDI recommends that all lubrication devices and lines be removed to minimize flow restrictions.

WARNING

If a fuel (pulse) lubricator has previously been installed in the system, disconnect and plug the line to eliminate spraying diesel fuel on the engine.

Care must be taken to ensure that all inlet supply line piping is no less than 1.5" (38 mm) and that all valves used are capable of passing the required air flow.

NOTE

Valves with a C_v of 40, or higher, are recommended.

If the supply line must be longer than 20 feet (6.1M), then the inlet supply line piping should be increased to 2" (50 mm) to assure proper performance by your *TURBOTWIN*.

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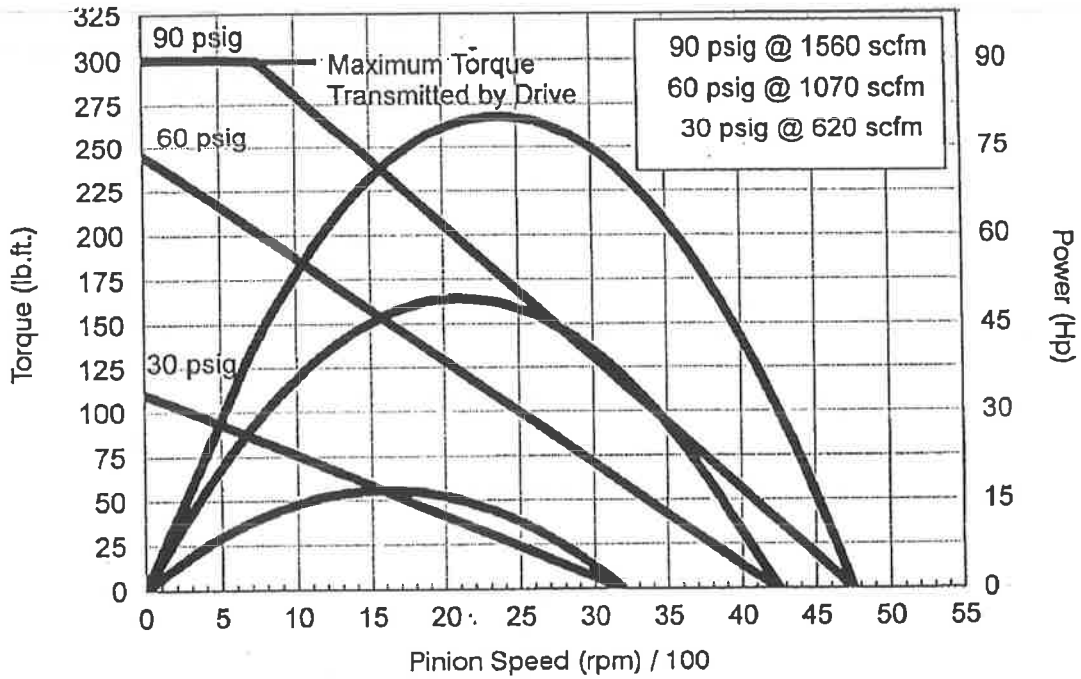


Figure 9. Performance Curves for Model T121B/T121D
(21 Nozzles, Air, 7.5:1)

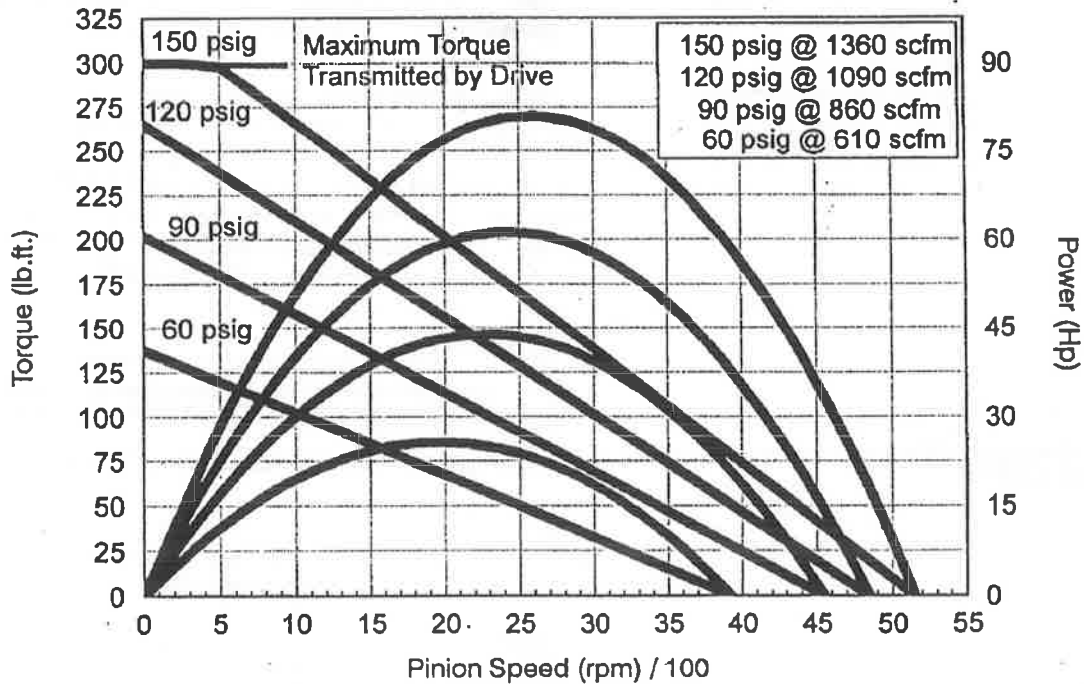


Figure 10. Performance Curves for Model T112B/T112D
(12 Nozzles, Air, 7.5:1)

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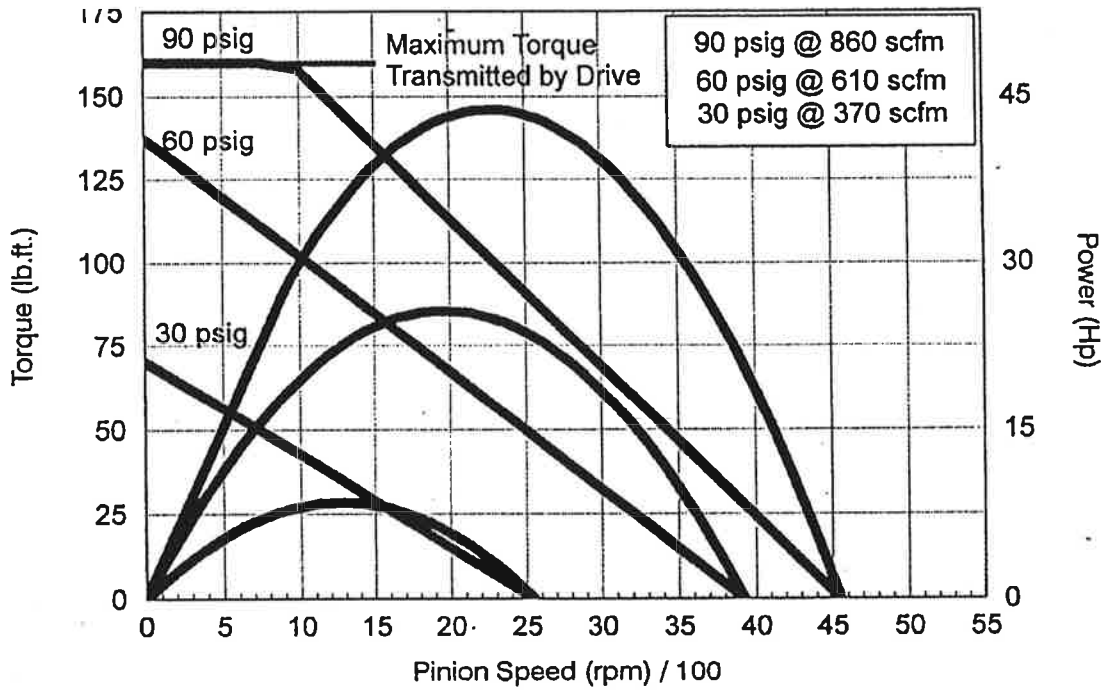


Figure 11. Performance Curves for Model T112F
(12 Nozzles, Air, 7.5:1)

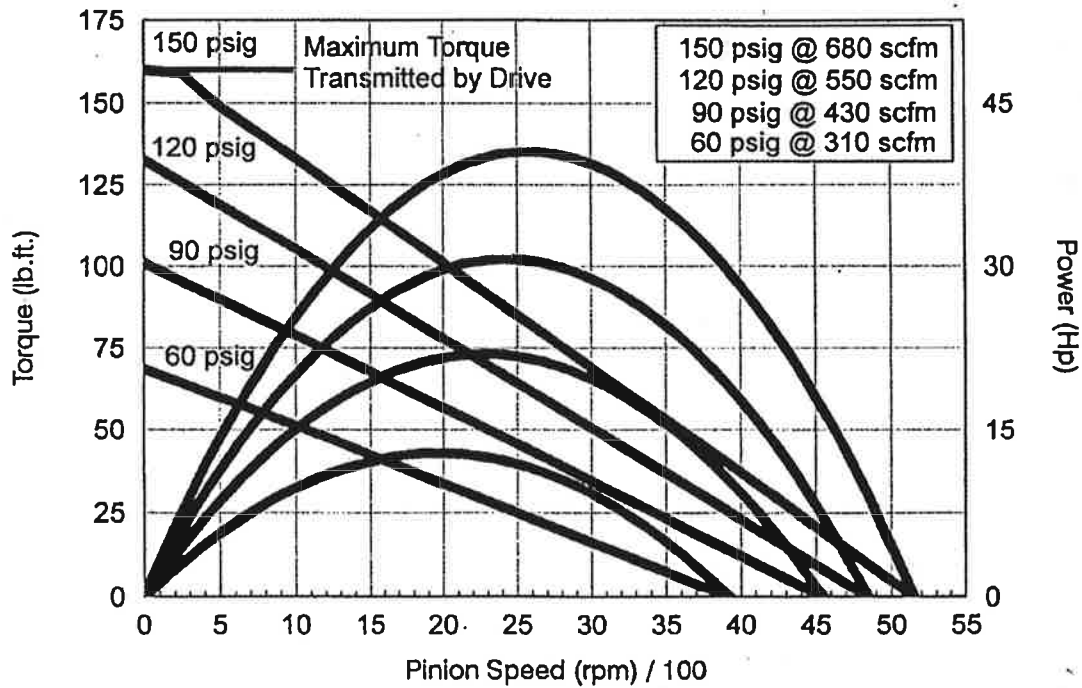
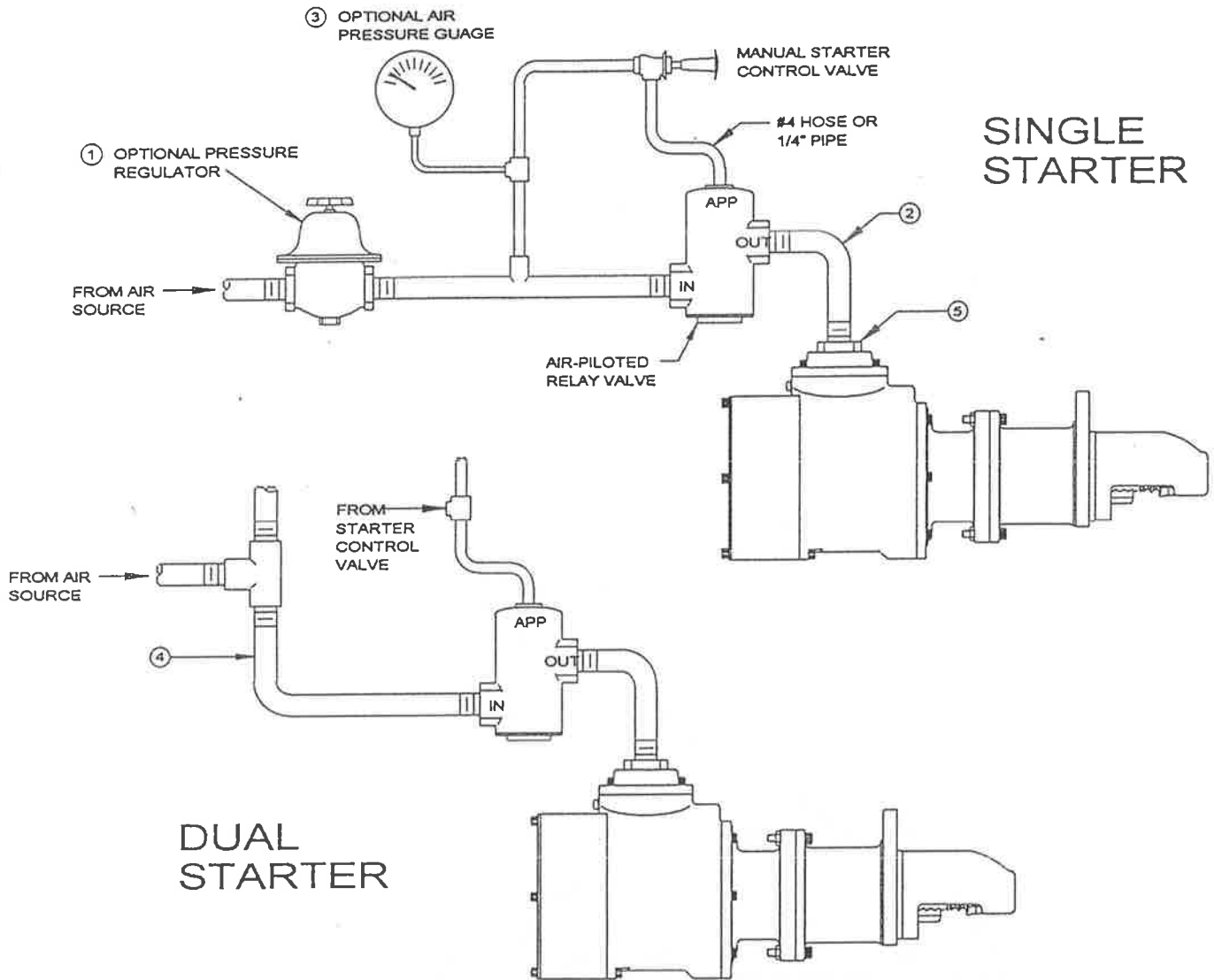


Figure 12. Performance Curves for Model T106F
(6 Nozzles, Air, 7.5:1)

STARTER INSTALLATION - AIR USAGE



NOTES:

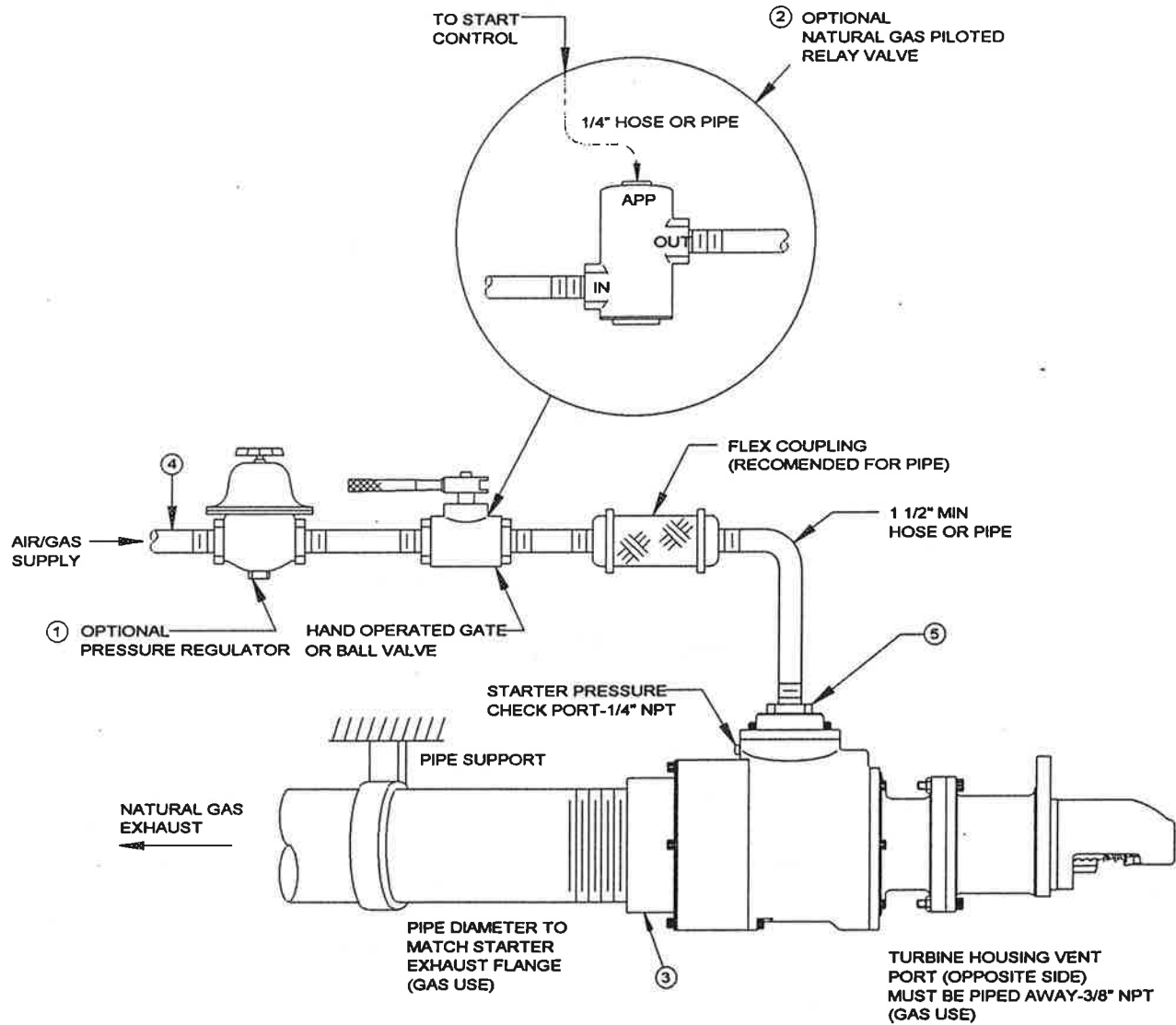
- ① IF DUAL STARTERS ARE USED, A SINGLE PRESSURE REGULATOR DEVICE SHOULD BE USED IF PRESSURE REGULATION IS REQUIRED.
- ② REFER TO SECTION 4.0 FOR HARDWARE AND ACCESSORIES AVAILABLE FROM TDI.
- ③ 4" NPT EXHAUST FLANGE - ALL STARTERS, 15 NOZZLES AND HIGHER.
3" NPT EXHAUST FLANGE - ALL STARTERS, 14 NOZZLES AND HIGHER.
- ④ INLET PIPE SIZE: 1.5" - ALL STARTERS, 14 NOZZLES AND LOWER
2.0" - ALL STARTERS, 15 NOZZLES AND LOWER
- ⑤ 2" TO 1" NPT REDUCING BUSHING - ALL STARTERS, 14 NOZZLES AND LOWER.

Figure 13. Typical Starter Installation - Compressed Air

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STARTER INSTALLATION - NATURAL GAS USAGE



NOTES:

- ① IF DUAL STARTERS ARE USED, A SINGLE PRESSURE REGULATOR DEVICE SHOULD BE USED IF PRESSURE REGULATION IS REQUIRED.
- ② REFER TO SECTION 4.0 FOR HARDWARE AND ACCESSORIES AVAILABLE FROM TDI.
- ③ 4" NPT EXHAUST FLANGE - ALL STARTERS, 15 NOZZLES AND HIGHER.
3" NPT EXHAUST FLANGE - ALL STARTERS, 14 NOZZLES AND HIGHER.
- ④ INLET PIPE SIZE: 1.5" - ALL STARTERS, 14 NOZZLES AND LOWER
2.0" - ALL STARTERS, 15 NOZZLES AND LOWER
- ⑤ 2" TO 1" NPT REDUCING BUSHING - ALL STARTERS, 14 NOZZLES AND LOWER.

Figure 14. Typical Starter Installation - Natural Gas

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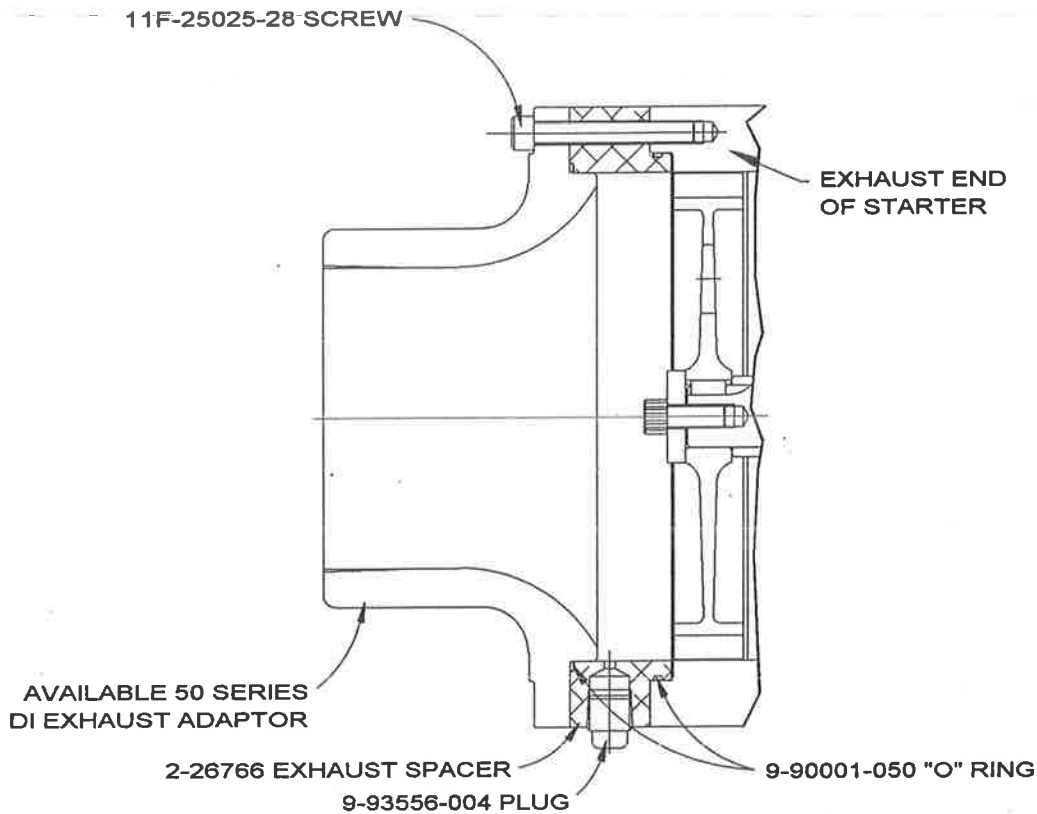


Figure 16. Part Number 52-26839 Exhaust Adaptor Kit

Because turbine starters such as the *TURBOTWIN* are sensitive to flow restrictions, care must be taken to use uniform hose or tubing and fittings for connection of the supply air line. Tees, elbows and line length must be kept to a minimum. TDI recommends that hose or flex couplings be installed to eliminate possible leakage caused by strain on the supply air line.

Normally, an air strainer is not required. In dirty environments, use of a #40 mesh Y-strainer is recommended. The *TURBOTWIN* is highly tolerant of dirt in the air line, however, the starter life can be increased with the use of the air strainer.

The pressure regulator is required when the air supply pressure is great enough to exceed the starter operating pressure (at the inlet port) and/or the maximum torque.

A manual ball valve may be used to admit air to the starter. The manual valve should be located in a safe position away from the engine.

A preferred valve is pilot-operated relay valve which can be pneumatically or electrically actuated. The valve can be

located very close or even on the starter inlet for better performance. Pneumatic or electrical control lines may be routed virtually anywhere for the customer's preferred operating station. This type of valve actuates from a fully closed to a fully open position very rapidly (usually 1/2 second or less). TDI offers a variety of relay valves such as P/N RLVA-25683-001-2-01 which is a 1-1/2" port, pneumatically actuated valve.

The supply line should be dry-fitted for proper alignment/location prior to final assembly. All pipe threaded joints should be sealed with Loctite Pipe Thread Sealant (TDI P/N 9-94085) or equivalent for leak tight joints prior to final assembly. Be sure to tighten all joints to proper torque after final assembly.

CAUTION

in cold climate conditions, care should be taken while designing your installation to prevent condensation from developing in the starter system. In systems with a regulator valve or relay valve, there is the possibility of freeze-up.

A tee connection with a quick disconnect can be added to

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the inlet. This will allow an external air source to be used to accomplish a "blow start" if the system freezes. Once the engine has been started, the other system components may be thawed.

This installation option may be especially useful in off-highway equipment.

CAUTION

Especially on new installations, it is strongly recommended to blow out the supply line with air to remove possible dirt and weld slag prior to final connection to the *TURBOTWIN* starter. Be sure to secure the free end of the supply line prior to the blow-down.

KIT PART NUMBER	DESCRIPTION	USED ON MODELS
52-420	Exhaust Guard Screen Kit	All
T100-27068	Exhaust Closure Plate Kit	All
T100-27015	3 Inch NPT 90 Degree Elbow Kit	All
52-26947	3 Inch NPT Straight Fitting Kit	All
52-26949	4 Inch NPT Straight Fitting Kit	All
T100-27075	Short Muffler Kit	T106F/T112F T121B/T121D
T100-27074	Long Muffler Kit	T121B/T121D
52-26839	Exhaust Adaptor Kit	All

Figure 17. Exhaust Hardware Kits

2.5 Inlet Pressure Port

A 1/4" NPT port is located on the exhaust side of the air inlet. This port may be used to check the supply pressure at the starter when the starter is operating. Remove the 1/4" NPT pipe plug and save for later use. Install a 1/4" minimum size tubing to the port. Route the tubing away from the starter to a safe location away from the engine. Install a pressure gauge on the tubing. This pressure monitoring line/gauge may be permanently installed. Use Loctite Pipe Thread Sealant or equivalent. Alternately, a pressure transducer may be installed at the pressure check port and electrical lines would be routed to a digital display at the operator's station.

This pressure port is invaluable in diagnosing air starter performance problems.

2.6 Exhaust Piping

The turbine exhaust may be plumbed away from the starter area. 3" NPT and 4" NPT exhaust fittings are available from

TDI. Also see Section 3. **All starters using natural gas must be piped away according to industry codes and local regulations.**

The performance of a turbine starter will be decreased because of back pressure when smaller than recommended exhaust piping is installed. When the starter's exhaust is to be piped away, refer to Figure 8 for minimum piping size and TDI kit numbers. If back pressure hampers starter performance, compensation can be made by increasing the supply pressure. Consult your TDI distributor for advice.

The various exhaust fitting options are listed and shown in Figures 17 and 18, respectively. The standard exhaust treatment is the turbine exhaust guard P/N 52-420. This exhaust guard should not be used with natural gas.

In installations with a starter length restriction, the 3" right angle exhaust elbow may be required. The 3" NPT 90 degree elbow kit is P/N T100-27015 and features a welded steel pipe with a male 3" NPT pipe thread. An aluminum adapter ring is included with this kit to attach this elbow fitting to the *TURBOTWIN*.

The exhaust closure plate kit is P/N T100-27068. This kit features a movable plate which protects the inside of the starter from dirt when the starter is not operating. The end plate opens during starter operation. This exhaust fitting should not be used with natural gas.

The 3" NPT straight exhaust fitting features a female 3" NPT pipe thread. This kit is P/N 52-26947. An adapter ring is included with this kit.

The 4" NPT straight exhaust fitting features a female 4" NPT pipe thread. This kit is P/N 52-26949. An adapter ring is included with this kit.

The muffler kit for the 6 or 12 nozzle *TURBOTWIN* starter is P/N T100-27075. This exhaust fitting should not be used with natural gas.

The muffler kit for the 21 nozzle *TURBOTWIN* starter is P/N T100-27074. This exhaust fitting should not be used with natural gas.

All older TDI Series 52 exhaust options may be used on the *TURBOTWIN* with the exhaust adaptor kit P/N 52-26839. A typical installation using the adapter ring is shown in Figure 16. **This adapter ring must be used with the older fittings, otherwise the starter will be damaged.**

Exhaust piping should be routed downward to help prevent any accumulation of condensate in the starter motor.

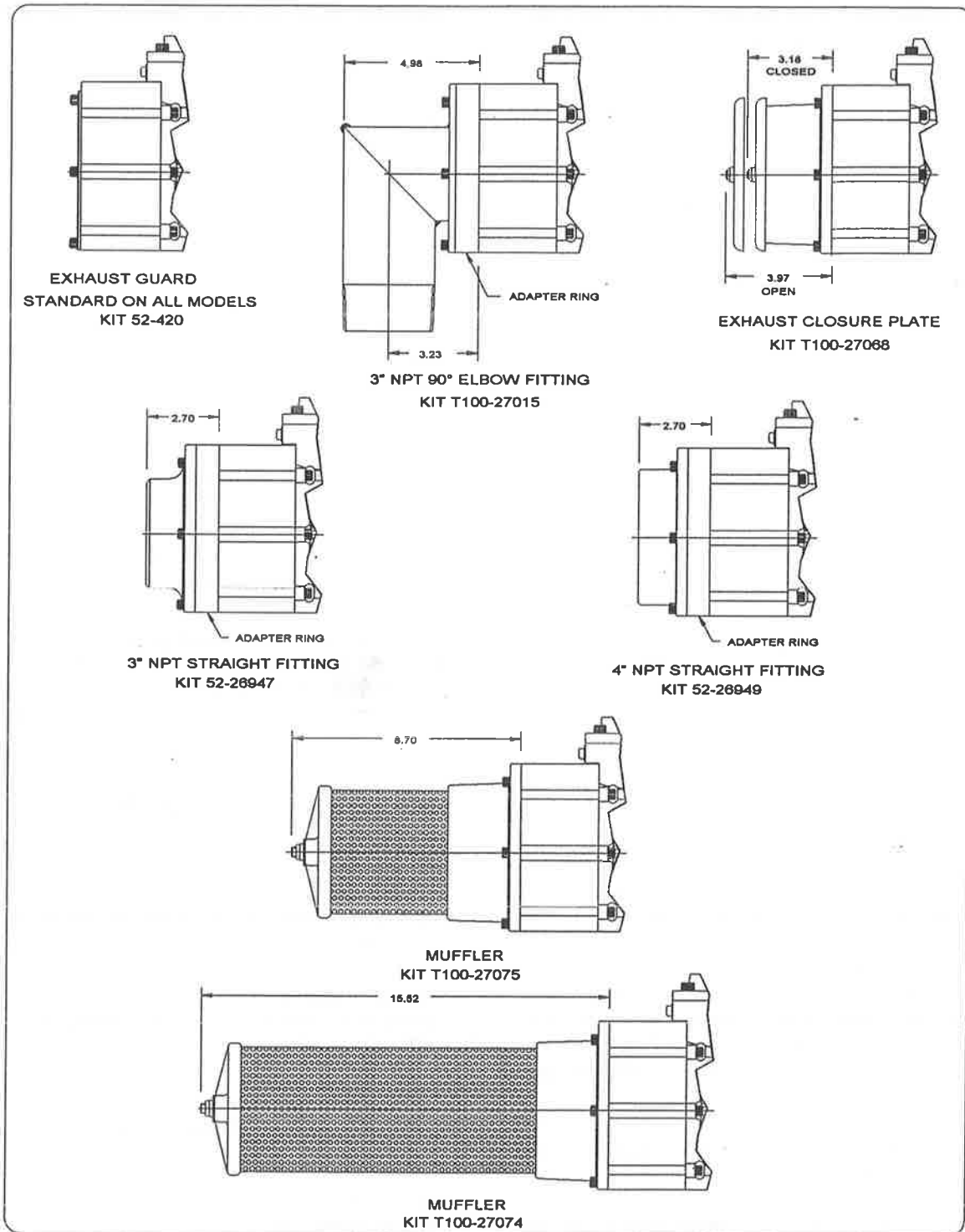


Figure 18. Illustrated Exhaust Hardware Options

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the overhung section of the starter is not otherwise supported, TDI recommends that the exhaust piping be supported with a suitable bracket(s).

2.7 Natural Gas Installation

The installation of the starter using natural gas is similar to the air installation except all fittings, piping, valves and regulators must be compatible with natural gas.

Proper control of natural gas is a major consideration when used in the starter system. **All starters using natural gas must be piped away on the exhaust according to industry codes and local regulations.**

There is a natural gas vent port in the turbine housing that is plugged for compressed air use. This vent is used to remove any natural gas which could leak past the primary turbine shaft seal. Remove this 3/8"NPT plug and install a line to carry gas away from the starter area and vent to atmosphere; refer to Figures 2,3,4 and 5. Do not connect this vent line to the starter exhaust line.

CAUTION

Do not connect the turbine housing vent line to the turbine exhaust line; exhaust gas can pressurize the turbine housing.

3.0 HARDWARE and ACCESSORIES

Refer to Figures 16 through 19 for exhaust hardware and installation accessories available from Tech Development.

DESCRIPTION	PART NUMBER
Pressure Regulator, Air, 1.5"	52-20724-100
Pressure Regulator, Air, 2.0"	52-20724-200
Pressure Gauge, 0 - 200 PSIG	52-21982
Pressure Gauge, with U-Clamp, 0 - 200 PSIG	52-21982-100
Manual Control Valve, Air	52-93504
Natural Gas Piloted Relay Valve, 1.5"	52-93505
Natural Gas Piloted Relay Valve, 2.0"	52-93505-100
Air Piloted Relay Valve, Buna-N, 1.5"	RLVA-25683-001-1-01
Air Piloted Relay Valve, Viton, 1.5"	RLVA-25683-001-2-01
Air Piloted Relay Valve, High Pressure, 1.5"	RLVA-25683-001-3-01
Solenoid Control Air Valve, 12VDC, 1.5" Buna-N	RLVA-25683-012-1-01
Solenoid Control Air Valve, 12VDC, 1.5" Viton	RLVA-25683-012-2-01

Figure 19. Installation Accessories

DESCRIPTION	PART NUMBER
Solenoid Control Air Valve, 24VDC, 1.5" Buna-N	RLVA-25683-014-1-01
Solenoid Control Air Valve, 24VDC, 1.5", Viton	RLVA-25683-024-2-01
Solenoid Control Air Valve, 110VDC, 1.5"	RLVA-25683-110-2-01
Solenoid Control Air Valve, 120 VAC, 1.5"	RLVA-25683-120-2-01
Valve, Natural Gas, Manually Operated / Spring Loaded, 1.5"	52-93508
Valve, Natural Gas, Manually Operated / Spring Loaded, 2.0"	52-93508-400
Pressure Regulator, Natural Gas, 2", 300 PSIG Max Upstream Pressure	52-93552
Pressure Regulator, Natural Gas, 2", 125 PSIG Max Upstream Pressure	52-93553
Y-Strainer, 1.5 NPT, Natural Gas, 600 PSIG	52-93549-100
Y-Strainer, 2.0" NPT, Natural Gas, 600 PSIG	52-93549-200
Y-Strainer, 1.5" NPT, Air, 250 PSIG	52-93550-100
Y-Strainer, 2.0" NPT, Air, 250 PSIG	52-93550-200
Grease, 1 Lb Can	9-94121
Grease, 16 Oz Tube	9-94121-002
Anti-Seize Compound, 1 Oz Tube	42-94081
Anti-Seize Compound, 1 Lb Can	9-94081
Sealant, Pipe Thread, Loctite 59231, 1.69 Oz Tube	9-94085

Figure 19. (Continued) Installation Accessories

4.0 STARTER OPERATION

Prior to operation, check that all connections are tight and free from leaks. Check the 1/4" NPT pipe plug (from Section 2.5) or a pressure gauge/transducer and air line is connected to the pressure port on the starter inlet.

WARNING

Do not operate the TDI **TURBOTWIN** starter with air pressure greater than the pressure rating on the nameplate. This pressure is to be measured at the starter inlet while the starter is running.

The maximum operating pressure limit is the inlet pressure when measured at the starter inlet pressure check port and reflects all supply air pipe and valving losses. In order to check the starter, a 1/4"NPT pipe tap connection is provided in the inlet housing to attach a pressure gauge/transducer; refer to Figures 4 and 5.) **IN NO CASE SHOULD INLET OPERATING PRESSURE EXCEED 200 PSIG (14.8 BAR) WITH AN OPEN EXHAUST!** This will exceed the maximum torque limit of the inertia drive assembly. The maximum

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operating pressure limit of all models of *TURBOTWIN* starters is shown in Figure 1. These maximum pressures assumes air as the working gas and an open exhaust (the standard turbine exhaust guard). The standard exhaust guard basically causes no back pressure.

The static supply pressure will always be higher than the operating pressure. As a guideline, the maximum pressure limit (proof pressure) that the *TURBOTWIN* starter housings may be subjected to is 600 PSIG (42 BAR). System pressure that exceeds the maximum operating limit must use a pressure reducer device to ensure that the operating pressure limit to the *TURBOTWIN* starter is maintained.

System pressure that exceeds the 600 PSIG (42 BAR) limit must, in addition to pressure reducer devices, incorporate a pressure relief valve, set below 600 PSIG (42 BAR), in the supply air line.

All appropriate local pressure codes and pressure limitations on other system components must be adhered to and would supersede the guidelines given in this manual.

Consult your TDI distributor if you have exhaust plumbing which creates back pressure and reduces starter performance. You may be able to increase the supply pressure to restore the lost power.

Follow the engine manufacturer's instructions for starting the engine.

4.1 Basic Operation

The basic operation of the starter follows:

Pressurized air or natural gas is admitted to the starter by the opening of the manual or relay valve. The air expands through the turbine which produces shaft rotation and torque. The acceleration of the drive assembly causes the pinion to advance and engage the ring gear of the engine. The starter motor torque causes the engine to accelerate. The fuel and ignition systems now fire the engine. The starter is stopped by closing the manual or relay valve.

The *TURBOTWIN* features a unique two stage turbine which limits the maximum starter speed from its aerodynamic design. The operator may prematurely decrease starter life by the continual operation of the starter after the engine has started. Upon a successful engine start, shut the air off to the starter immediately. Minimizing the time the starter is operating unloaded (i.e. the engine is running) will maximize the starter life. If a start is aborted, a restart may be attempted after the engine and the starter have come to rest.

WARNING

Do not engage the starter while the engine is running.

The drive air pressure is the primary starter control parameter. It is important, especially on new installations, to measure this pressure during several engine starts. The secondary parameter is the starter pinion speed. This speed is usually measured by knowledge of the engine starting speed and the starter cranking ratio. The cranking ratio is the number of ring gear teeth divided by the number of pinion teeth. The starter pinion speed is then found by multiplying the engine speed by the cranking ratio. The pinion speed is usually 2000-3500 rpm for a typical engine starting speed.

If the engine fails to function properly when first operated, or its performance deteriorates with use, refer to the Operator's Trouble Shooting Guide, Section 7.0. If you cannot solve the problem, or repair is necessary, contact your local TDI *TURBOTWIN* distributor or dealer.

4.2 Manual Valve Operation

The operator opens a valve manually to admit pressurized air to the starter. As the engine approaches starting engine speed, the operator must monitor the various engine parameters or listen for the engine firing. Upon engine firing, the operator must stop the air flow to the starter by closing the manual valve.

Leaving the air on to the starter more than one second after the engine is running, may result in damage to the starter.

4.3 Automated Start Panel

As mentioned previously, the starter drive pressure will need to be set. This pressure is measured at the starter inlet.

The speed control parameter will then need to be set. Engine starting speed along with the cranking ratio number can be used to determine starter pinion speed. The pinion speed is usually 2000-3500 rpm for a typical engine starting speed. Once the start sequence has begun, the air is admitted to the starter. The starter begins to accelerate the engine. Once the firing speed of the engine is reached, the automated start panel may start fuel to the engine (diesel). The engine will begin to accelerate under its own power. The starter should be dropped out of the sequence at an rpm slightly higher than the firing speed, but certainly less than the engine idle speed.

The automated start panel should be set to monitor engine

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speed and/or starter speed to determine air on and air off. Do not use simply time as a control parameter. Avoiding excessive over speed of the starter after the engine is firing will maximize the starter life.

5.0 PREVENTIVE MAINTENANCE

The TDI *TURBOTWIN* starters provide distinct advantages of size and efficiency as compared to electric motor, vane-type or other turbine-type starters. It is important to properly install the starter to receive full benefit of these advantages. Repair technicians or service organizations without turbine starter experience should not attempt to repair this machine until they receive factory approved training from TDI, or its representatives.

Proper operation and repair of your TDI *TURBOTWIN* starter will assure continued reliable and superior performance for many years.

5.1 Every Six (6) Months

Perform the following procedures at six(6) months intervals if the normal cranking cycle is 0 - 10 seconds.

5.1.1 Check the amount and condition of grease in the planetary gearbox. If gearbox requires re-greasing, only use TDI grease. Approximately one (1) pint of grease is needed to repack the gearbox.

5.1.2 Check the turbine bearing and carrier output bearings for freedom of rotation without excessive play between races. If bearings are damaged, replace them with genuine TDI parts. Refer to TDI Service Manual for part numbers.

5.1.3 Place a small amount of chassis lube on the starter's pinion teeth.

5.2 Every Three (3) Months

Follow the six (6) month procedures if there is severe starter loading or extended duration crank cycles. Also perform these procedures every three (3) months when starter is used for motoring the engine for maintenance or valve adjustments.

Motoring Crank Cycle: 10 -60 seconds

Extended Crank Cycle: 60 seconds or longer

6.0 STARTER DISASSEMBLY AND REPAIR

The TDI service manual P/N T1-701 provides a step by step procedure to assemble and disassemble the *TURBOTWIN* starter. All models are covered by this manual.

Section 2.2 discusses the partial disassembly in detail to change the orientation of the air inlet relative to the starter mounting flange.

Repair technicians or service organizations without turbine starter experience should not attempt to repair this machine until they receive factory approved training from TDI or its representatives. If repair is required, consult your local TDI *TURBOTWIN* dealer or distributor.

For safe and reliable operation of your TDI *TURBOTWIN* starter, use only genuine TDI replacement parts. The component part numbers are found in the Illustrated Parts Breakdown which is P/N T1-703. All models are covered in this publication.

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TROUBLE	PROBABLE CAUSE	SOLUTION
1. Starter does not run; small air flow from exhaust.	A. Relay valve not fully open.	A. Repair or replace relay valve.
	B. Nozzle blockage.	B. Remove blockage or obstruction from nozzles.
2. Starter does not run; normal air flow from exhaust.	A. Broken turbine rotor.	A. Replace all damaged parts.
	B. Broken gear train.	B. Repair or replace geartrain.
	C. Damaged starter drive.	C. Repair or replace starter drive.
3. Reduced Starter output power.	A. Inlet air pressure too low.	A. Increase air pressure in 10 PSIG (0.6 BAR) increments; DO NOT EXCEED OPERATING LIMIT.
	B. Inlet supply piping too small.	B. Supply piping must be a minimum of 1.5" diameter.
	C. Pressure regulator orifice too small.	C. Increase orifice size or replace pressure regulator
	D. Inlet supply line valve (ball, gate, relay, plug) too small.	D. Install larger valve.
	E. In line lubricator installed in supply line.	E. Remove lubricator.
	F. Y-Strainer in supply line clogged.	F. Clean strainer.
	G. Excessive back pressure; exhaust restricted.	G. Clean exhaust piping or increase size to at least the minimum diameter recommended.
	H. Damaged turbine nozzle.	H. Replace turbine nozzle.
	I. Broken starter drive.	I. Repair or replace starter drive.
	J. Wrong rotation starter.	J. Replace with starter or proper rotation.
	K. Wrong size starter.	K. Check the Application Guide for the correct starter.
4. Engine cranks too quickly.	A. Inlet air pressure too high.	A. Decrease air pressure in 10 PSIG (0.6 BAR) increments. OR If there is a manual shut-off valve in the supply line, partially close it. OR Install a restriction orifice in the inlet supply line.
	B. Wrong size starter.	B. Check the Application Guide for the correct starter.

7.0 OPERATOR'S TROUBLE SHOOTING GUIDE

If repair is required, consult your local TDI *TURBOTWIN* dealer or distributor.

For your nearest TDI dealer contact:

Phone: (513)898-9600 Customer Service
 Fax: (513)898-8431 Tech Development Inc
 6800 Poe Avenue
 Dayton, Ohio 45414

TDI TURBOTWIN
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5.0 WARRANTY

TDI TURBOSTART ENGINE STARTER WARRANTY

Tech Development Inc. Warrants to the original user of the TDI TURBOTWIN starters that the starters and related components manufactured by TDI will be free from defects in material and workmanship for a period of One (1) Year from the date of purchase by such user. The conditions of this warranty are: a) TDI is notified within this period by return of such product to TDI or its authorized distributor or dealer, transportation prepaid by user; b) such product has been installed according to TDI's specifications; c) such product has not been misused, abused, or improperly maintained by user; d) the defect is not the result of normal wear and tear; and e) such starter product has not been repaired with parts not manufactured or authorized by TDI and that TDI installation and repair procedures as outlined in the appropriate manual were properly followed.

Tech Development Inc. shall, at its option, either repair or replace, without charge, any such starter product found upon TDI's examination to be so defective, or by mutual agreement, refund the user's purchase price in exchange for such starter product. Repairs or replacements under this warranty are warranted for the remainder of the original warranty period.

Tech Development Inc. Makes no other warranty, and IMPLIED WARRANTIES INCLUDING ANY WARRANTY OR MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE ARE HEREBY DISCLAIMED.

This warranty constitutes the entire obligation of Tech Development Inc. Relating to the sale and use of such product, and TDI's maximum liability is limited to the purchase price of such product at the date of purchase. In no event shall TDI be liable for incidental, indirect, consequential or special damages of any nature from the sale of such engine starter product.

RECOMMENDED ALARM AND SHUTDOWN SETPOINTS

The following is a list of recommended "alarm" and "shutdown" setpoints by engine series for various engine operating parameters. These values can be used as a guide when designing protection or monitoring systems.

The "alarm" values shown are suggested values – they can be changed to suit a specific application or measurement device. By utilizing controls that simultaneously shut off the fuel supply and ignition system upon reaching a "shutdown" value, the potential for engine damage is reduced.

CAUTION: Alarm and shutdown values indicate deviation from designed operation and are not meant for continuous engine service. Engine and control systems must be designed to and operated at normal values. Disregard may result in engine damage.

Alarm and shutdown values are based on using dry natural gas of 900 BTU/cu.ft. (35.38 MJ/m³ [25,V(0;101.325)]) Saturated Lower Heating Value (SLHV) as fuel. Refer to the "Gaseous Fuel Specification for Waukesha Engines" standard sheet, S-7884-6 or latest version, and the "Lubricating Oil Recommendations for Waukesha Engines" standard sheet, S-1015-29 or latest version, for typical changes to operating temperatures for jacket water and lube oil when running on landfill or digester gas fuels.

Refer to the most recent version of the *Gas Engine Price Book* to determine which shutdown devices are included as standard equipment with any specific engine model.

EN 124417 8/99 Revised
EN 124390 8/99 Revised
EN 124244 6/99 New Release

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Title - RECOMMENDED ALARM AND SHUTDOWN SETPOINTS

DR. RWS 6/99
CH. RWS 6/99
APP. JMD 6/99

S-
08382-2

AT25GL / AT27GL

JACKET WATER OUTLET TEMPERATURE:

Standard Cooling System:

Normal: 180° F (82° C) for continuous rating.
200° F (93° C) for intermittent rating.
Alarm: 10° F (5.5° C) above normal / design temperature.
Shutdown: 20° F (11° C) above normal / design temperature.

Elevated Temperature, Solid Water Cooling System:

Normal: 210° – 250° F (99° – 121° C) for solid water.
Alarm: 5° F (3° C) above normal / design operating temperature¹.
Shutdown: 10° F (5.5° C) above normal / design operating temperature¹.

LUBE OIL HEADER TEMPERATURE:

Normal: 172° F (78° C)
Alarm: 187° F (86° C)
Shutdown: 197° F (92° C)

LUBE OIL HEADER PRESSURE:

Normal: 60 – 65 psi (415 – 450 kPa)
Alarm: 50 psi (345 kPa)
Shutdown: 45 psi (310 kPa)

INTAKE MANIFOLD TEMPERATURE:

AT25GL Models

Normal: Up to 10° F (5.5° C) above design intercooler water inlet temperature.
Alarm: 20° F (11° C) above design intercooler water inlet temperature.
Shutdown: 30° F (17° C) above design intercooler water inlet temperature.

AT27GL Models

Normal: Up to 10° F (5.5° C) above design intercooler water inlet temperature.
Alarm: 15° F (11° C) above design intercooler water inlet temperature.
Shutdown: 20° F (17° C) above design intercooler water inlet temperature.

INTAKE MANIFOLD PRESSURE:

Contact Waukesha Sales Engineering.

MAIN BEARING TEMPERATURE:

Shutdown: 250° F (121° C)

OVERSPEED:

Shutdown: Not to exceed 10% over governed speed.

- (1) Waukesha Power Systems Code 1105, 1105A, or equivalent pressure / temperature shutdown system is recommended when jacket water temperature exceeds 210° F (99° C).
- (2) Do not revise any values on this page without revising the same values on the "AT General Operating Limits" and "Diagram Temperature/Pressure Test Points and Pump Settings" s-sheets for the 8L, 12V, and/or 16VATGL engines.

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Title - RECOMMENDED ALARM AND SHUTDOWN SETPOINTS

DR. RWS 6/99
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VHP

JACKET WATER OUTLET TEMPERATURE:

Standard Cooling System:

Normal: 180° F (82° C) for continuous rating.
200° F (93° C) for intermittent rating.
Alarm: 10° F (5.5° C) above normal / design temperature.
Shutdown: 20° F (11° C) above normal / design temperature.

Elevated Temperature Solid Water Cooling System:

Normal: 210° – 235° F (99° – 113° C) for solid water.
Alarm: 5° F (3° C) above normal / design operating temperature¹.
Shutdown: 10° F (5.5° C) above normal / design operating temperature¹.

Ebullient Cooling System:

Normal: 212° – 250° F (100° – 121° C)
Alarm: See Note 2 below.
Shutdown: See Note 2 below.

LUBE OIL HEADER TEMPERATURE:

Normal: 180° F (82° C)
Alarm: 195° F (91° C)
Shutdown: 205° F (96° C)

LUBE OIL HEADER PRESSURE:

Six and Twelve Cylinder Models:

Normal: 50 – 60 psi (345 – 415 kPa)
Alarm: 30 psi (207 kPa)
Shutdown (except 5115GL model): 20 psi (138 kPa)
Shutdown (5115GL model): 25 psi (172 kPa)

Sixteen Cylinder Models:

Normal: 50 – 60 psi (345 – 415 kPa)
Alarm: 25 psi (172 kPa)
Shutdown: 15 psi (103 kPa)

- (1) Waukesha Power Systems Code 1105, 1105A, or equivalent shutdown system is recommended when jacket water temperature exceeds 210° F (99° C).
- (2) Waukesha Power Systems Code 1106, 1106A, or equivalent shutdown system is recommended for ebulliently cooled engines.

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Title - RECOMMENDED ALARM AND SHUTDOWN SETPOINTS

DR. RWS 6/99
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VHP (cont.)

INTAKE MANIFOLD TEMPERATURE (GSI & GL Engines):

Normal: Up to 10° F (5.5° C) above design intercooler water inlet temperature.
Alarm: 15° F (8.5° C) above design intercooler water inlet temperature.
Shutdown: 20° F (11° C) above design intercooler water inlet temperature.

INTAKE MANIFOLD PRESSURE:

Contact Waukesha Sales Engineering.

MAIN BEARING TEMPERATURE:

Shutdown: 250° F (121° C)

OVERSPEED:

Shutdown: Not to exceed 10% over governed speed.

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Title - **RECOMMENDED ALARM AND SHUTDOWN SETPOINTS**

DR. RWS 6/99

CH. RWS 6/99

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S-
08382-2

VGf

JACKET WATER OUTLET TEMPERATURE:

Standard Cooling System (<= 176 BMEP Engines):

Normal: 180° F (82° C) for continuous rating.
200° F (93° C) for intermittent rating.
Alarm: 10° F (5.5° C) above normal / design temperature.
Shutdown: 20° F (11° C) above normal / design temperature.

Elevated Temperature, Solid Water Cooling System (<= 176 BMEP Engines):

Normal: 210° – 265° F (99° – 130° C) for solid water.
Alarm: 5° F (3° C) above normal / design temperature¹.
Shutdown: 10° F (5.5° C) above normal / design temperature¹.

Elevated Temperature, Solid Water Cooling System (200 BMEP Engines):

Normal: 210° F (99° C) for solid water.
Alarm: 10° F (5.5° C) above normal / design temperature¹.
Shutdown: 15° F (8.5° C) above normal / design temperature¹.

LUBE OIL HEADER TEMPERATURE:

<= 176 BMEP Engines

Jacket Water Outlet Temperature of 180° F (82° C) and Intercooler Temperatures of 85° – 130° F (29° – 54° C).

All Models

Normal: 170° – 195° F (76.5° – 90.5° C)
Alarm: 200° F (93° C)
Shutdown: 205° F (96° C)

Jacket Water Outlet Temperature of 265° F (129° C) and Intercooler Temperatures of 85° – 130° F (29° – 54° C).

All Models

Normal: 170° – 195° F (76.5° – 90.5° C)
Alarm: 200° F (93° C)
Shutdown: 205° F (96° C)

200 BMEP Engines

Jacket Water Outlet Temperature of 210° F (99° C) and Intercooler Temperatures of 158° – 176° F (70° – 80° C).

GLD Model Only

Normal: 190° F (88° C)
Alarm: 200° F (93° C)
Shutdown: 205° F (96° C)

(1) Waukesha Power Systems Code 1105, 1105A, or equivalent pressure / temperature shutdown system is recommended when jacket water temperature exceeds 210° F (99° C)

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Title - **RECOMMENDED ALARM AND SHUTDOWN SETPOINTS**

DR. RWS 6/99
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VGF (con't)

LUBE OIL HEADER PRESSURE:

F18/H24 Models

Normal: 67 -- 83 psi (462 -- 572 kPa)
Alarm: 40 psi (276 kPa)
Shutdown: 35 psi (241 kPa)

L36/P48 Models

Normal: 47 -- 63 psi (324 -- 434 kPa)
Alarm: 40 psi (276 kPa)
Shutdown: 35 psi (241 kPa)

INTAKE MANIFOLD TEMPERATURE:

</= 176 BMEP Engines (GL/GLD/GSID Models)

With Standard Intercooler Water Temperatures of 85° -- 130° F (29° -- 54° C)

Normal: Up to 10° F (5.5° C) above design intercooler water temperature.
Alarm: 15° F (8.5° C) above design intercooler water temperature.
Shutdown: 20° F (11° C) above design intercooler water temperature.

With Elevated Intercooler Water Temperatures of 131° -- 176° F (55° -- 80° C)

Normal: Up to 10° F (5.5° C) above design intercooler water temperature.
Alarm: 10° F (5.5° C) above design intercooler water temperature.
Shutdown: 15° F (8.5° C) above design intercooler water temperature.

200 BMEP Engines (GLD Model Only)

With Elevated Intercooler Water Temperatures of 158° -- 176° F (70° -- 80° C)

Normal: Up to 10° F (5.5° C) above design intercooler water temperature.
Alarm: 10° F (5.5° C) above design intercooler water temperature.
Shutdown: 15° F (8.5° C) above design intercooler water temperature.

INTAKE MANIFOLD PRESSURE:

Contact Waukesha Sales Engineering.

MAIN BEARING TEMPERATURE:

Contact Waukesha Sales Engineering.

OVERSPEED:

Shutdown: Not to exceed 15% over governed speed.

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Title - RECOMMENDED ALARM AND
SHUTDOWN SETPOINTS

DR. RWS 6/99

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VSG

JACKET WATER OUTLET TEMPERATURE:

Normal: 180° F (82° C)
Alarm: 200° F (93° C)
Shutdown: 210° F (99° C)

LUBE OIL HEADER TEMPERATURE:

With a Jacket Water Temperature of 180° F (82° C).

F11G Model

Normal: 205° F (96° C)
Alarm: 215° F (102° C)
Shutdown: 225° F (107° C)

F11GSI Model

Normal: 190° F (89° C)
Alarm: 200° F (93° C)
Shutdown: 210° F (99° C)

LUBE OIL HEADER PRESSURE:

Normal: 65 – 87 psi (450 – 600 kPa)
Alarm: 40 psi (276 kPa)
Shutdown: 30 psi (207 kPa)

INTAKE MANIFOLD TEMPERATURE (GSI Engines):

Normal: Up to 15° F (8.5° C) above design intercooler water inlet temperature.
Alarm: 20° F (11° C) above design intercooler water inlet temperature.
Shutdown: 25° F (14° C) above design intercooler water inlet temperature.

INTAKE MANIFOLD PRESSURE (GSI Engines):

Contact Waukesha Sales Engineering.

MAIN BEARING TEMPERATURE:

Contact Waukesha Sales Engineering.

OVERSPEED:

Shutdown: Not to exceed 15% over governed speed.

EN 124417 8/99 Revised
EN 124390 8/99 Revised
EN 124244 6/99 New Release

F1197

JACKET WATER OUTLET TEMPERATURE:

Normal: 180° F (82° C)
Alarm: 200° F (93° C)
Shutdown: 210° F (99° C)

LUBE OIL HEADER TEMPERATURE:

Normal: 160° – 210° F (71° – 99° C)
Alarm: 225° F (107° C)
Shutdown: 235° F (113° C)

LUBE OIL HEADER PRESSURE:

Normal: 40 – 50 psi (276 – 345 kPa)
Alarm: 15 psi (103 kPa)
Shutdown: 10 psi (69 kPa)

INTAKE MANIFOLD TEMPERATURE:

Not Applicable.

INTAKE MANIFOLD PRESSURE:

Contact Waukesha Sales Engineering.

MAIN BEARING TEMPERATURE:

Contact Waukesha Sales Engineering.

OVERSPEED:

Shutdown: Not to exceed 15% over governed speed.

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EN 124390 8/99 Revised
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Title - **RECOMMENDED ALARM AND SHUTDOWN SETPOINTS**

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F817

JACKET WATER OUTLET TEMPERATURE:

Normal: 180° F (82° C)
Alarm: 195° F (91° C)
Shutdown: 205° F (96° C)

LUBE OIL HEADER TEMPERATURE:

Normal: 160° – 230° F (71° – 110° C)
Alarm: 240° F (116° C)
Shutdown: 250° F (121° C)

LUBE OIL HEADER PRESSURE:

Normal: 35 – 45 psi (241 – 310 kPa)
Alarm: 15 psi (103 kPa)
Shutdown: 10 psi (69 kPa)

INTAKE MANIFOLD TEMPERATURE:

Not Applicable.

INTAKE MANIFOLD PRESSURE:

Contact Waukesha Sales Engineering.

OVERSPEED:

Shutdown: Not to exceed 15% over governed speed.

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Title - RECOMMENDED ALARM AND SHUTDOWN SETPOINTS

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APP. JMD 6/99

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08382-2

VR

JACKET WATER OUTLET TEMPERATURE:

Normal: 180° F (82° C)
Alarm: 205° F (96° C)
Shutdown: 210° F (99° C)

LUBE OIL HEADER TEMPERATURE:

Normal: 210° F (99° C)
Alarm: 225° F (107° C)
Shutdown: 230° F (110° C)

LUBE OIL HEADER PRESSURE:

VR 155

Normal: 25 – 35 psi (172 – 241 kPa)
Alarm: 15 psi (103 kPa)
Shutdown: 10 psi (69 kPa)

VR220 and VR330

Normal: 25 – 50 psi (172 – 345 kPa)
Alarm: 15 psi (103 kPa)
Shutdown: 10 psi (69 kPa)

INTAKE MANIFOLD TEMPERATURE:

Not Applicable.

INTAKE MANIFOLD PRESSURE:

Contact Waukesha Sales Engineering.

OVERSPEED:

Shutdown: Not to exceed 15% over governed speed.

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EN 124390 8/99 Revised
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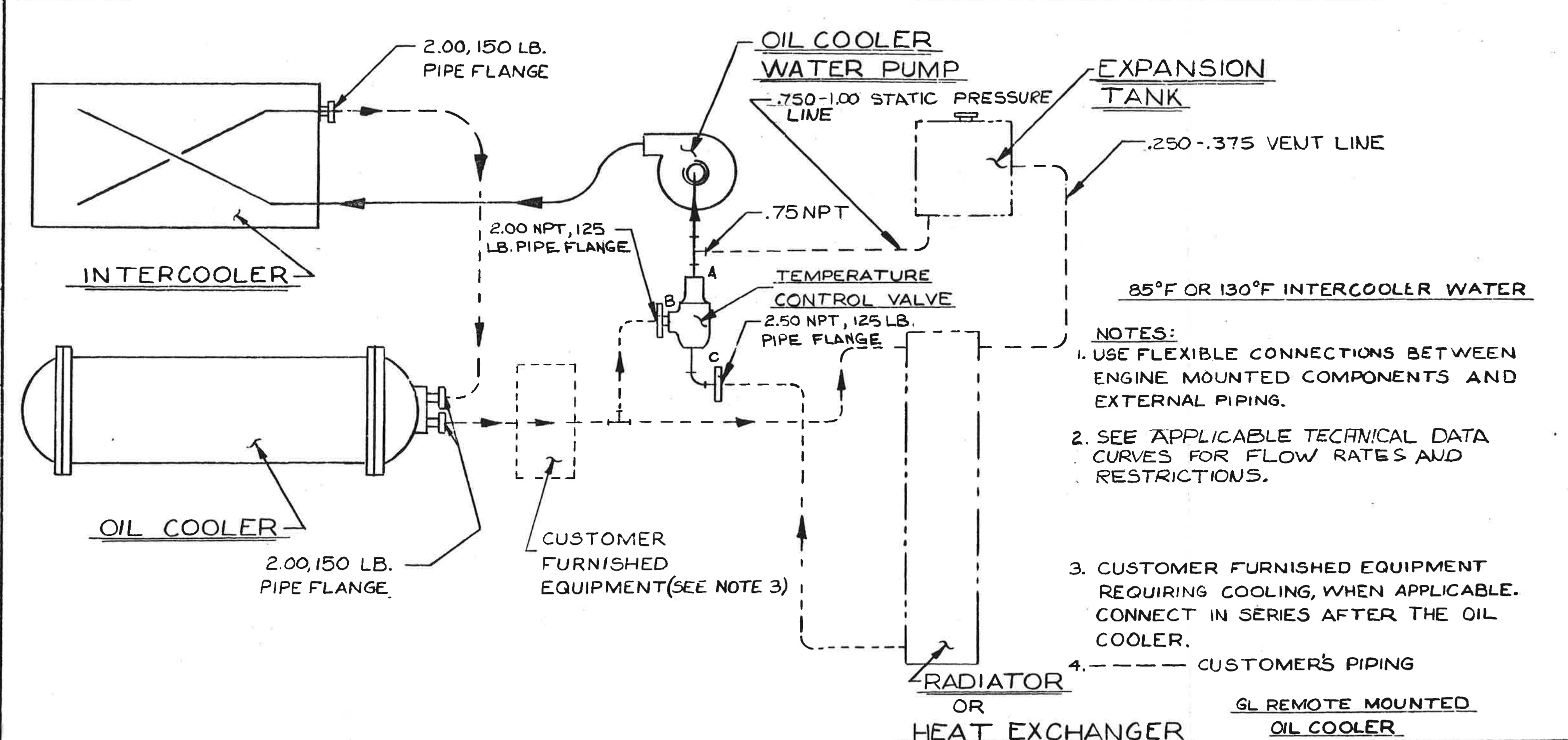
Title - RECOMMENDED ALARM AND
SHUTDOWN SETPOINTS

DR. RWS 6/99
CH. RWS 6/99
APP. JMD 6/99

S-
08382-2

109343	4-87	RELEASED	111182	8-88	ADDED NOTES .750-1.00 STATIC PRESSURE LINE (E-1), .250-.375 VENT LINE (G-2) NOTE 2 WAS: PRESSURE DROP THROUGH COOLING SYSTEM AND PIPING FROM OIL COOLER OUTLET TO WATER PUMP INLET, MUST NOT EXCEED 10 PSI. FOR 100 GPM FLOW RATE. (F-3).					
109344	4-87	2.00 NPT, 125 LB PIPE FLANGE WAS 2.00 NPT (C-2). 2.50 NPT, 125 LB PIPE FLANGE WAS 2.50 NPT. (D-3)	111182	8-88						
109344	4-87		111182	8-88						

602-4190 9S	ITEM	PART NO.	REQD.	NAME
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- NOTES:**
1. USE FLEXIBLE CONNECTIONS BETWEEN ENGINE MOUNTED COMPONENTS AND EXTERNAL PIPING.
 2. SEE APPLICABLE TECHNICAL DATA CURVES FOR FLOW RATES AND RESTRICTIONS.
 3. CUSTOMER FURNISHED EQUIPMENT REQUIRING COOLING, WHEN APPLICABLE. CONNECT IN SERIES AFTER THE OIL COOLER.
 4. - - - - CUSTOMER'S PIPING



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DIMENSIONS ARE IN INCHES

UNLESS OTHERWISE SPECIFIED

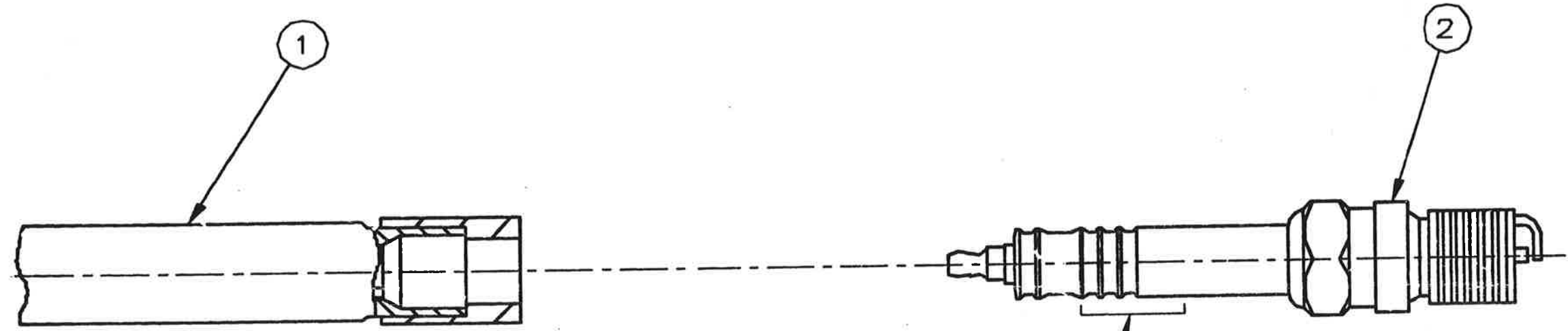
NAME
SCHEMATIC WATER PIPING

MODELS VHP 12 cyl. GL	REFERENCE DRAWINGS LR 7923-440 SB 5614-180 C.C.	MATERIAL HEAT TREATMENT	DR. DJS DATE 4/12/87 CK. HWB DATE 4-16-87 APP. DATE 4-30-87	B FILE	 WAUKESHA, WIS.	PART NO. SB 5614-209	SHEET 1 OF 1 SCALE NONE
--------------------------------	--	----------------------------	---	-----------	--------------------	--------------------------------	----------------------------

7802	8-94	RELEASED	1211/2	11-96	DU PONT KRYTOX GPL-206 DOW CORNING 4 (E4)
3011	9-94	ITEM 1 AS SPEC WAS 211357H (F1) ITEM 2 AS SPEC WAS 80999T (F1)	124558	10-99	REDRAWN ON AUTOCAD
3987	6-95	SILICON COATING ON THE SPARK PLUG WAS ON THE BOOT.			

S-07232-147

ITEM	PART NO.	RECD.	NAME
1	AS SPEC		CABLE ASM., SPARK PLUG
2	AS SPEC		SPARK PLUG

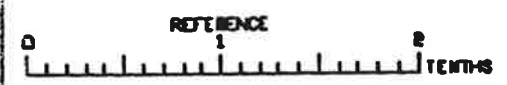


LIGHTLY COAT SPARK PLUG CERAMIC
WHERE INDICATED WITH A HIGH
TEMPERATURE DIELECTRIC GREASE
SUCH AS DU PONT KRYTOX GPL-206
OR EQUIVALENT.

AUTOCAD
MAKE NO REVISIONS
ON THIS REPRODUCIBLE

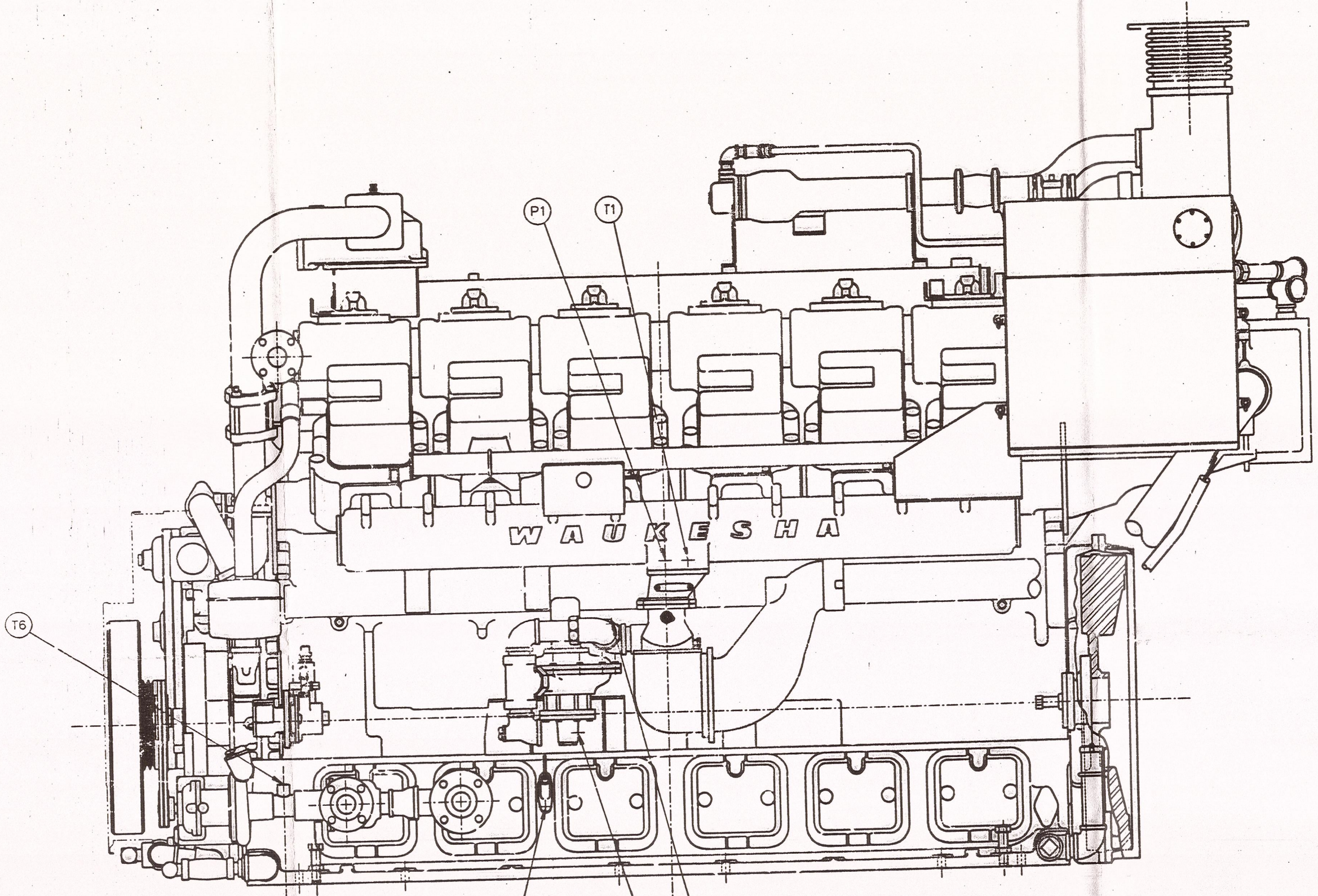
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MENTAL TO THE INTEREST OF WAUKESHA
ENGINE DIVISION.



MODELS	REFERENCE DRAWINGS	MATERIAL SEE ABOVE	DR. CBW DATE 8-3-94	B FILE	 WAUKESHA WI	NAME
VHP	211357H	HEAT TREATMENT	CK GGG DATE 8-8-94			PART NO.
5115	C.C.		APP. RMP DATE 8-8-94			S-07232-147
					SHEET 1 OF 1	SCALE NONE

A	B	C	D	E	F	G	H	J	K	L	M	N	P	R	S
123786	1-99	RELEASED													
5-07232-201															
ITEM	PART NO.	REQ.	NAME												



LEFT SIDE VIEW

OFFICIAL PARAMETER NAMES

- PRESSURES**
P1 INTAKE MANIFOLD
P2 EXHAUST MANIFOLD
P3 EXHAUST BACK PRESSURE
P4 OIL
P5 CARBURATOR AIR
P6 CARBURETOR FUEL
P7 PRECHAMBER FUEL
P8 CRANKCASE VACUUM
P9 JACKET WATER

- TAP ON THE INLET TO THE MANIFOLD (INSIDE OR OUTSIDE IS OK)
TAP IN THE BOTTOM OF THE TURBINE INLET ELBOW
TAP IN THE TOP OF THE Y PIPE
BOTTOM TAP OF PRESSURE PANEL ON RB
FISHER 99 BALANCE LINE TEE
TAP ON TOP OF THE ELBOW GOING TO THE CARB
TAP ON FRONT END OF PRECHAMBER MANIFOLD (RIGHT BANK)
TAP JUST BELOW THE DIPSTICK
N/A

TEMPERATURES

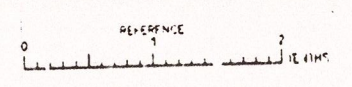
- T1 INTAKE MANIFOLD
T2 EXHAUST MANIFOLD
T3 EXHAUST STACK
T4 OIL
T5 JACKET WATER OUT
T6 AUXILIARY WATER IN

- TAP ON THE INLET TO THE MANIFOLD (INSIDE OR OUTSIDE IS OK)
TAP IN THE BOTTOM OF THE TURBINE INLET ELBOW
TAP IN THE TOP OF THE Y PIPE OR UP TO 24" ABOVE Y PIPE
TAP ON THE SHORT PIPE FROM STRAINER TO CRANKCASE
TAP IN RIGHT SIDE OF HEADER
TAP RIGHT BEFORE THE PUMP INLET

OTHER

- EP EXHAUST PROBE

TAP IN SIDE OF TURBINE INLET ELBOW



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UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES.

MODELS	REFERENCE DRAWINGS	MATERIAL
L5108CL		HEAT TREATMENT
L5790GL		
L7042GL	C.C.	

DR. *DJD* DATE 3-5-99
OK. *DEM* DATE 3-5-99
APP. *AK* DATE 3-2-99

D Waukesha **DRESSER**
WAUKESHA WI

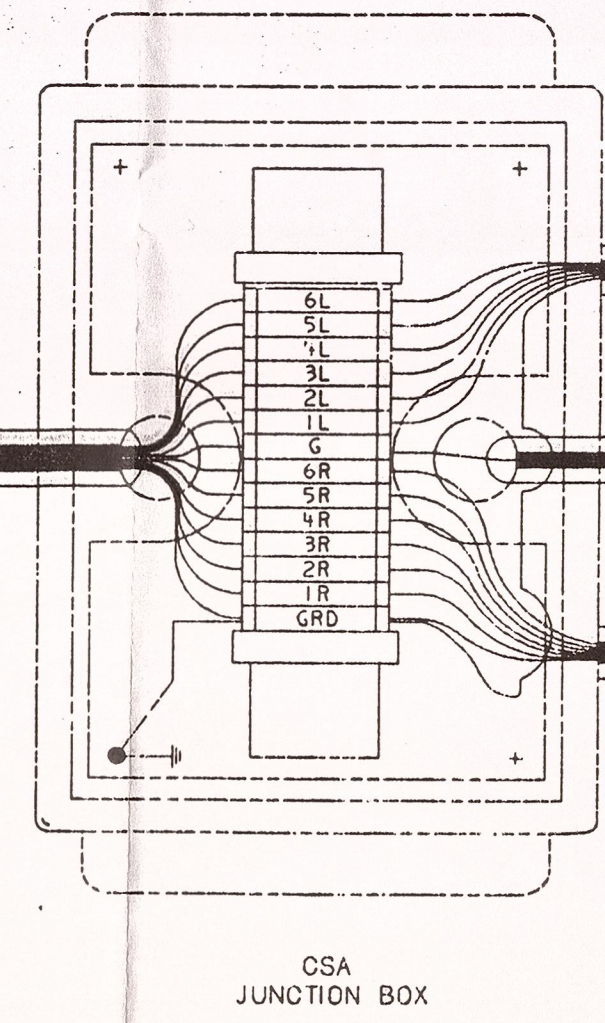
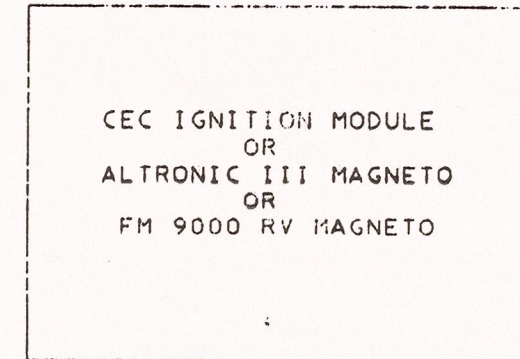
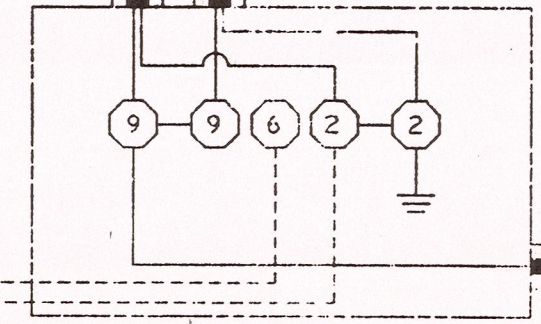
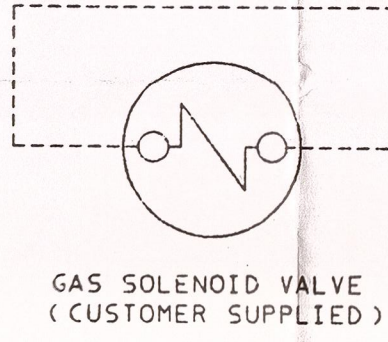
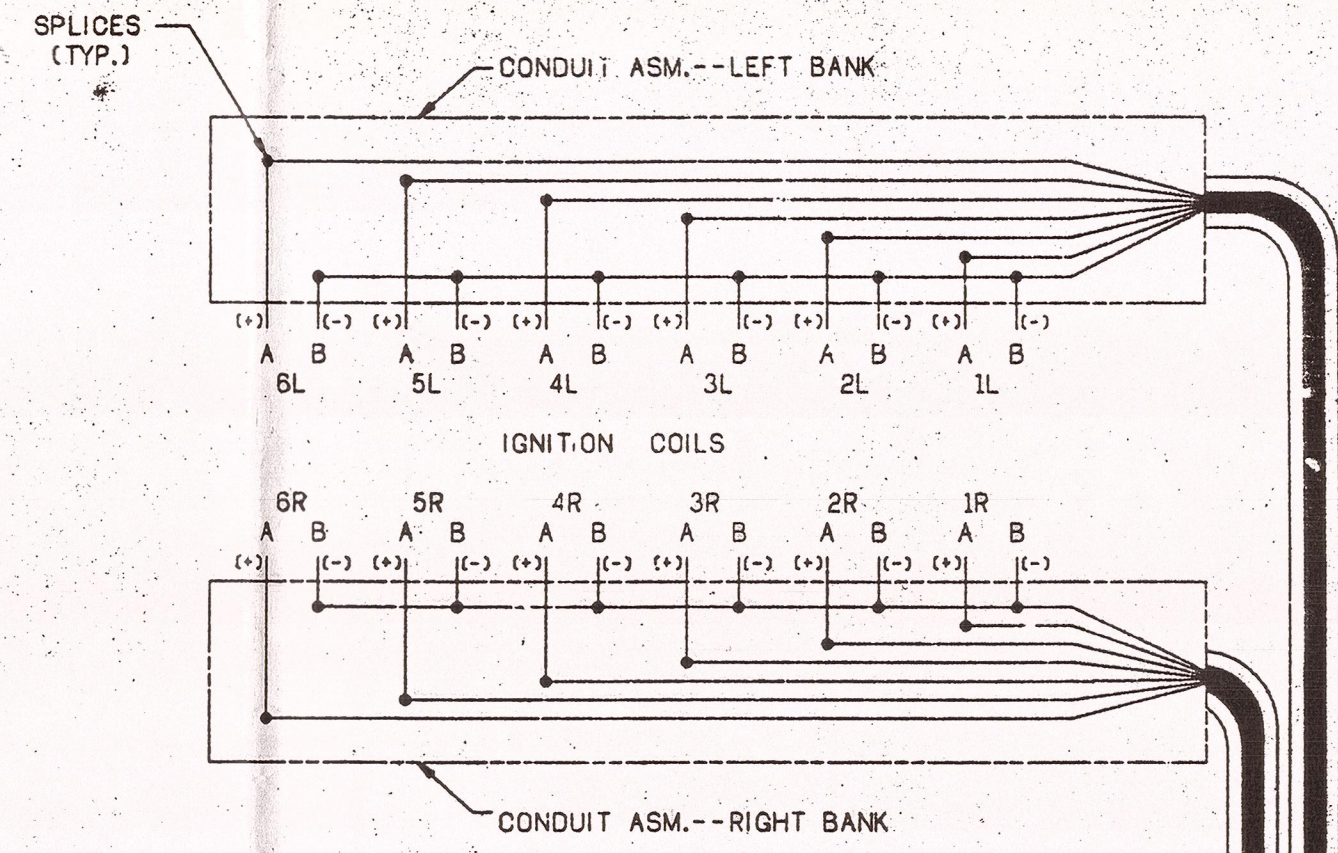
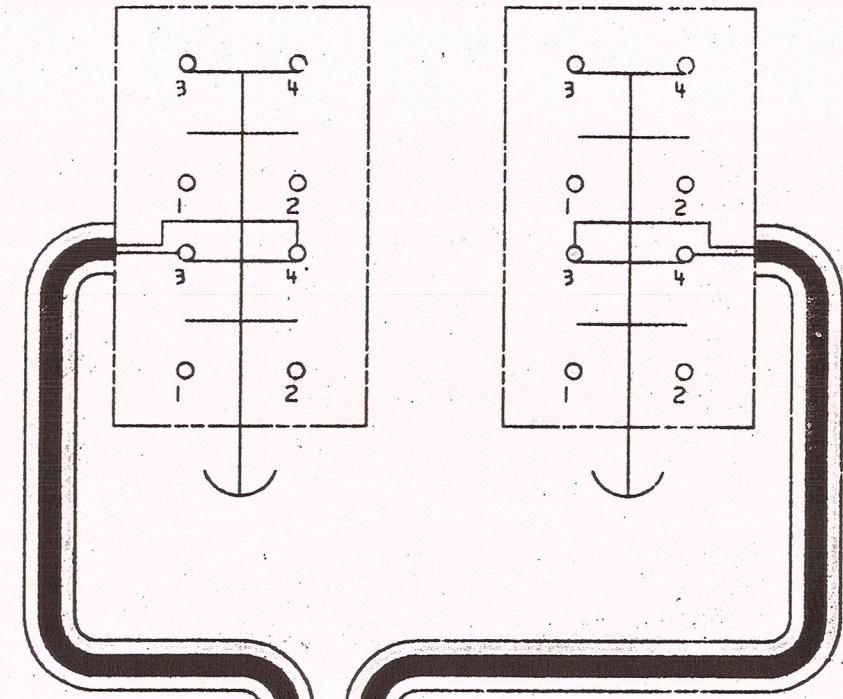
NAME
DIAGRAM
AND PRE-
POINTS
PART NO
S-07
SHEET 1 OF

03-09-99
03-09-99

TERMINAL BLOCK LABEL	IGNITION SYSTEM ASSEMBLY WIRE LABELS		
	CEC	ALTRONIC III	FAIRBANKS MORSE 9000 RV
6L	B	B	T
5L	N	K	D
4L	F	F	N
3L	R	M	B
2L	D	D	R
1L	L	I	F
6R	K	H	J
5R	C	C	S
4R	P	L	C
3R	E	E	P
2R	M	J	E
1R	A	A	A
G	G	G	H
GRD	J	N	G

ON/OFF SWITCH RIGHT BANK
 (PULL TO RUN/PUSH TO STOP)
 SWITCH SHOWN IN STOP MODE.

ON/OFF SWITCH LEFT BANK
 (PULL TO RUN/PUSH TO STOP)
 SWITCH SHOWN IN STOP MODE.



CAUTION !!!
 IT IS THE CUSTOMER'S RESPONSIBILITY TO PROVIDE GAS SHUTOFF DUE TO HIGH WATER TEMPERATURE, OVERSPEED, LOW LUBE OIL PRESSURE AND WHEN THE ON/OFF SWITCH IS IN THE OFF POSITION.

ENGINE FIRING ORDER
 1R - 6L - 5R - 2L - 3R - 4L
 6R - 1L - 2R - 5L - 4R - 3L

- NOTES:
 1. ALL W.E.D. WIRING TO BE #18, RATED 600 VOLTS.
 2. ENGINE TO BE GROUNDED PER LOCAL ELECTRICAL CODE.
 3. ALL SHIELDED WIRES SHOWN INSIDE DOTTED LINES.
 4. ----- CUSTOMER WIRING.

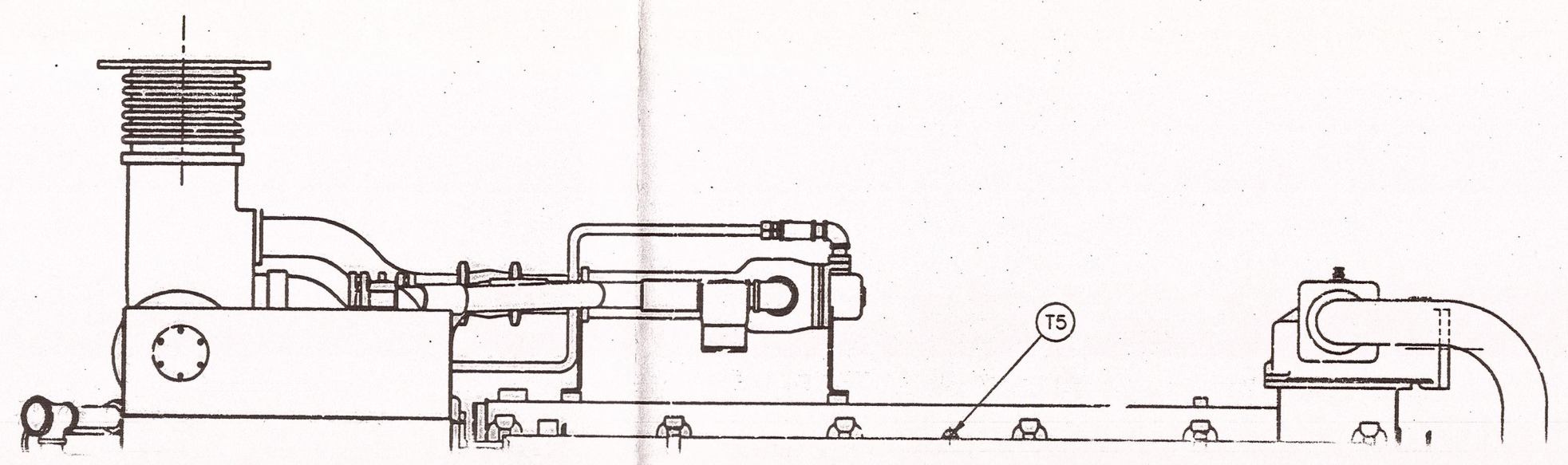
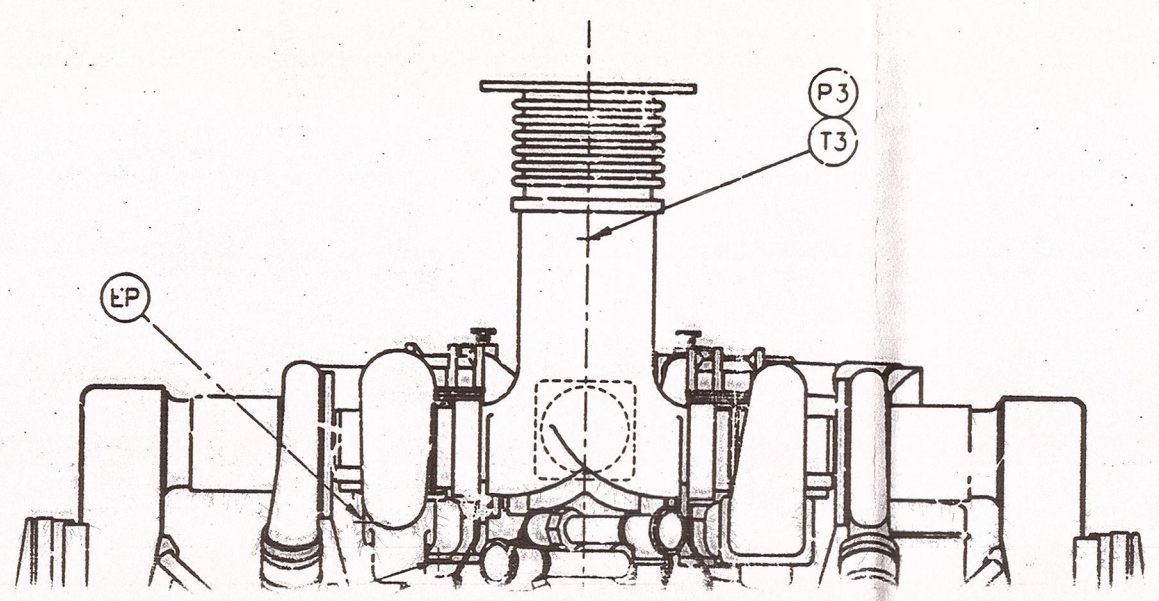
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 DIMENSIONS ARE IN INCHES. TWO-PLACE MACHINE DIMENSIONS ±.03. THREE PLACE MACHINE DIMENSIONS ±.010. ANGLES 10°-30°. BREAK SHARP CORNERS .010-.020. SHEET METAL FABRICATION TOLERANCES PER 5-8580. CONCENTRICITY (T.I.R.) OF ANY TWO MACHINED DIAMETERS AROUND A COMMON AXIS SHALL BE WITHIN 1/2 THE SUM OF THE TOTAL TOLERANCES ON THOSE DIAMETERS.

A | B | C | D | E | F | G | H | J | K | L | M | N | P | R | S

5-07232-201

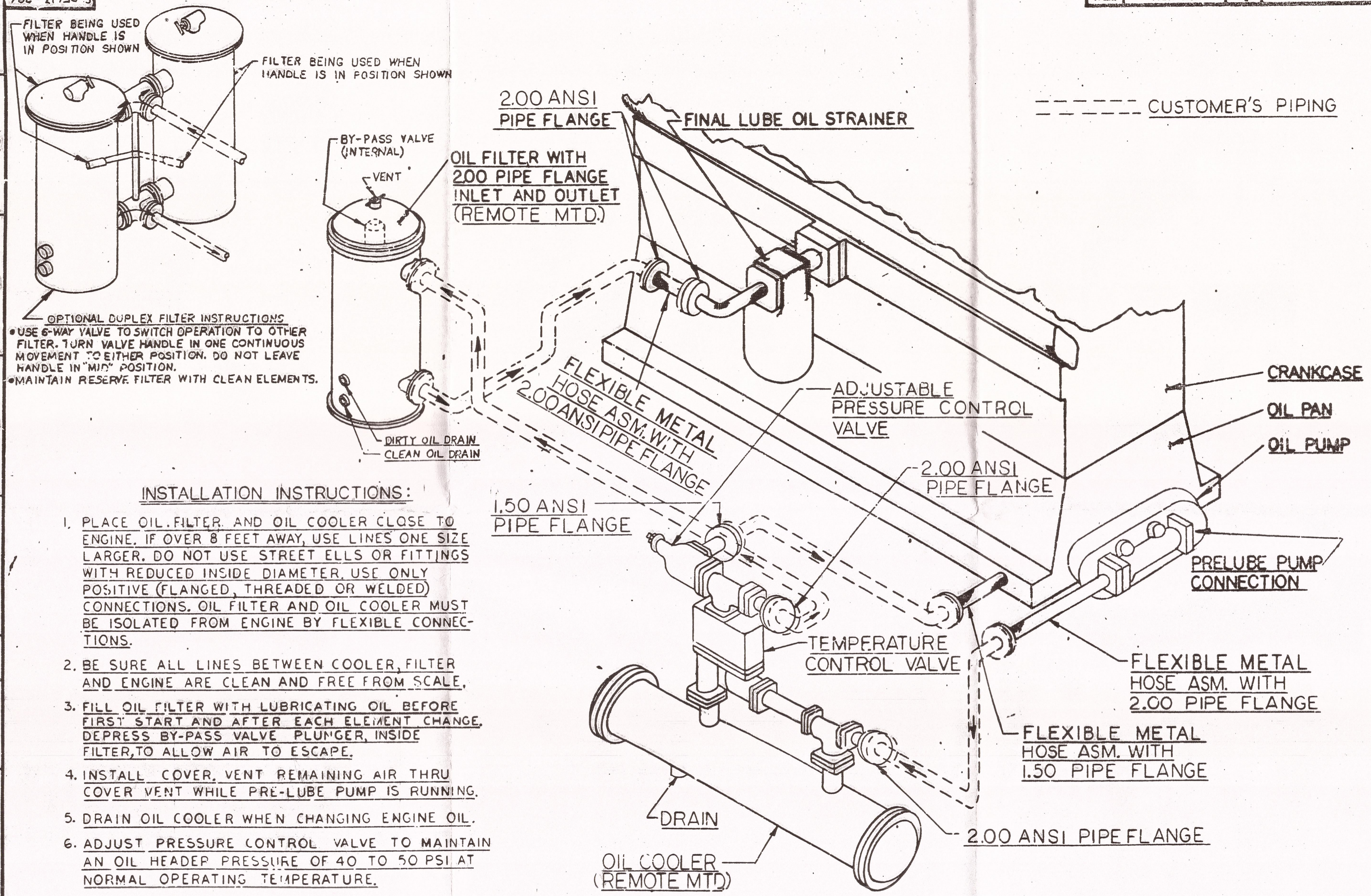
ITEM	PART NO.	REQD.	NAME
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2
3
4



	A	B	C	D	E	F	G	H	J	K	L
113369	2-91	RELEASED	121425	1-97	A211857 WAS GA208 423 C 3						
117924	9-94	ADDED DUPLEX FILTERS (B-2)			A211859 WAS MA208 629 A.						
121425	1-97	FLEXIBLE WAS CORRECTED (E-2, H-6)									
		5-05615-286 WAS SC5615-286									
		DELETED 121425-506									
982-91950-5											

ITEM	PART NO.	REQD.	NAME
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INSTALLATION INSTRUCTIONS:

1. PLACE OIL FILTER AND OIL COOLER CLOSE TO ENGINE. IF OVER 8 FEET AWAY, USE LINES ONE SIZE LARGER. DO NOT USE STREET ELLS OR FITTINGS WITH REDUCED INSIDE DIAMETER. USE ONLY POSITIVE (FLANGED, THREADED OR WELDED) CONNECTIONS. OIL FILTER AND OIL COOLER MUST BE ISOLATED FROM ENGINE BY FLEXIBLE CONNECTIONS.
2. BE SURE ALL LINES BETWEEN COOLER, FILTER AND ENGINE ARE CLEAN AND FREE FROM SCALE.
3. FILL OIL FILTER WITH LUBRICATING OIL BEFORE FIRST START AND AFTER EACH ELEMENT CHANGE. DEPRESS BY-PASS VALVE PLUNGER, INSIDE FILTER, TO ALLOW AIR TO ESCAPE.
4. INSTALL COVER. VENT REMAINING AIR THRU COVER VENT WHILE PRE-LUBE PUMP IS RUNNING.
5. DRAIN OIL COOLER WHEN CHANGING ENGINE OIL.
6. ADJUST PRESSURE CONTROL VALVE TO MAINTAIN AN OIL HEADER PRESSURE OF 40 TO 50 PSI AT NORMAL OPERATING TEMPERATURE.

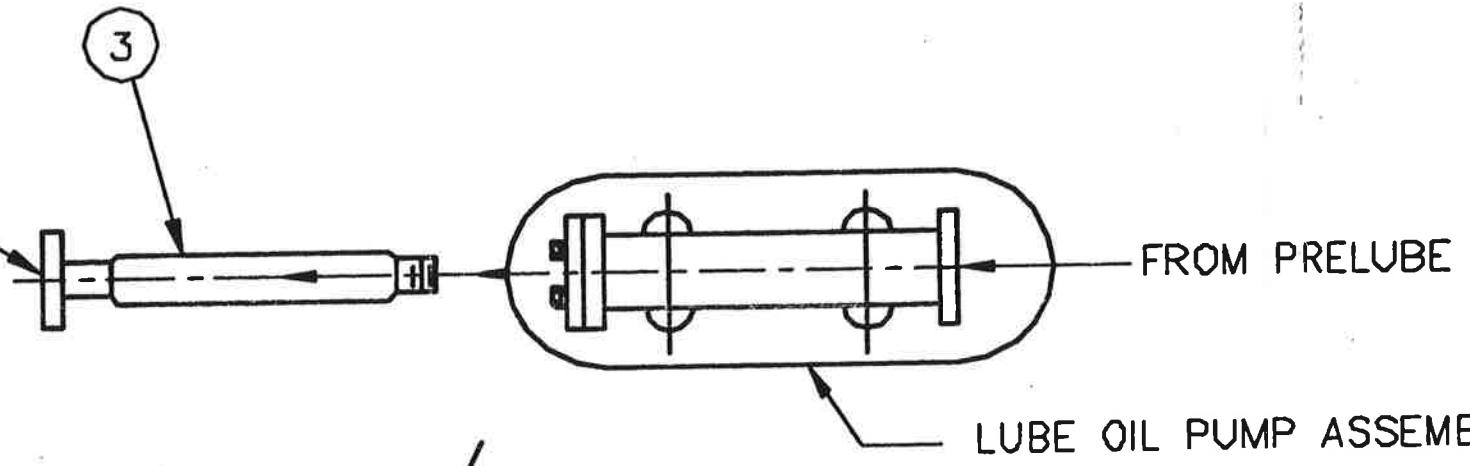
REMOTE MOUNTED OIL COOLER

186002	4-91	RELEASED,SUPERSEDES SB5613-232
124558	10-99	REDRAWN ON AUTOCAD

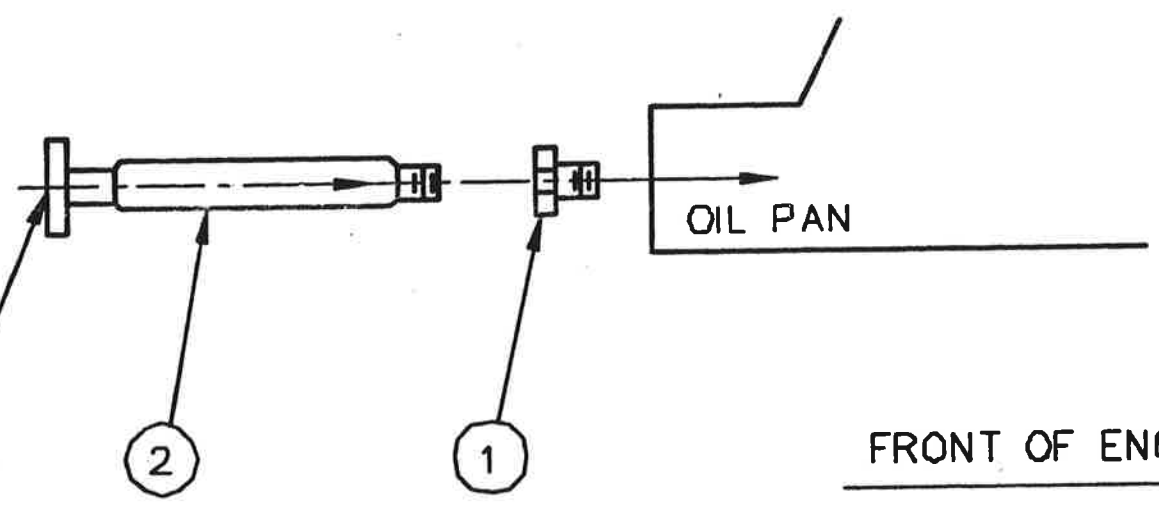
S-05613-288

ITEM	PART NO.	RECD.	NAME
1	78212W	1	BUSHING, RED. 2.00-1.50
* 2	207534	1	HOSE ASM., FLEX. 1.50 NPT
* 3	207534A	1	HOSE ASM., FLEX. 2.00 NPT

2.00, 150LB. PIPE FLANGE CONNECTION TO REMOTE MOUNTED OIL COOLER



1.50, 150 LB. PIPE FLANGE CONNECTION FROM PRESSURE REGULATING VALVE ON OIL COOLER.



* ITEMS ARE SHIPPED LOOSE

LUBE OIL PLUMBING FOR REMOTE MOUNTED 8.00 OR 10.00 DIA. OIL COOLER

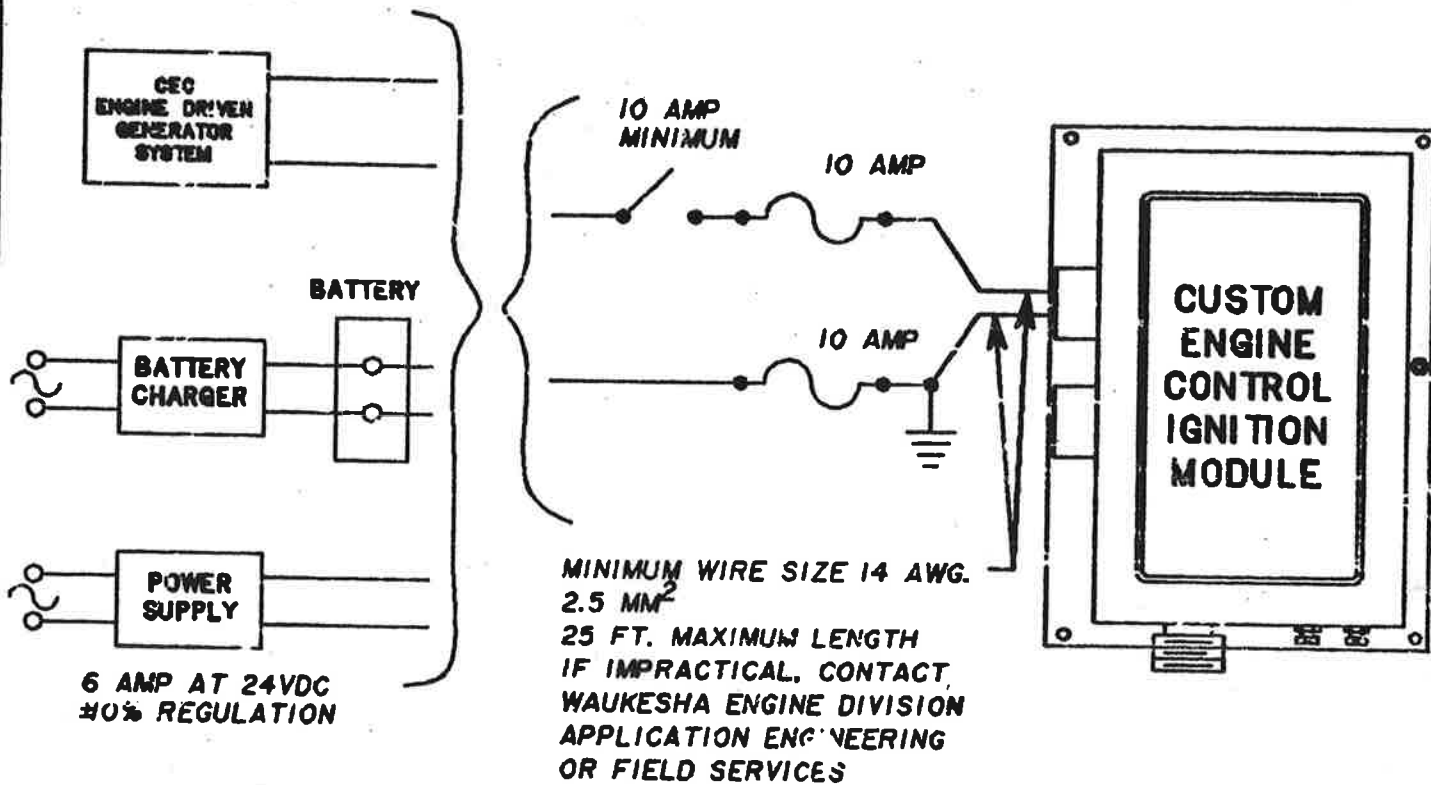
AUTOCAD
MAKE NO REVISIONS
ON THIS REPRODUCIBLE

THIS PRINT IS PROVIDED ON A RESTRICTED BASIS. NOT TO BE USED IN ANY WAY DETRIMENTAL TO THE INTEREST OF VAUKESHA ENGINE DIVISION.

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES.



MODELS	REFERENCE DRAWINGS	MATERIAL	DR. SFT	DATE 4-24-91	B	Waukesha WAUKESHA WI	NAME
VHP 12	SC5613-286		CK SFT	DATE 4-24-91			DIAGRAM, OIL PLUMBING
CYL GAS	C.C.	HEAT TREATMENT	APP. SFT	DATE 4-24-91			PART NO. S-05613-288
						FILE	SHEET 1 OF 1 SCALE NONE



NOTES:

An AC to DC power supply is not preferred unless care is taken to eliminate the possibility of a momentary loss of AC power which will result in an engine shutdown. An AC voltage filter (battery) is recommended to eliminate voltage fluctuations.

The CEC Ignition System will function properly with a power source as defined above. However, if the supply is capable of providing a pulse current (higher current level for a shorter period of time such that the average current is the same), the ignition will utilize that pulse capability. In this case, the voltage fluctuations on the supply wiring, including the ground return to the power source, may cause erratic operation of other electrical devices. For this reason, it is recommended that the ignition power source wiring, specifically the ground return, be sized for at least 30 amps even though the average current will be less than 6 amps.

CAD
MAKE NO REVISIONS
ON THIS REPRODUCTION



TITLE
**POWER REQUIREMENTS
CEC IGNITION MODULE**

DR. 8-3-93
CH. 8-12-93
APP. 8-12-93

SA
8311-

PROPAK SYSTEMS LTD POSTAL BAG # 2, AIRDRIE, ALBERTA, CANADA T4B 2C3				DISPLACEMENT PUMP			SHEET OF	
				FILE NO: 11.7.P		REQ.#		
CUSTOMER : APACHE CANADA LIMITED				REV	BY	DATE	REVISION DESCRIPTION	
PLANT : 1478HP HAMBURG COMPRESSOR PACKAGE				0	GWW	00.09.20	FOR PURCHASE	
SERVICE : ENGINE & COMPRESSOR LUBE OIL TRANSFER PUMP								
JOB NO. : 99420 TAG NO: P-260								
MFR. : WILDEN MODEL NO: T2/AAAB/BN/BN/ABN T2								
1	SERVICES : ENGINE LUBE OIL TRANSFER PUMP							
2								
3	NO OF PUMP REQD	1	NO OF DRIVER REQD	N/A		SUPPLIED BY	WAJAX PROCESS TECH.	
4	PUMP MFR	WILDEN	TYPE	DIAPHRAGM		MOUNTED BY	PROPAK	
5	DESIGN CONDITIONS					PERFORMANCE		
6	LIQUID	SAE 30W LUBE OIL				RATIO	1:1	
7	FLOW : MIN	CFD	N/A	SUCTION :	MIN	psig	MAXIMUM FLOW	gpm 35
8		NOR	CFD	N/A		NOR	AIR INLET	1/4" FNPT
9		MAX	CFD	N/A		MAX	FLUID INLET	1" FNPT
10	TEMP : MIN	° F	50	DISCHARGE :	MIN	psig	FLUID OUTLET	3/4" FNPT
11		NOR	° F	70		NOR	MAX OPERATING PRESSURE	125 psig
12		MAX	° F	200		MAX	SOLIDS MAX DIAMETER	1/8"
13	VISCOSITY: MIN	cP	2279	DIFF PRESS :	MIN	psig		
14		NOR	cP	767		NOR	WEIGHT	lb 26
15		MAX	cP	22		MAX	DISCH. PRESS. HEAD	psig 40
16	DENSITY : MIN	lb / cu. ft	55.8	VAPOR PRESS TEMP	° F		INLET GAS PRESSUR	psig 100
17		NOR	lb / cu. ft	55.4	VAPOR PRESS	psig	LIQUID FLOW	gpm 35
18		MAX	lb / cu. ft	52.7	NPSHA	in ATM	GAS CONSUMPTION	SCFM 13
19	CORROSION CAUSED BY			SOLIDS		NONE		
20								
21	CONSTRUCTION & MATERIALS							
22	CASING	ALUMINUM			WETTED PARTS		ALUMINUM	
23	GEAR / ROTOR				AIR CHAMBERS		ALUMINUM	
24	STATOR				CENTER SECTION		ALUMINUM	
25	WEAR PLATE				AIR VALVE		BRASS	
26	CONNECTION: GAS INLET	1/4" FNPT			DIAPHRAGMS		BUNA-N (RED DOT)	
27	CONNECTION: GAS OUTLET	1/2" FNPT			VALVE BALL		BUNA-N (RED DOT)	
28	CONNECTION: SUCTION	1" FNPT			VALVE SEAT		ALUMINUM	
29	DISCHARGE	3/4" FNPT			VALVE SEAT O-RING		BUNA-N (RED DOT)	
30								
31	DRIVER DETAILS (NOT APPLICABLE)							
32	DIRECT COUPLED				PUMP RPM		ELECTRIC MOTOR	
33	BELT DRIVE				ENCLOSURE		VOLTS/ PHASE/ CYCLES	
34	GEAR / GEAR MOTOR				MFR		FRAME	
35	VARIABLE SPEED				BEARING / LUBE		TYPE	
36	DRIVER RPM				INSULATION		FULL LOAD AMPS	
37	-POWER AT MAX RPM	Hp					LOCKED ROTOT AMP	
38	-POWER AT MIN RPM	Hp					TEMP RISE ° F	
39	BASE				DRIP RIM		COUPLING - MFR	
40	WEIGHT-PUMP & BASE	lb					- MODEL	
41	- DRIVE	lb						
42								
43								
44								
45								
46	MISC. INFORMATION							
47	SURFACE PREP	MFR. STD.	PAINT SPEC/ COLOR		MFR. SRD.			
48								
49								
50								
51								
52								
53								
54	REMARKS:							
55								

PROPAK SYSTEMS LTD POSTAL BAG # 2, AIRDRIE, ALBERTA, CANADA T4B 2C3				DISPLACEMENT PUMP			SHEET OF							
				FILE NO: 11.7.P			REQ.#							
CUSTOMER : APACHE CANADA LIMITED				REV	BY	DATE	REVISION DESCRIPTION							
PLANT : 1478HP HAMBURG COMPRESSOR PACKAGE				0	GWW	00.09.20	FOR PURCHASE							
SERVICE : ENGINE & COMPRESSOR LUBE OIL TRANSFER PUMP														
JOB NO. : 99420 TAG NO: P-270														
MFR. : WILDEN MODEL NO: T2/AAAB/BN/BN/ABN T2														
1 SERVICES : COMPRESSOR LUBE OIL TRANSFER PUMP														
2														
3 NO OF PUMP REQD			1		NO OF DRIVER REQD		N/A	SUPPLIED BY	WAJAX PROCESS TECH.					
4 PUMP MFR			WILDEN		TYPE		DIAPHRAGM	MOUNTED BY	PROPAK					
5 DESIGN CONDITIONS						PERFORMANCE								
6 LIQUID			SAE 30W LUBE OIL			RATIO		1:1						
7 FLOW : MIN			CFD		N/A		SUCTION : MIN	psig	MAXIMUM FLOW	gpm	35			
8			NOR		CFD		N/A		NOR	psig	AIR INLET	1/4" FNPT		
9			MAX		CFD		N/A		MAX	psig	FLUID INLET	1" FNPT		
10 TEMP : MIN			° F		50		DISCHARGE : MIN		psig	FLUID OUTLET	3/4" FNPT			
11			NOR		° F		70		NOR	psig	MAX OPERATING PRESSURE	125 psig		
12			MAX		° F		200		MAX	psig	SOLIDS MAX DIAMETER	1/8"		
13 VISCOSITY: MIN			cP		2279		DIFF PRESS : MIN		psig					
14			NOR		cP		767		NOR	psig	WEIGHT	lb	26	
15			MAX		cP		22		MAX	psig	DISCH. PRESS. HEAD	psig	40	
16 DENSITY : MIN			lb / cu. ft		55.8		VAPOR PRESS TEMP		° F	INLET GAS PRESSUR	psig	100		
17			NOR		lb / cu. ft		55.4		VAPOR PRESS	psig	LIQUID FLOW	gpm	35	
18			MAX		lb / cu. ft		52.7		NPSHA	in	ATM	GAS CONSUMPTION	SCFM	13
19 CORROSION CAUSED BY				SOLIDS				NONE						
20														
21 CONSTRUCTION & MATERIALS														
22 CASING			ALUMINUM			WETTED PARTS		ALUMINUM						
23 GEAR / ROTOR						AIR CHAMBERS		ALUMINUM						
24 STATOR						CENTER SECTION		ALUMINUM						
25 WEAR PLATE						AIR VALVE		BRASS						
26 CONNECTION: GAS INLET			1/4" FNPT			DIAPHRAGMS		BUNA-N (RED DOT)						
27 CONNECTION: GAS OUTLET			1/2" FNPT			VALVE BALL		BUNA-N (RED DOT)						
28 CONNECTION: SUCTION			1" FNPT			VALVE SEAT		ALUMINUM						
29 DISCHARGE			3/4" FNPT			VALVE SEAT O-RING		BUNA-N (RED DOT)						
30														
31 DRIVER DETAILS (NOT APPLICABLE)														
32 DIRECT COUPLED						PUMP RPM		ELECTRIC MOTOR						
33 BELT DRIVE						ENCLOSURE		VOLTS/ PHASE/ CYCLES						
34 GEAR / GEAR MOTOR						MFR		FRAME						
35 VARIABLE SPEED						BEARING / LUBE		TYPE						
36 DRIVER RPM						INSULATION		FULL LOAD AMPS						
37 -POWER AT MAX RPM			Hp				LOCKED ROTOT AMP							
38 -POWER AT MIN RPM			Hp				TEMP RISE ° F							
39 BASE						DRIP RIM		COUPLING - MFR						
40 WEIGHT-PUMP & BASE			lb				- MODEL							
41 - DRIVE			lb											
42														
43														
44														
45														
46 MISC. INFORMATION														
47 SURFACE PREP			MFR. STD.		PAINT SPEC/ COLOR		MFR. SRD.							
48														
49														
50														
51														
52														
53														
54 REMARKS:														
55														

P-260/270/276



Safety Supplement



WILDEN®

AIR OPERATED DOUBLE DIAPHRAGM PUMPS

A DOVER RESOURCES COMPANY



WILDEN PUMP & ENGINEERING CO.

Consignes de sécurité - Supplément à la notice de service

LIRE ATTENTIVEMENT CETTE NOTICE AVANT D'INSTALLER, D'UTILISER, OU DE REPARER LA POMPE.

Cette notice de sécurité s'applique à toutes les pompes WILDEN et comprend les instructions de sécurité pour mise en service, utilisation, installation et maintenance.

En complément à cette notice, de plus amples détails concernant l'installation, les opérations de maintenance et la recherche des pannes vous seront fournis dans la notice de service de la pompe concernée.

Dans cette notice, vous serez informés des dangers par les signes suivants:

 **ATTENTION** = Dangers ou pratiques dangereuses pouvant provoquer des lésions corporelles ou des dommages matériels.

ATTENTION

- A réception du matériel, vérifier l'état de l'emballage et faire éventuellement des réserves auprès du transporteur en cas de détérioration.
- Déballez la pompe et constatez son état. Vérifier sa conformité par rapport à la commande.
- Enlever les obturateurs de protection avant de raccorder la tuyauterie.
- Vérifier le serrage des vis et écrous. Resserrer aux couples préconisés si besoin.

• Certaines pompes Wilden peuvent être utilisées en immersion quand les colliers, la boulonnerie, le bloc central et le distributeur sont compatibles chimiquement.

L'échappement de la pompe doit être remonté à l'air libre au moyen d'un tube compatible avec le produit pompé et d'une section suffisante pour ne pas freiner la pompe.

- Les pompes alimentaires doivent être stérilisées avant usage.

ATTENTION

- Avant d'intervenir sur la pompe, couper l'air comprimé et l'alimentation électrique si elle est présente. Vidanger les tuyauteries avant de démonter les connexions aspiration et refoulement et, si nécessaire, rincer la pompe.
- Porter des lunettes de sécurité lorsque la pompe fonctionne et lors d'interventions. Si une membrane se perce, le fluide pompé peut être expulsé par l'échappement de la pompe.

ATTENTION

- La tuyauterie d'aspiration et de refoulement doit être prévue pour supporter la pression et la température de service et être compatible chimiquement avec le fluide pompé.

Le diamètre de la tuyauterie d'aspiration doit être au minimum égal à celui de la taille de la pompe, voire plus dans le cas de pompage de fluides visqueux. Le tuyau doit supporter la dépression importante de la pompe sans s'écraser. Prévoir un tuyau renforcé. La tuyauterie de refoulement doit être également au minimum du diamètre de sortie de la pompe. Une tuyauterie d'un diamètre plus important peut être indispensable dans le cas de longueurs importantes avec un fluide visqueux. Il ne doit pas y avoir de prises d'air et les raccordements doivent être réalisés dans les règles de l'art. La pompe ne doit en aucun cas supporter la tuyauterie. Le raccordement sera effectué sans contraintes mécaniques.

ATTENTION

- Ne pas dépasser 0.7 bar à l'aspiration de la pompe (0.5 bar pour les membranes PTFE). En dépassant cette limite, la durée de vie des membranes peut être fortement réduite et provoquer une fuite de produit à l'échappement de la pompe.

 **ATTENTION:** Ne dépasser en aucun cas 8.5 bars en alimentation d'air. La pompe M1 est limitée à 7.5 bars, et la pompe M8 haute pression à 5.5 bars.

1.0 Le mouvement alternatif de la pompe peut induire une certaine instabilité durant le fonctionnement. Les pieds doivent être correctement fixés sur un sol plat et de niveau.

1.1 Certaines pompes Wilden peuvent être utilisées en immersion quand les colliers, la boulonnerie, le bloc central et le distributeur sont compatibles chimiquement.

L'échappement de la pompe doit être remonté à l'air libre au moyen d'un tube compatible avec le produit pompé et d'une section suffisante pour ne pas freiner la pompe.

1.2 Ne pas dépasser la taille maximum de particule admissible pour chaque type de pompe. Consulter votre distributeur Wilden pour plus d'informations et utiliser une filtration adéquate.

1.3 Installation détaillée.

Les recommandations d'utilisations sont indiquées dans le chapitre 7 de votre notice de service.

 **ATTENTION: 1.4** S'assurer que les réservoirs sont équipés d'une mise à l'air avant de démarrer la pompe. Celle-ci peut engendrer une dépression importante qui risque de conduire à leur déformation.

SUPPLÉMENT À LA NOTICE DE SERVICE

ATTENTION: 1.5

Attention à l'électricité statique. Un incendie ou une explosion sont possibles surtout lorsque des liquides inflammables sont pompés. La pompe, la tuyauterie, les vannes, les réservoirs et tous les autres équipements doivent impérativement être raccordés à la masse.

ATTENTION: 1.6 TEMPÉRATURE DE SERVICE

Les matériaux de construction de la pompe ainsi que la tuyauterie d'aspiration et de refoulement doivent être prévus pour supporter la pression et la température de service et être compatible chimiquement avec le fluide pompé (à vérifier dans le guide Wilden E4).

ATTENTION: 1.7 BRUIT DE FONCTIONNEMENT

Les bruits d'échappement et de fonctionnement de la pompe peuvent dépasser 75 dba dans certaines conditions notamment lorsque la pression d'alimentation en air est importante et que la pression au refoulement est nulle. Réduire la pression d'air d'alimentation de la pompe. Canaliser l'échappement en dehors de la zone de travail.


ATTENTION: 1.8 FLUIDES POMPÉS DANGEREUX

- Les opérations de maintenance concernant la prévention des ruptures de membranes sont détaillées dans le chapitre 8 de la notice de service.
- Quand cela est possible, utiliser le système de détection de rupture Wil-Gard™ II (non ADF) qui détecte la présence du fluide entre la membrane PTFE et sa contre-membrane.
- Vérifier le serrage des colliers, vis et écrous. Resserrer aux couples préconisés dans la notice de service si besoin.
- L'utilisateur doit impérativement demander la fiche de sécurité du fluide pompé à son fabricant afin de vérifier les signes de sécurité.

1.9 COMPATIBILITÉ CHIMIQUE

 ATTENTION: a. Les matériaux de construction de la pompe doivent toujours être compatibles avec le fluide pompé. A vérifier dans le guide de résistance chimique Wilden (E4) ou demander un complément d'information à votre distributeur Wilden.

 ATTENTION: b. Explosion : certains fluides comme les solvants halogénés ou chlorés (trichloréthylène par ex.) ne doivent jamais être pompés avec une pompe en construction aluminium.

 ATTENTION: c. Vérifier les compatibilités chimiques dans le cas de variations de températures et/ou de concentrations. Dans le cas d'une rupture de membrane, l'air et huile du circuit de commande entrant en contact avec le fluide peuvent provoquer une explosion. Vérifier la compatibilité de l'air et de l'huile de lubrification ou utiliser une pompe à fonctionnement en air sec.

2.0 MODE OPÉRATEUR:

 ATTENTION: 2.1 S'assurer que le personnel utilisateur est suffisamment compétent et a bien subi une formation sur le matériel. Lire attentivement la notice de service et les consignes de sécurité avant la mise en service.

Limites de températures

Polypropylène	32°F to 175°F	0°C to 79°C
PVDF	10°F to 225°F	-12°C to 107°C
Acétal chargé carbone	-20°F to 150°F	-28.9°C to 65.6°C
Teflon® PFA	-20°F to 300°F	-28.9°C to 148.9°C
Neoprene	0°F to 200°F	-17.8°C to 93.3°C
Buna-N®	10°F to 180°F	-12.2°C to 82.2°C
NordeI®	-60°F to 280°F	-51.1°C to 137.8°C
Viton®	-40°F to 350°F	-40°C to 176.7°C
Wil-Flex™	-40°F to 225°F	-40°C to 107.2°C
Polyurethane	10°F to 150°F	12.2°C to 65.6°C
Saniflex™	-20°F to 220°F	-28.9°C to 104.4°C
Teflon® PTFE	40°F to 300°F	4.4°C to 148.9°C





WILDEN PUMP & ENGINEERING CO.

SICHERHEITS-BESTIMMUNGEN


Anhang zur Konstruktions-, Betriebs- und Wartungsanleitung

VOR INSTALLATION, INBETRIEISNAHME ODER WARTUNG IMMER ZUERST DIESES HANDBUCH LESEN!

Diese für alle Wilden-Pumpen geltenden Sicherheits-Bestimmungen enthält Anweisungen zum sicheren Einbauen, Betreiben und Warten Ihrer Pumpe.

Zusätzlich zu diesem Handbuch finden Sie ausführlichere Anweisungen zu Installation, Betrieb und Wartung sowie zur Fehlersuche in der zur jeweiligen Pumpe gehörenden Konstruktions-, Betriebs- und Wartungsanleitung.

In diesem Handbuch finden Sie Warnhinweise, die auf Gefahren aufmerksam machen. Diesen Warnhinweisen ist jeweils das folgende Symbol vorangestellt:

 **VORSICHT!** = Gefahren oder unsichere Vorgehensweisen, die schwere, wenn nicht tödliche Verletzungen oder beträchtliche Sach-/Vermögensschäden zur Folge haben können.

VORSICHT!

- Das erhaltene Pumpenmodell auf Übereinstimmung mit dem Auftrag bzw. Datenblatt prüfen.
- Alle Schrauben gemäß den Angaben in der Drehmomenttabelle nachziehen. Versandverschlüsse entfernen.
- Bei Pumpen, die getaucht werden sollen, müssen sowohl die benetzten als auch die nicht benetzten Teile mit dem zu pumpenden Produkt verträglich sein.
- Bei getauchten Pumpen muß ein Schlauch an den Entlüftungsanschluß der Pumpe angeschlossen werden, der oberhalb des Flüssigkeitsspiegels endet. Pumpen sind vor dem Einbau gründlich mit Wasser durchzuspülen.
- FDA-, USDA- und 3A-Pumpen sind vor Benutzung zu desinfizieren.

VORSICHT!

- Druckluftleitung vor dem Anschließen an die Pumpe 10 bis 20 Sekunden lang durchblasen, um sicherzugehen, daß sich keine Fremdkörper mehr in der Rohrleitung befinden.
- Immer Schutzbrille tragen, da bei einem Bruch der Membran die Prozeßflüssigkeit aus dem Entlüftungsanschluß herauspritzen kann.

 **VORSICHT!** Alle Saug- und Druckleitungen bzw. -rohre müssen so ausgelegt sein, daß sie dem Druck und der Temperatur der spezifischen Anwendung widerstehen können.


 **VORSICHT!** Am Saugstutzen der Pumpe sollte ein Druck von 0,7 bar (10 psig) nicht überschritten werden; andernfalls droht vorzeitiger Verschleiß und Ausfall von Teilen.

 **VORSICHT!** Der Druck der Druckluftzufuhr darf 8,5 bar (125 psi) nicht übersteigen (bei UL-geführten Modellen 50 psi).

- 1.0** Aufgrund der Hin- und Herbewegung der Pumpe können bei normalem Betrieb seitliche Schwankungen auftreten. Aus diesem Grund sollten Pumpen mit Füßen mit Hilfe von Bolzen auf Baustahl- bzw. Betonelementen befestigt werden.
- 1.1** Die meisten Wilden-Pumpen eignen sich für Tauchanwendungen nur dann, wenn sowohl ihre benetzten als auch ihre nicht benetzten Teile mit dem zu pumpenden Produkt verträglich sind. Bei für Tauchanwendungen vorgesehenen Pumpen muß ein Schlauch an den Entlüftungsanschluß der Pumpe angeschlossen werden, der oberhalb des Flüssigkeitsspiegels endet.
- 1.2** Jede Wilden-Pumpe läßt feste Partikel bis zu einem bestimmten maximalen Durchmesser passieren. Wenn die Möglichkeit besteht, daß feste Partikel mit größerem Durchmesser in die Pumpe gesaugt werden können, muß ein Sieb in die Saugleitung eingebaut werden, um eine Beschädigung der Pumpe und damit verbundene Gefahren für den Bediener zu vermeiden.

1.3 Installierungs-Anweisungen

Detaillierte Installierungs-Anweisungen finden Sie im Abschnitt 7 oder im Handbuch "Konstruktion, Betrieb und Wartung" für Ihre Pumpe.

 **VORSICHT! 1.4** Die richtige Belüftung von Tanks und Kesseln, aus denen Flüssigkeit abgesaugt wird, muß sicherstellt sein. Wegen der Fähigkeit der Pumpe, starken Unterdruck zu erzeugen, kann eine schlechte Belüftung dieser Versorgungstanks zu deren Implosion führen, wenn die Flüssigkeit ganz abgesaugt wird.

SICHERHEITS-BESTIMMUNGEN

VORSICHT! 1.5 ELEKTRISCHE GEFAHREN

Durch elektrostatische Aufladung kann Funkenbildung entstehen. Bei Förderung entzündlicher Flüssigkeiten kann dies zu Entzündungen bzw. Explosionen führen. Pumpen, Ventile, Behälter, u. anderes Zubehör muß geerdet werden.

VORSICHT! 1.6 TEMPERATURGEFAHREN

Die gepumpte Flüssigkeit muß laut der Wilden-Korrosionstabelle (E4) mit den Konstruktionswerkstoffen und Temperaturgrenzen der Pumpe verträglich sein.




VORSICHT! 1.7 DURCH LÄRM VERURSACHTE GEFAHREN

Der Geräuschpegel der Pumpe kann unter gewissen Betriebsbedingungen 75 Dexibel überschreiten, z. B. bei hoher Druckzuführung oder wenn das Abflußrohr sehr eng oder gar nicht vorhanden ist. Werden Pumpen über längere Zeit unter solchen Bedingungen betrieben, sind in der Nähe dieser Pumpen arbeitende Bediener gefährdet. Geeigneten Gehörschutz verwenden.

VORSICHT! 1.8 GEFAHRSTOFFE

- a. Instandhaltung entsprechend Punkt 8 Ihrer Betriebsanleitung verhindert Membranbruch.
- b. Mit Teflon® ausgerüstete Wilden-Pumpen sollten, wo möglich, mit dem Wil-Gard™ II Membranüberwachungssystem ausgestattet werden, das Membrandefekte erkennt, bevor gefahrenträchtige Prozeßflüssigkeit entweichen kann.
- c. **HINWEIS:** Sämtliche Befestigungsschrauben sind darauf zu prüfen, ob sie den in Abschnitt 8 der Konstruktions-, Betriebs- und Wartungsanleitung angegebenen Anzugsdrehmomenten entsprechend angezogen sind.
- d. Vom Chemikalien-Lieferanten ist für alle zu pumpenden Produkte ein Gefahrstoff-Datenblatt mit den entsprechenden Hinweisen für den Umgang mit diesen anzufordern.

1.9 CHEMISCHE VERTRÄGLICHKEIT

-  **VORSICHT!** a. Beim Spezifizieren einer Pumpe für eine bestimmte Anwendung ist darauf zu achten, daß benetzte Pumpenwerkstoffe und Elastomere mit der Prozeßflüssigkeit verträglich sind. Weitere Informationen entnehmen Sie bitte der Wilden-Korrosionstabelle (E4), oder Sie erhalten sie von Ihrem autorisierten Wilden-Händler.
-  **VORSICHT!** b. Explosive Reaktion: Bestimmte Stoffe wie halogenierte Kohlenwasserstoffe dürfen wegen möglicher explosiver Reaktionen nicht mit aus Aluminium bestehenden Pumpen gefördert werden.
-  **VORSICHT!** c. Die chemische Verträglichkeit bestimmter Werkstoffe einer Pumpenkonstruktion, insbesondere benetzte Kunststoffteile, kann bei veränderlicher Produktkonzentration und -temperatur schwanken. Weitere Informationen erhalten Sie von Ihrem autorisierten Wilden-Händler.

2.0 BEDIENUNG

-  **VORSICHT! 2.1** Bedienung der Pumpe nur durch geschultes u. eingewiesenes Personal unter Beachtung d. Sicherheitsbestimmungen, des Pumpenhandbuches u. der Betriebsanleitung.

Temperatur Grenzen

Polypropylene	32°F to 175°F	0°C to 79°C
PVDF	10°F to 225°F	-12°C to 107°C
Carbon-Filled		
Acetal	-20°F to 150°F	-28.9°C to 65.6°C
Teflon® PFA	-20°F to 300°F	-28.9°C to 148.9°C
Neoprene	0°F to 200°F	-17.8°C to 93.3°C
Buna-N®	10°F to 180°F	-12.2°C to 82.2°C
Nordel®	-60°F to 280°F	-51.1°C to 137.8°C
Viton®	-40°F to 350°F	-40°C to 176.7°C
Wil-Flex™	-40°F to 225°F	-40°C to 107.2°C
Polyurethane	10°F to 150°F	12.2°C to 65.6°C
Saniflex™	-20°F to 220°F	-28.9°C to 104.4°C
Teflon® PTFE	40°F to 300°F	4.4°C to 148.9°C





WILDEN PUMP & ENGINEERING CO.

MANUALE DI SICUREZZA


Supplemento del Engineering Operation and Maintenance Manual
(Manuale d'Uso e Manutenzione)

LEGGERE SEMPRE QUESTO MANUALE PRIMA DI INSTALLARE, AVVIARE O EFFETTUARE LA MANUTENZIONE.

Questo manuale di sicurezza si applica a tutte le pompe Wilden e comprende istruzioni per l'avviamento, l'uso, l'installazione e la manutenzione.

Oltre a questo manuale, istruzioni più dettagliate su installazione, esercizio, manutenzione e riparazione sono date nel manuale Engineering, Operation and Maintenance (Norme d'uso e Manutenzione) allegato ad ogni pompa.

In questo manuale sono descritti i probabili rischi da evitare. Questo tipo di informazione è preceduto dal seguente logo.

 **ATTENZIONE** = Rischi o manovre pericolose che potrebbero causare lesioni personali gravi, morte o considerevoli danni al prodotto o alle cose.

ATTENZIONE

- Controllare il modello della pompa ricevuta a fronte di un ordine o di una specifica.
- Serrare nuovamente i bulloni secondo le specifiche fornite dalla tabelle delle coppie.
- Rimuovere i tappi di plastica.
- Le pompe usate in applicazioni sommerse devono avere sia le parti a contatto del fluido che quelle a contatto con l'aria compatibili con il materiale pompato.
- Le pompe usate in applicazioni sommerse devono avere un flessibile collegato allo scarico dell'aria e l'aria di scarico conogliata sopra la superficie del liquido.
- Le pompe devono essere lavate con acqua prima di essere installate.
- Le pompe FDA, USDA e 3A devono essere sanitizzate prima dell'installazione.

ATTENZIONE

- Soffiare la tubazione dell'aria per 10-20 secondi prima di collegarla alla pompa per essere sicuri che siano eliminati eventuali detriti.
- Indossare sempre gli occhiali protettivi. In caso di rottura delle membrane possono verificarsi espulsioni del materiale pompato dallo scarico dell'aria.

 **ATTENZIONE:** Tutte le tubazioni ed i flessibili di aspirazione e di mandata dovranno essere calcolati per resistere alla pressione e alla temperatura richieste dall'applicazione in questione.


 **ATTENZIONE:** Non superare 0,7 barg di pressione del liquido all'aspirazione della pompa; questo potrebbe provocare la rottura prematura delle parti di usura.

 **ATTENZIONE:** Non superare 8,5 barg di pressione aria di alimentazione. I modelli approvati U.L. non devono superare 3,5 barg.

- 1.0** A causa dell'azione alternativa della pompa, fenomeni di spinta laterale possono verificarsi durante il normale funzionamento, pertanto le pompe dotate di piedini devono essere fissate a un piano di supporto in metallo.
- 1.1** La maggior parte delle pompe Wilden può essere usata in applicazioni sommerse solo quando tutte le parti che la compongono (a contatto e non a contatto del fluido) siano compatibili con il prodotto pompato.
- 1.2** Ogni pompa Wilden è caratterizzata da una dimensione massima di solidi pompabili. Quando esiste la possibilità che solidi più grandi possano essere aspirati dalla pompa, un filtro deve essere montato sulla tubazione di aspirazione per prevenire danni alla pompa e conseguenti rischi per l'operatore.

1.3 Istruzione Dettagliata

Consultare la sezione 7 del manuale d'uso e manutenzione della pompa.

 **ATTENZIONE: 1.4** Assicurarsi che i serbatoi contenenti il liquido da pompare siano adeguatamente areati. A causa dell'elevato grado di vuoto generato dalla pompa una areazione non adeguata di questi serbatoi può causare l'implosione quando venissero completamente svuotati.

⚠ ATTENZIONE: 1.5 RISCHI DA ELETTRICI

Prevenire la formazione di cariche elettrostatiche. Fiamme o esplosioni possono essere generate, specialmente in presenza di liquidi infiammabili. La pompa, e tubazioni, le valvole, i serbatoi e tutti gli altri componenti devono essere provvisti di una adeguata messa a terra.

⚠ ATTENZIONE: 1.6 RISCHI DI TEMPERATURA

I fluidi pompati devono essere compatibili con i materiali di costruzione della pompa ed i limiti di temperatura ammessi come riportato nella Tabella di compatibilità chimica della Wilden.

⚠ ATTENZIONE: 1.7 RISCHI DA ELEVATA RUMOROSITA'

La rumorosità della pompa può superare i 75 dba in alcune condizioni operative, come, per esempio quando l'alimentazione dell'aria è a pressione elevata e assenza o bassi valori di prevalenza in mandata. Lunghi periodi di funzionamento in tali condizioni possono creare pericolo per gli operatori vicini alla pompa. Usare adeguate protezioni dell'udito.

⚠ ATTENZIONE: 1.8 MATERIALI PERICOLOSI

- a. Le istruzioni indicate nella sezione 8 del manuale d'uso e manutenzione della pompa devono essere seguite per la rottura della membrana.
- b. Dove possibile, le pompe Wilden dovrebbero essere equipaggiate con il sistema di monitoraggio Wilden Wil-Gard II™, che rileva la rottura della membrana prima che il fluido pericoloso esca dalla pompa.
- c. **AVVISO:** Tutti gli elementi di serraggio devono essere controllati per assicurarsi che siano stati serrati con le coppie di serraggio specificate nella Sezione 8 del Engineering Operation and Maintenance Manual (Manuale d'Uso e Manutenzioni).
- d. L'utilizzatore dovrebbe ottenere dal fornitore le Norme di Sicurezza per tutti i materiali pompati con adeguate istruzioni sui modi di maneggiarli.

1.9 COMPATIBILITA' CHIMICA

⚠ ATTENZIONE:a. Quando si seleziona una pompa per una certa applicazione i materiali costruttivi a contatto con il fluido pompato e gli elastomeri devono essere chimicamente compatibili con esso. Consultare la Tabella di compatibilità chimica della Wilden o la Generalcontrol per maggiori dettagli.

⚠ ATTENZIONE:b. Reazione esplosiva: Alcuni materiali come i solventi alogenati non dovrebbero essere pompati con una pompa in alluminio perchè potrebbe verificarsi una reazione esplosiva.

⚠ ATTENZIONE:c. Per alcuni tipi di pompa, in particolare per quelle con le parti a contatto del fluido in plastica, la compatibilità chimica verso alcuni fluidi può variare cambiando la temperatura e la concentrazione del prodotto. Consultare la Generalcontrol, distributore autorizzato, per maggiori informazioni.

2.0 FUNZIONAMENTO

⚠ ATTENZIONE:2.1 Assicurarsi che tutti gli operatori siano adeguatamente istruiti e che si attengano scrupolosamente alle istruzioni di esercizio e manutenzione indicate in questo manuale di sicurezza, nella guida per l'utilizzatore e nel Manuale d'Uso e Manutenzione della pompa.

Limiti Di Temperatura

Polypropylene	32°F to 175°F	0°C to 79°C
PVDF	10°F to 225°F	-12°C to 107°C
Carbon-Filled		
Acetal	-20°F to 150°F	-28.9°C to 65.6°C
Teflon® PFA	-20°F to 300°F	-28.9°C to 148.9°C
Neoprene	0°F to 200°F	-17.8°C to 93.3°C
Buna-N®	10°F to 180°F	-12.2°C to 82.2°C
Nordel®	-60°F to 280°F	-51.1°C to 137.8°C
Viton®	-40°F to 350°F	-40°C to 176.7°C
Wil-Flex™	-40°F to 225°F	-40°C to 107.2°C
Polyurethane	10°F to 150°F	12.2°C to 65.6°C
Saniflex™	-20°F to 220°F	-28.9°C to 104.4°C
Teflon® PTFE	40°F to 300°F	4.4°C to 148.9°C





SUPLEMENTO DE SEGURANÇA WILDEN PUMP & ENGINEERING CO. MANUAL DE SEGURANÇA

Suplemento do manual de engenharia, operação e manutenção das bombas Wilden

POR FAVOR LEIA AS INSTRUÇÕES DESSE MANUAL ANTES DE INSTALAR, OPERAR E PARA REALIZAR MANUTENÇÃO NA SUA BOMBA WILDEN.

Esse manual de segurança abrange todas as bombas Wilden e a informação nele contido refere-se a segura instalação, uso e manutenção de sua bomba.

Adicional a este manual, informações e instruções mais detalhadas referente a instalação, operação e manutenção são encontradas na manual de Engenharia, Operação e Manutenção da bomba em questão.

O manual de segurança contém importante informação referente a possíveis problemas na área de segurança. Esse tipo de informação é procedido pelo seguinte sinal.

⚠ CAUTELA!!!! Uso indevido desse produto pode resultar em ferimentos graves ou morte, ou falha do produto, ou danos materiais e a propriedade.

⚠ CAUTELA!!

- Verifique o modelo da bomba e a sua nota fiscal ou tabela de especificações.
- Aperte todos as porcas para as especificações na tabela.
- Retire todos os plug.
- Bombas submergidas necessitam ter todas as partes (em contato com a solução e estéril) testadas para compatibilidade com solução em questão.
- Bombas submersas necessitam ter uma mangueira conectada na saída do escapamento para atmosfera.
- E aconselhável lavar as bombas antes de instala-las.
- Bombas com denominação FDA, USDA e 3A necessitam passar por um processo sanitário antes do uso.

⚠ CAUTELA!!

- Antes de conectar linha de ar, tenha certeza que linha esta desobstruída.
- Sempre use óculos de proteção quando operando as bombas. Caso ocorra fratura ou falha do diafragma, solução poderá escapar pela saída do escapamento.

⚠ CAUTELA!!

Certifique-se que as linhas de tubulação de entrada e saída, além das conexões sejam designadas a suportar as temperaturas e pressões em questão.

⚠ CAUTELA!!

Pressão na entrada do líquido não deve exceder 0.7 bar (10 psig).

⚠ CAUTELA!! Pressão na entrada do ar não deve exceder 8.5 bar (125 psig). Nas Bombas listadas UL, Pressão não deve exceder 50 psig.

1.0 Devido á acção recíproca da bomba, pode ter instabilidades laterais durante a operação normal. Por isso as bombas com patas devem ser sujeitas a estruturas metálicas ou concreto.

1.1 Quase todas as bombas Wilden podem ser submergidas, contanto que todos os materiais presentes na bomba sejam compatíveis quimicamente com a solução a ser bombeada. Bombas submersas precisam ter uma mangueira conectada na saída do escapamento para atmosfera.

1.2 Cada modelo das bombas Wilden tem a capacidade de bombear partículas sólidas. O uso de um crivo é recomendado quando houver a possibilidade de que partículas sólidas maiores que a capacidade da bomba para prevenir falha ou rompimento do diafragma e risco de acidentes com o operador.

1.3 Instruções De Instalação

Instruções detalhadas sobre a instalação são fornecidas na secção 7 do manual de engenharia, operação e manutenção.

⚠ CAUTELA!! 1.4 Certifique-se para que haja ventilação apropriada nos tanques que armazenam líquidos bombeados. Devido a alta capacidade de sucção da bomba, tanques que não são devidamente ventilados podem implodir quando bombeado.

⚠ CAUTELA!! 1.5

Prevenir a formação de eletricidade estática. Fogo ou explosão podem ocorrer especialmente na presença de líquidos inflamáveis. A bomba, as válvulas, e outros equipamentos devem ser aterrados.

⚠ CAUTELA!! 1.6 EFEITOS DA TEMPERATURA

Material bombeado deve ser compatível com material de construção da bomba e limites de temperatura – favor consultar Guia de resistência química da Wilden (E4).

⚠ CAUTELA!! 1.7 RISCOS NOCIVOS COM RELAÇÃO A POLUIÇÃO SONORA

O ruído da bomba pode ultrapassar 75 DBA Devido a certas condições de operação. Por exemplo: Alta pressão de entrada de ar e pouca contrapressão na descarga. Exposição durante elevados períodos pode ocasionar efeitos nocivos ao operador e/ou pessoas nas proximidades. Use devida proteção sonora.

⚠ CAUTELA!! 1.8 RISCOS COM RELAÇÃO A MATERIAIS

- Instruções na seção 8 do Manual de Uso, Manutenção e Operação devem ser seguidas para evitar falha prematura do diafragmas.
- Quando possível, bombas que usam elastômeros Teflon® devem disponer do sistema Wil-Gard™ Monitoramento de Diafragma, que ira detectar falha do diafragma antes do que o material escape pela saída de ar.
- AVISO:** Todos os parafusos e porcas devem ser checados para assegurar que os mesmos estão em conformidade com as especificações dadas na seção 8 do manual de Engenharia, Operacao e Manutenção.
- Usuário deve obter Planilha de Dados de Material e Segurança do fabricante de todos os materiais bombeados e como reagir em caso de emergência.

1.9 COMPATIBILIDADE QUÍMICA

- CAUTELA!!** a. Material de construção das bombas Wilden devem ser compatíveis com a solução a ser bombeada. Favor consultar o guia química (E4) ou o seu distribuidor local das bombas Wilden para maiores informações.
- CAUTELA!!** b. Reação Explosiva: Materiais como solventes não devem ser bombeadas usando bombas de alumínio devido ao alto risco de explosão.
- CAUTELA!!** c. Certos materiais podem sofrer ataque químico quando exposto a temperaturas e/ou mudança de concentração do liquido bombeado. Favor consultar o seu distribuidor local das bombas Wilden para maiores informações.

2.0 OPERAÇÃO

- CAUTELA!!** 2.1 Certifique-se que operadores são treinados quanto á operação e utilização das bombas Wilden. Favor observar cautela e práticas definidas nesse Manual de Segurança, no Manual do Usuário, e no Manual de uso, Manutenção e Operação.

Limites de Temperatura

Polipropileno	32°F to 175°F	0°C to 79°C
PVDF	10°F to 225°F	-12°C to 107°C
Acetal com recheio de carvão	-20°F to 150°F	-28.9°C to 65.6°C
Teflon® PFA	-20°F to 300°F	-28.9°C to 148.9°C
Neoprene	0°F to 200°F	-17.8°C to 93.3°C
Buna-N®	10°F to 180°F	-12.2°C to 82.2°C
Nordel®	-60°F to 280°F	-51.1°C to 137.8°C
Viton®	-40°F to 350°F	-40°C to 176.7°C
Wil-Flex™	-40°F to 225°F	-40°C to 107.2°C
Poliuretano	10°F to 150°F	12.2°C to 65.6°C
Saniflex™	-20°F to 220°F	-28.9°C to 104.4°C
Teflon® PTFE	40°F to 300°F	4.4°C to 148.9°C





VEILIGHEIDS SUPPLEMENT:

LEES DIT MANUAL VOORDAT U DE POMP INSTALLEERT, IN GEBRUIK NEEMT OF REPAREERT

Dit veiligheidsblad geldt voor alle WILDEN pompen en bevat instructies voor een veilige installatie, gebruik en onderhoud voor Uw WILDEN membraanpomp.

Behalve dit veiligheidsblad, vind U meer detail informatie in het Engineering, Operation and Maintenance (EOM) manual dat is meegeleverd met de pomp. Raadpleeg de installatie, gebruiksaanwijzingen en onderhoudsinstructie in het EOM manual.

In het EOM manual wordt u gewaarschuwd voor mogelijke gevaren. Hierbij treft u altijd het volgende symbool aan:

 **WAARSCHUWING** = Gevaarlijke of onveilige situatie die kan leiden tot ernstig letsel, de dood of ernstige materiaal schade.

WAARSCHUWING

- Controleer of u de juiste pomp heeft ontvangen.
- Trek alle bouten en moeren na, zoals aangegeven In het EOM manual onder 8E.
- Verwijder alle afdek pluggen.
- Pompen die u als onderwaterpomp gebruikt, moeten zowel aan de vloeistofzijde als aan de luchtzijde chemisch bestand zijn tegen het te verpompen medium.
- Pompen die u geheel onderdompelt moeten aan de luchtuitlaat worden voorzien van een lucht-afvoerslang om de uitlaat boven het peil te brengen van de vloeistof die moet worden verpompt.
- Spoel de pomp grondig met water voor ingebruikname
- FDA, USDA en 3A pompen moeten worden gereinigd voor ingebruikname.

WAARSCHUWING

- Laat de luchtleiding 10 tot 20 seconden door blazen, voordat u deze bevestigd aan de pomp. Dit om te zorgen dat alle vuil uit de luchtleiding is verdwenen.
- Draag altijd een veiligheidsbril als U de pomp bedient, als er een membraanbreuk optreed, kan de vloeistof die U verpompt uit de lucht-uitlaat komen..

 **WAARSCHUWING:** Alle zuigleidingen en persleidingen moeten geschikt zijn om de druk die ontstaat in Uw toepassingen te kunnen weerstaan.

 **WAARSCHUWING:** Zorg dat de vloeistof voordruk op de inlaat van de pomp nooit méér bedraagt dan 0,7 BAR. U voorkomt hiermee voortijdige slijtage van de elastomeren. hetgeen weer kan leiden het lekken van vloeistof door de lucht-uitlaat van de pomp.

 **WAARSCHUWING:** Maximale luchtdruk mag niet meer bedragen dan 8,5 BAR. (3,5 BAR bij UL-modellen en 5,5 BAR bij type HP250).

- 1.0** Door het bewegen van de membranen in de pomp is het mogelijk dat de pomp zich beweegt. Voor permanente installatie moet de pomp op een bevestigingsplaat worden gemonteerd. De bodem moet bij voorkeur vlak zijn.
- 1.1** De meeste WILDEN pompen kunt u gebruiken als onderwaterpomp, pompen die u geheel onderdompelt, moeten zowel aan de vloeistofzijde als aan de luchtzijde resistent zijn tegen het te verpompen product. Pompen die u geheel onderdompelt moeten aan de luchtuitlaat worden voorzien van een lucht-afvoerslang om de lucht uitlaat boven het peil te brengen van de vloeistof die moet worden verpompt.
- 1.2** Elke type WILDEN pomp heeft een specifieke vrije doorlaat. Om te voorkomen dat te grote vaste delen de werking van de pomp verstoren en persoonlijk letsel veroorzaken, is het wenselijk een filter in de zuigleiding te monteren.

1.3 Installatie Instructies

Gedetailleerde installatie instructies kunt U vinden in Section 7 van het bij de pomp behorende Engineering, Operation, and Maintenance manual.

 **WAARSCHUWING: 1.4** Het vacuum in de pomp kan leiden tot implosie van vaten en tanks bij het legen van deze vaten en tanks. Zorg altijd voor een goede ventilatie van vaten en tanks.

WAARSCHUWING: 1.5 ELECTRISCHE RISICO'S

Neem maatregelen om statische electriciteit te voorkomen. Voorkom explosies en brandgevaar. speciaal bij het verpompen van licht ontvlambare vloeistoffen. De pomp, het leidingnet, kleppen, containers en andere toegepaste materialen moeten op de juiste wijze worden geaard.

WAARSCHUWING: 1.6 TEMPERATUUR LIMieten

Het materiaal en de temperatuurlimieten van de pomp moeten geschikt zijn voor de vloeistoffen die worden verpompt. Raadpleeg hiervoor de Wilden Chemical Resistance Guide (E4) of neem contact op met Holland Air Pumps voor meer informatie.

WAARSCHUWING: 1.7 GELUIDSNIVEAU

Onder bepaalde omstandigheden kan het geluidsniveau van de pomp hoger zijn dan 75 dba. Dit komt voor bij een hoge inlaatluchtdruk en weinig of geen tegendruk. Langdurig werken in deze condities kunnen een gevaar opleveren voor Uw gehoor. Gebruik geschikte gehoorbescherming.

WAARSCHUWING: 1.8 GEVAARLIJKE VLOEISTOFFEN

- Onderhouds instructies in section twee van uw pomp Engineering, Operations and Maintenance Manual moeten worden opgevolgd om membraanbreuk te voorkomen.
- Het gebruik van een WIL-GARD™ II lekdetectie-systeem (bij TEFLON® membranen) geeft u een waarschuwingssignaal bij membraanbreuk. Hierdoor kunt u voorkomen dat de gevaarlijke vloeistoffen ongemerkt via de luchtuitlaat uit de pomp lekken en dat u in contact komt met deze vloeistof.
- LET OP:** Trek alle bouten en moeren na, zoals aangegeven in de tabel in het EOM manual section 8.
- Als u de pomp gebruikt voor het verpompen van gevaarlijke vloeistoffen dient u in het bezit te zijn van een materiaal veiligheids data sheet van de betreffende vloeistof.


1.9 CHEMISCHE RESISTENTIE

 **WAARSCHUWING: a.** Bij de selectie van een pomp voor een bepaalde toepassing, moet u er zeker van zijn dat de pompmaterialen die in contact komen met de vloeistof ook chemisch geschikt zijn voor deze vloeistoffen. Raadpleeg de Wilden Chemical Resistance Guide (E4) of neem contact op met Holland Air Pumps.

 **WAARSCHUWING: b.** Sommige vloeistoffen, zoals b.v. gehalogeneerde solvents kunnen, onder bepaalde omstandigheden, alu minium of galvaniseerde delen aantasten.

 **WAARSCHUWING: c.** De chemische resistentie van de materialen van uw WILDEN pomp, speciaal de kunststof uitvoeringen, kan zich veranderen indien de temperatuur en concentratie van de vloeistof die u verpompt zich wijzigt. Neem contact op met Holland Air Pumps voor meer informatie.

2.0 BEDIENING

 **WAARSCHUWING: 2.1** Zorg dat iedereen die de WILDEN pomp gebruikt op de hoogte is van de veiligheidsvoorschriften en gebruiksaanwijzingen zoals beschreven in deze handleiding en in dit veiligheidsblad, de pomp gebruikers gid en in uw pomp Engineering, Operation and Maintenance Manual. Gebruik oog- en oorbescherming als u de pomp bedient.

Temperatuur Limieten

Polypropylene	32°F to 175°F	0°C to 79°C
PVDF	10°F to 225°F	-12°C to 107°C
Carbon-Filled		
Acetal	-20°F to 150°F	-28.9°C to 65.6°C
Teflon® PFA	-20°F to 300°F	-28.9°C to 148.9°C
Neoprene	0°F to 200°F	-17.8°C to 93.3°C
Buna-N®	10°F to 180°F	-12.2°C to 82.2°C
Nordel®	-60°F to 280°F	-51.1°C to 137.8°C
Viton®	-40°F to 350°F	-40°C to 176.7°C
Wil-Flex™	-40°F to 225°F	-40°C to 107.2°C
Polyurethane	10°F to 150°F	12.2°C to 65.6°C
Saniflex™	-20°F to 220°F	-28.9°C to 104.4°C
Teflon® PTFE	40°F to 300°F	4.4°C to 148.9°C





SÄKERHETSILAGA

WILDEN PUMP & ENGINEERING CO.

SÄKERHETSHANDBOK

Tillägg till Teknik-, drifts- och underhållshandbok

Läs alltid denna handbok före montering, start eller underhåll.

Denna säkerhetshandbok gäller för samtliga pumpar från Wilden och innehåller anvisningar för säkert handhavande vid installation, användande och underhåll av din pump.

Dessutom finns ytterligare installationsanvisningar, förslag till drifts- och underhållsanvisningar samt felsökningsrutiner i Teknik-, drifts- och underhållsmanual för respektive pump.

I denna handbok förekommer varningar för övriga risker. Denna typ av anvisning föregås av nedanstående symbol.

 **VARNING** = Risker eller osäkra rutiner som kan leda till svår personskada, dödsfall eller till avsevärd skada på produkt eller egendom.

VARNING

- Kontrollera att mottagen pumpmodell överensstämmer med specifikation.
- Dra åt samtliga skruvar enligt specifikation i tabell för åtdragningsmoment.
- Ta bort alla transportsäkringar och pluggar.
- Materialet i såväl vätskeberörda delar som torra delar på dränkbara pumpar ska vara kompatibelt med den pumpade vätskan.
- Dränkbara pumpar ska vara försedda med luftslang vid pumpens luftutsläpp som ska leda utloppsluften över vätskenivån.
- Spola noggrant igenom pumpen med vatten före montering.
- FDA-, USDA- och 3A-godkända pumpar bör genomgå sanitär rengöring innan användande.

VARNING

- Blås igenom luftledning i 10-20 sekunder innan den monteras på pump för att kontrollera att ledningarna är fria från allt skräp.
- Bär alltid skyddsglasögon vid arbete med pump. Om ett membran brister kan den- pumpade vätskan tvingas ut genom luftutsläppet.

 **VARNING:** Alla inlopps- och utloppsrör/slangar ska vara konstruerade så att de kan tåla den aktuella tillämpningens tryck och temperatur.

 **VARNING:** Vätskans inloppstryck får inte överskrida 0,7 bar. Detta kan medföra förtida slitage och haveri.

 **VARNING:** Drivtrycket får inte överskrida 8,5 bar. För UL-klassade modeller bör drivtrycket inte överskrida 3,4 bar.

1.0 På grund av pumpens växelverkande arbetssätt kan sidoinstabilitet uppstå vid normal drift. Pumpar med fot skall därför bultas fast med gummifötter i stål- eller betongkonstruktion.

1.1 De flesta pumpar från Wilden kan nedsänkas i vätska om materialet i såväl vätskeberörda- som torra delar är kemiskt resistent mot den pumpade vätskan. Om pumpen ska nedsänkas i vätska bör en slang monteras på pumpens luftutsläpp och utloppsluften ledas över vätskenivån. Varje pump från Wilden klarar en viss partikelstorlek. Om det finns en risk för att större fasta partiklar kan sugas in i pumpen bör en sil eller ett grovfilter användas i sugledningen för att förhindra att skada uppstår på pumpen med medföljande risk för operatören.

1.3 Installationsanvisningar

Detaljerade anvisningar för installation återfinnes i avsnitt 7 i Teknik-, drifts- och underhållsmanualen (EOM) för respektive pump.

 **VARNING 1.4** Kontrollera att de tankar eller behållare som rymmer vätskelagret från vilken pumpen suger är väl ventilerade. På grund av pumpens starka förmåga att skapa vakuum kan otillräcklig ventilation av lagringstankar leda till implosion när en tank har tömts helt på vätska.

⚠️ **VARNING: 1.5 ELEKTRISKA FAROR**

Åtgärder för att förhindra uppkomst av gnistor från statisk uppladdning måste vidtagas. Vid pumpning kan brand eller explosion uppstå. Pumpen, rörledningar, ventiler, förvaringskärl eller annan utrustning måste jordanslutas.

⚠️ **VARNING 1.6 RISKER VID HÖG TEMPERATUR**

Vätskan som ska pumpas bör vara kompatibel med materialet som pumpen är tillverkad av samt angivna maxvärden för temperatur, se Wilden Chemical Resistance Guide (E4).

⚠️ **VARNING: 1.7 FAROR ORSAKADE AV BULLER**

Pumpens ljudnivå kan överskrida 75 dba under vissa driftsbetingelser så som vid högt drivtryck och litet eller inget mottryck av vätska på pumpens trycksida. Långa driftsperioder vid sådana förhållanden kan skapa risker för operatör som arbetar nära pumparna. Använd hörselskydd.

⚠️ **VARNING: 1.8 FARLIGA MATERIAL**

- Underhållsinstruktionerna i avsnitt åtta (8) i din Teknik- drifts- och underhållsmanual måste följas för att undvika mem branhaveri.
- Där det är möjligt bör Teflon® bestyckade pumpar från Wilden förses med Wil-Gard™ II membranövervakningssystem. Detta system upptäcker eventuellt membranbrotts innan vätskan tränger ut ur pumpen.
- OBS:** Alla bultar och skruvar bör kontrolleras så att de är dragna med angivet åtdragningsmoment innan start, se avsnitt 8 i Teknik-, drift- och underhållshandboken.
- Handhavaren bör införskaffa varuinformation från leverantören av vätskan som ska pumpas. Dessa innehåller erforderliga hanteringsanvisningar för respektive vätska.

1.9 KEMISK KOMPATIBILITET/RESISTENS

⚠️ **VARNING: a.** Vid val av pump för en speciell applikation, måste pumpens vätskeberörda delar och gummimaterial vara av sådant material att de är kompatibla med processvätskorna. Se Wilden Chemical Resistance Guide (E4), eller rådgör med din auktoriserade leverantör av Wildenprodukter.

⚠️ **VARNING: b.** Explosiv reaktion: Vissa vätskor, som t ex lösningsmedel med halogenkolväte bör inte pumpas med en pump som har vätskeberörda delar i aluminium på grund av risken för möjlig explosiv reaktion.

⚠️ **VARNING: c.** Vissa materials/vätskors kemiska kompatibilitet med en speciell pumpkonstruktion, speciellt med vätskeberörda delar i plast, kan förändras med variationer i vätskornas koncentration och temperatur. Rådgör med auktoriserad leverantör av Wildenprodukter.

2.0 DRIFT

⚠️ **VARNING: 2.1** Se till att samtliga operatörer har fått relevant utbildning och att de utövar ett säkert drift- och underhållshandhavande samt följer säkerhets- och underhållsrutinerna angivna i denna säkerhetsbilaga, användarhandboken och Teknik- drifts- och underhållsmanualen.

Temperaturbegränsningar

Polypropylene	32°F to 175°F	0°C to 79°C
PVDF	10°F to 225°F	-12°C to 107°C
Carbon-Filled		
Acetal	-20°F to 150°F	-28.9°C to 65.6°C
Teflon® PFA	-20°F to 300°F	-28.9°C to 148.9°C
Neoprene	0°F to 200°F	-17.8°C to 93.3°C
Buna-N®	10°F to 180°F	-12.2°C to 82.2°C
Nordel®	-60°F to 280°F	-51.1°C to 137.8°C
Viton®	-40°F to 350°F	-40°C to 176.7°C
Wil-Flex™	-40°F to 225°F	-40°C to 107.2°C
Polyurethane	10°F to 150°F	12.2°C to 65.6°C
Saniflex™	-20°F to 220°F	-28.9°C to 104.4°C
Teflon® PTFE	40°F to 300°F	4.4°C to 148.9°C





SIKKERHEDSSUPPLEMENT

WILDEN PUMP & ENGINEERING CO. SIKKERHEDSMANUAL

Supplement til Brugsanvisning

LÆS ALTID DENNE MANUAL FØR INSTALLATION, OPSTART ELLER VEDLIGEHOLDELSE.

Denne sikkerhedsmanual gælder for alle Wilden pumper og indeholder instruktioner i sikker installation, brug og vedligeholdelse af Deres pumpe.

For mere detaljerede instruktioner i installation, anbefalet drift, vedligeholdelse samt fejlfinding, se Brugsanvisningen for den pumpetype det drejer sig om.

I denne manual kan der være advarsler mod risici.

Foran denne type information vil følgende mærkat blive vist.


 **ADVARSEL** = Risici eller farlig fremgangsmåde som kan resultere i alvorlig personskade, død eller alvorlig beskadigelse af produkt eller ejendom.


ADVARSEL


- Check at modtaget pumpemodell svarer til ordren og specifikationen.
- Spænd alle bolte til specifikationerne i moment tabellen.
- Fjern forsendelsens blindpropper.
- På pumper som skal anvendes nedsænket i væske skal både væskeberørte og ikke-væskeberørte dele være kompatible med materialet der skal pumpes.
- Nedsænkede pumper skal have en slange tilsluttet til pumpens luftafgang og slangen føres op over væskenniveauet.
- Pumper bør skylles grundigt igennem med vand før installation.
- FDA, USDA OG 3A pumper bør steriliseres før brug.

ADVARSEL

- Blæs slanger igennem i 10-20 sekunder før de sættes på pumper for at sikre at alt løst materiale er fjernet.
- Brug altid sikkerhedsbriller. Ved membranbrud kan materialet der pumpes blive presset ud gennem luftafgangen.

 **ADVARSEL:** Alle indsugnings- og afgangsslanger skal være designet til at modstå tryk og temperatur for den specifikke applikation.

 **ADVARSEL:** Overstig ikke 0,7 bar (10 psig) væske indsugningstryk, da dette skaber slid og fejl.

 **ADVARSEL:** Overstig ikke 8,5 bar (125 psig) luftryk. UL-godkendte modeller bør ikke overstige 3,4 bar (50 psi) luftryk.

1.0 Grundet pumpens frem og tilbagegående bevægelse kan rystelser opstå under normal brug, derfor skal pumperne fast spændes. Pumper med fod bør derfor så vidt muligt boltes fast til overfladen.

1.1 De fleste Wilden pumper kan kun anvendes i neddykkede applikationer, når både væskeberørte og ikke-væskeberørte dele er kompatible med materialet der pumpes. Hvis pumpen skal anvendes neddykket, bør en slange tilsluttes pumpens luftafgang så afgangsluften føres over væskenniveauet.

1.2 Hver Wilden pumpe tillader en bestemt max. partikel størrelse. Ved enhver risiko for at større partikler kan blive suget ind i pumpen, bør et filter installeres på sugesiden for at undgå beskadigelse af pumpen og deraf følgende risiko for brugeren.

1.3 Instruktion til installation

Detalieret de Instruktioner til installation er i kapitel 7 i manualen.

 **ADVARSEL: 1.4** Sørg for ordentlig ventilation af tanke/beholdere som indeholder væsken. På grund af en pumpe høje suge evne kan dårlig ventilation af disse forsyningstanke føre til implosion (sammenklapning) af tanke når væsken er fuldstændig evakueret.

⚠ ADVARSEL: 1.5 ELEKTRISKE RISICI

Sørg for at forebygge statisk elektricitet. Brand eller eksplosion kan være resultatet, specielt ved håndtering af brændbare væsker. Pumpen, slangeføring, ventiler, beholdere eller andet apparatur skal jordes.

⚠ ADVARSEL: 1.6 TEMPERATUR RISICI

Materialet der pumpes skal være kompatibelt med pumpens konstruktionsmaterialer og angivne temperatur grænser som anført i Wilden Chemical Resistance Guide (E4).

⚠ ADVARSEL: 1.7 STØJGENERENDE RISICI

Pumpestøj kan overstige 75 dba under specielle forhold som f.eks. højt lufttryk og lavt modtryk. Længere tids drift under disse betingelser kan skabe en risiko for brugere, som arbejder i nærheden af pumperne. Brug af høreværn.

⚠ ADVARSEL: 1.8 FARLIGE MATERIALER

- Vedligeholdelsesanvisningerne i afsnit 8 i pumpens brugsanvisning skal følges for at forebygge membranbrud.
- Når det er muligt bør Wilden pumper med Teflon® forsynes med Will-Gard™ II lækage alarm, som opdager membranbrud før farligt materiale kommer ud af pumpen.
- BEMÆRK:** Alle spændbånd bør checkes for tilspænding ifølge moment specifikationerne anført i sektion 8 i Brugsanvisningen.
- Der bør anskaffes et materiale sikkerhedsdatablad for alle materialer der pumpes for korrekte håndteringsinstruktioner.

1.9 KEMISK KOMPATIBILITET

- ⚠ **ADVARSEL:** a. Når en pumpe specificeres til en bestemt applikation skal pumpens væskeberørte materialer og membran materialer være kompatible med procesvæsken. Se Wilden Chemical Resistance Guide (E4) eller kontakt Deres forhandler.
- ⚠ **ADVARSEL:** b. Eksplosiv reaktion: Visse materialer såsom halogeneret kulbrinte opløsningsmidler bør ikke pumpes med en aluminium pumpe på grund af en mulig eksplosiv reaktion.
- ⚠ **ADVARSEL:** c. Visse materialers kemiske kompatibilitet med en speciel pumpe konstruktion, specielt plastik væske berørte dele, kan ændre sig når materialekoncentration og temperatur varierer. Kontakt Deres lokale forhandler.

2.0 DRIFT

- ⚠ **ADVARSEL: 2.1** Sørg for at alle brugere er korrekt trænet i og anvender sikkerheds- og vedligeholdelsesanvisningerne anført i denne sikkerhedsmanual, Pump Users's Guide og pumpens brugsanvisning. Derudover bør sikkerhedsbriller og høreværn anvendes når det er nødvendigt.

Temperaturgrænser

Polypropylene	32°F to 175°F	0°C to 79°C
PVDF	10°F to 225°F	-12°C to 107°C
Carbon-Filled		
Acetal	-20°F to 150°F	-28.9°C to 65.6°C
Teflon® PFA	-20°F to 300°F	-28.9°C to 148.9°C
Neoprene	0°F to 200°F	-17.8°C to 93.3°C
Buna-N®	10°F to 180°F	-12.2°C to 82.2°C
Nordel®	-60°F to 280°F	-51.1°C to 137.8°C
Viton®	-40°F to 350°F	-40°C to 176.7°C
Wil-Flex™	-40°F to 225°F	-40°C to 107.2°C
Polyurethane	10°F to 150°F	12.2°C to 65.6°C
Saniflex™	-20°F to 220°F	-28.9°C to 104.4°C
Teflon® PTFE	40°F to 300°F	4.4°C to 148.9°C





WILDEN PUMP & ENGINEERING CO.

KÄYTTÖTURVALLISUUSTIEDOTE

Lue tämä turvallisuustiedote aina ennen pumpun asennusta, käyttöönottoa ja huoltoa. Tämä turvallisuustiedote koskee kaikkia WILDEN pumppumalleja ja sisältää ohjeet pumppunne turvallista asennusta, käyttöä ja huoltoa varten.

Yksityiskohtaisemmat ohjeet on annettu pumppumallikohtaisesti Käyttö ja Huolto käsikirjassa.

Käsikirjassa varoitetaan mahdollisista vaaratekijöistä. Vaaratekijöiden kohdalla tekstissä käytetään alla olevaa varoitusmerkkiä.

 **VAROITUS** = turvatoimien laiminlyönti voi aiheuttaa henkilövahinkoja, invalideettia, hengenmenon tai huomattavia tuote- tai omaisuusvahinkoja.

 **VAROITUS**

- Tarkista, että vastaanotettu pumppumalli vastaa tilattua tai spesifioitua pumppumallia.
- Kiristä kaikki pumpun pultit kiristysmomenttitaulukon mukaisesti.
- Poista pumpusta kuljetustulpat.
- Uppopumpun materiaalit, sekä neste että ilmaosat, on oltava materiaailtaan yhteen sopivat pumpattavan nesteen kanssa.
- Uppopumpun poistoilma on johdettava letkulla nestepinnan yläpuolelle.
- Pumput on huolella huuhdeltava vedellä ennen käyttöönottoa.
- FDA, USDA ja 3A luokitellut pumput on desinfioidava ennen käyttöönottoa.

 **VAROITUS**

- Puhalla paineilmalinjaa 10-20 sekuntia ennen pumpun liittämistä, näin varmistat ettei paineilmalinjassa ole epäpuhtauksia.
- Käytä aina suojalaseja pumppua käsitellessäsi.

Rikkoutunut kalvo voi aiheuttaa vuodon ja pumpattava neste voi roiskua poistoilman mukana ympäristöön.

 **VAROITUS:** Kaikki imu- ja poistoputket/letkut ja liittimet on mitoitettava riittävän kestäviksi käytetyn paineen ja lämpötilan suhteen.

 **VAROITUS:** Älä ylitä 0,7 bar nestepainetta pumpun imupuolella. Ylipaine voi aiheuttaa ennenaikaista kulumista ja osien vioittumista.

 **VAROITUS:** Älä ylitä 8,5 bar syöttöilmanpainetta. UL-luetteloitujen mallien syöttöilmanpaine ei saa ylittää 3,5 baria.


1.0 Pumpussa voi esiintyä normaalikäytössä sen edestakaisesta liikkeestä johtuvaa poikittaissuuntaista epuuvakaisuutta. Jalustalliset pumput on siksi kiinnitettävä pulteilla kiinteään teräs- tai betonirakenteeseen.

1.1 WILDEN pumppuja voidaan käyttää uppopumppuina ainoastaan jos sekä pumpun nesteosat että ilmaosat ovat yhteensopivat pumpattavan nesteen kanssa. Mikäli pumppua käytetään uppopumppuna on poistoilma johdettava letkulla nestepinnan yläpuolelle.

1.2 Jokaiselle WILDEN pumpulle on ilmoitettu suurin sallittu kiintoainekoko. Mikäli on mahdollista, että kiintoainekoko ylittää suurimman sallitun koon, on ennen pumppua asennettava imusuodin estämään pumpun rikkoutuminen ja käyttäjän vahingoittuminen.

1.3 Asennusohjeet

Pumppumallien yksityiskohtaiset asennusohjeet löytyvät valmistajan Engineering, Operation, and Maintenance Manual osasta 7.

 **VAROITUS: 1.4** Varmista että säiliössä, mistä neste pumpataan, on riittävän suuri korvausilma-aukko. Pumpun suuri imuteho voi aiheuttaa säiliön litistymisen, jollei korvausilman saanti ole riittävä.

⚠️•VAROITUS: 1.5 SÄHKÖTEKNISET VAARATEKIJÄT

Sähköstaattinen kipinäointi on estettävä. Muutoin seurauksena voi olla tulipalo tai räjähdys etenkin herkästi syttyviä nesteitä käsiteltäessä. Pumppu, putket, venttiilit, säiliöt ja muut varusteet on maadoitettava.

⚠️•VAROITUS: 1.6 LÄMPÖTILASTA JOHTUVAT VAARATEKIJÄT

Tarkista, että pumpattava neste on pumpun nesteosien materiaaleilta ja annetuilta lämpötilarajoiltaan yhteensopiva. Soveltuvuuden voi tarkistaa materiaalitaulukosta WILDEN CHEMICAL RESISTANCE GUIDE (E4).

⚠️•VAROITUS: 1.7 MELUSTA JOHTUVIA VAAROJA

Pumpun aiheuttama melu voi ylittää 75 dba joissakin käyttöolosuhteissa, esimerkiksi pumpun syöttöpaineen ollessa korkea tai antopaineen ollessa alhainen tai sen kokonaan puuttuessa.

⚠️•VAROITUS: 1.8 VAARALLISET NESTEET

- Pumpun rakenne-, käyttö- ja huolto-oppaan kahdeksannessa luvussa annettuja huolto-ohjeita on noudatettava, jotta vältetään kalvon vioittuminen.
- Mikäli mahdollista on Teflon®-kalvoja käyttävät pumput varustettava Wil-Gard™ kalvonvalvontajärjestelmällä. Tällöin kalvonrikkoutuminen havaitaan ennen kuin vaarallinen neste vuotaa pumpusta ulos.
- HUOM:** Tarkista, että kaikkien pulttien kiristysmomentit vastaavat käyttöohjetaulukon kiristysmomenttiarvoja.
- Oikeat nesteiden käsittelytiedot saadakse on pumppukäyttäjän hankittava jokaisen pumpattavan nesteen käyttöturvallisuustiedote nesteen toimittajalta.

1.9 KEMIALLINEN YHTEENSOPIVUUS

⚠️•VAROITUS: a. Määriteltäessä pumppua määrättyyn käyttötarkoitukseen on pumpun nesteosien materiaalien sekä kalvo- ja venttiilipallomateriaalien oltava yhteensopiva pumpattavan nesteen kanssa. Yhteensopivuus tarkistetaan materiaalitaulukosta WILDEN CHEMICAL RESISTANCE GUIDE (E4) tai valtuutetulta WILDEN edustajalta.

⚠️•VAROITUS: b. Räjähdys reaktio: Eräät materiaalit, kuten halogenoidut hiilivedyt, eivät sovellu pumpattaviksi alumiinirunkoisella pumpulla, koska ne voivat aiheuttaa räjähtävän kemiallisen reaktion.

⚠️•VAROITUS: c. Määrättyjen nesteiden kemiallinen yhteensopivuus pumpun nesteosien kanssa voi vaihdella nesteen väkevyyden ja lämpötilan mukaan. Tämä koskee erityisesti nestettä koskettavia pumpun muoviosia.

2.0 KÄYTTÖ

⚠️•VAROITUS: 2.1 On myös varmistauduttava siitä, että pumpun kaikki käyttäjät ovat saaneet asianmukaisen koulutuksen pumpun käyttöön ja että he noudattavat tässä turvaohjeessa, pumpun käyttöohjeessa sekä pumpun rakenne-, käyttö- ja huolto-oppaassa selostettua käyttö- ja huoltomenettelyä.

Lämpötilarajat

Polypropylene	32°F to 175°F	0°C to 79°C
PVDF	10°F to 225°F	-12°C to 107°C
Carbon-Filled		
Acetal	-20°F to 150°F	-28.9°C to 65.6°C
Teflon® PFA	-20°F to 300°F	-28.9°C to 148.9°C
Neoprene	0°F to 200°F	-17.8°C to 93.3°C
Buna-N®	10°F to 180°F	-12.2°C to 82.2°C
Nordel®	-60°F to 280°F	-51.1°C to 137.8°C
Viton®	-40°F to 350°F	-40°C to 176.7°C
Wil-Flex™	-40°F to 225°F	-40°C to 107.2°C
Polyurethane	10°F to 150°F	12.2°C to 65.6°C
Saniflex™	-20°F to 220°F	-28.9°C to 104.4°C
Teflon® PTFE	40°F to 300°F	4.4°C to 148.9°C





ΣΥΜΠΛΗΡΩΜΑ ΑΣΦΑΛΕΙΑΣ

WILDEN PUMP & ENGINEERING CO.
ΕΓΧΕΙΡΙΔΙΟ ΑΣΦΑΛΕΙΑΣ

Συμπλήρωμα στο εγχειρίδιο λειτουργίας, συντήρησης και τεχνικών οδηγιών

ΠΑΝΤΑ ΝΑ ΔΙΑΒΑΖΕΤΑΙ ΠΡΩΤΑ ΑΥΤΟ ΤΟ ΕΓΧΕΙΡΙΔΙΟ ΠΡΙΝ ΤΗΝ ΕΓΚΑΤΑΣΤΑΣΗ, ΤΗΝ ΕΚΚΙΝΗΣΗ Ή ΤΗΝ ΣΥΝΤΗΡΗΣΗ

Αυτό το εγχειρίδιο ασφαλείας έχει εφαρμογή σε όλες τις αντλίες WILDEN και περιλαμβάνει οδηγίες για την ασφαλή λειτουργία, χρήση και συντήρηση της αντλίας σας.

Επιπρόσθετα από αυτό το εγχειρίδιο, λεπτομερέστερες πληροφορίες, προτεινόμενες οδηγίες λειτουργίας και συντήρησης και οδηγός αντιμετώπισης προβλημάτων, δίδονται στο αντίστοιχο εγχειρίδιο τεχνικών οδηγιών, λειτουργίας και συντήρησης της αντλίας.

Σε αυτό το εγχειρίδιο μπορεί να προειδοποιηθείτε για διαφόρους κινδύνους. Αυτού του τύπου η προειδοποίηση σημαίνεται με το ακόλουθο σήμα.


 **ΠΡΟΣΟΧΗ** = Κίνδυνοι ή μη ασφαλείς πρακτικές που μπορεί να προκαλέσουν σοβαρό τραυματισμό, θάνατο ή σημαντικές υλικές ζημιές.

 **ΠΡΟΣΟΧΗ**

- Ελέγξτε τον τύπο της αντλίας που παραλάβατε σε σύγκριση με την παραγγελία σας.
- Σφίξτε ξανά όλες τις βίδες σύμφωνα με τις προδιαγραφές του πίνακα ροπών.
- Αφαιρέστε όλες τις τάπες της μεταφοράς.
- Οι αντλίες που θα λειτουργήσουν σαν υποβρύχιες πρέπει να έχουν και τα βρεχόμενα και τα μη βρεχόμενα μέρη συμβατά με το αντλούμενο υγρό.
- Οι αντλίες που λειτουργούν σαν υποβρύχιες πρέπει να έχουν στην εξαγωγή του αέρα προσαρμοσμένο σωλήνα ο οποίος να καταλήγει πάνω από την επιφάνεια του υγρού.
- Οι αντλίες πρέπει να ξεπλένονται καλά με νερό, πριν την εγκατάσταση.
- Οι αντλίες FDA, USDA και 3A, πρέπει να απολυμαίνονται πριν την χρήση τους.

 **ΠΡΟΣΟΧΗ**

- Ξεφουσίξτε την γραμμή του αέρα για 10-20 δευτερόλεπτα πριν να συνδέσετε την αντλία και βεβαιωθείτε ότι όλη η σωληνογραμμή είναι καθαρή από σκουπίδια.
- Πάντα να φοράτε γυαλιά ασφαλείας, όταν λειτουργεί η αντλία. Αν σπάσει κάποιο διάφραγμα, το αντλούμενο υγρό μπορεί να εκτιναχθεί από την εξαγωγή του αέρα.


 **ΠΡΟΣΟΧΗ:** Όλες οι σωληνογραμμές και τα εξαρτήματά τους πρέπει να σχεδιάζονται για να αντέχουν την πίεση και την θερμοκρασία των προδιαγραφών.

 **ΠΡΟΣΟΧΗ:** Να μην υπερβαίνετε τα 0.7 bar (10 psig) πίεση υγρού στην είσοδο της αντλίας. Διαφορετικά δημιουργείται κίνδυνος πρόωρης φθοράς της αντλίας.

 **ΠΡΟΣΟΧΗ:** Η πίεση του αέρα τροφοδοσίας να μην υπερβαίνει τα 8 bar (125 psig). Για τις αντλίες με προδιαγραφές UL η πίεση του αέρα να μην υπερβαίνει τα 50 psig.

- 1.0 Λόγω της παλινδρομικής λειτουργίας της αντλίας, μπορεί να συμβούν διάφορες αστάθειες κατά την κανονική λειτουργία της αντλίας. Πρέπει λοιπόν οι αντλίες που έχουν πόδια να βιδώνονται σε μεταλλική / τσιμενένια βάση.
- 1.1 Οι περισσότερες αντλίες WILDEN μπορούν να λειτουργήσουν σαν υποβρύχιες μόνο αν όλα τα μέρη τους είναι συμβατά με το αντλούμενο υγρό. Εάν η αντλία πρόκειται να εργασθεί σαν υποβρύχια, πρέπει να έχουν στην εξαγωγή του αέρα προσαρμοσμένο σωλήνα ο οποίος να καταλήγει πάνω από την επιφάνεια του υγρού.
- 1.2 Κάθε αντλία WILDEN, έχει ένα μέγιστο όριο διέλευσης στερεών. Όταν υπάρχει πιθανότητα να αναρροφηθούν στερεά μεγαλύτερας διαμέτρου, θα πρέπει να τοποθετείται ένα φίλτρο στη γραμμή αναρρόφησης ώστε να εμποδίζεται η πρόκληση βλάβης στην αντλία και τυχόν κίνδυνοι στον χειριστή της.
- 1.3 Οδηγίες εγκατάστασης

α. Λεπτομερείς οδηγίες εγκατάστασης δίνονται στο Τμήμα 7 του εγχειρίδιου γιγουργίας και συντήρησης της αντλίας.

 **ΠΡΟΣΟΧΗ:** 1.4 Εξασφαλίστε καλό εξαερισμό τυχόν δοχείων από τα οποία γίνεται η άντληση του υγρού. Λόγω της μεγάλης αναρροφητικής ικανότητας της αντλίας, μπορεί τα δοχεία να ετραγού εάν δεν διαθέτουν επαρκή εξαερισμό.

⚠️ ΠΡΟΣΟΧΗ: 1.5 ΗΛΕΚΤΡΙΚΟΙ ΚΙΝΔΥΝΟΙ

Πάρτε μέτρα αποτροπής στατικού ηλεκτρισμού. Μπορεί να προξενηθεί σπινθήρας, ειδικά όταν διακινούνται εύφλεκτα υγρα. Η αντλία, οι σωλήνες, οι βάνες, οι σεξαμενές ή τυχόν άλλα υλικά πρέπει να είναι γειωμένα.

⚠️ ΠΡΟΣΟΧΗ: 1.6 ΚΙΝΔΥΝΟΙ ΘΕΡΜΟΚΡΑΣΙΑΣ

Τα αντλούμενο υλικό πρέπει να είναι συμβατό με τα υλικά κατασκευής της αντλίας και τα συγκεκριμένα όρια θερμοκρασίας αυτών, όπως αυτά εκθέτονται στον Οδηγό Χημικής Ανθεκτικότητας της WILDEN (E4).

⚠️ ΠΡΟΣΟΧΗ: 1.7 ΚΙΝΔΥΝΟΙ ΠΑΡΑΓΟΜΕΝΟΙ ΑΠΟ ΘΟΥΡΥΒΟ

α. Ο θόρυβος της αντλίας μπορεί να ξεπεράσει τα 75 dba σε ορισμένες λειτουργίες, όπως πχ. σε περίπτωση τροφοδοσίας με αέρα υψηλής πίεσης ή σε λειτουργία σε μικρό ή σε μηδενικό μανομετρικό.

Παρατεταμένη περίοδος λειτουργίας κάτω από τέτοιες καταστάσεις μπορεί να δημιουργήσει κινδύνους στο χειριστή κοντά στην αντλία. Χρησιμοποιήστε κατάλληλες συσκευές προστασίας της ακοής.

⚠️ ΠΡΟΣΟΧΗ: 1.8 ΕΠΙΚΙΝΔΥΝΑ ΥΛΙΚΑ

- Οι οδηγίες συντήρησης στο τμήμα 8 του μηχανολογικού εγχειριδίου λειτουργίας και συντήρησης πρέπει να ακολουθούνται για την αποφυγή καταστροφής των διαφραγμάτων.
- Όπου είναι δυνατόν οι αντλίες WILDEN με Teflon® θα πρέπει να εφοδιάζονται με το WIL-GARD™ II Σύστημα Ελέγχου Διαρροών Διαφραγμάτων το οποίο ανιχνεύει διαρροή του διαφράγματος πριν επικίνδυνα υλικά εξαχθούν από την αντλία.
- ΠΑΡΑΤΗΡΗΣΗ: Όλοι οι σφικτήρες και οι βίδες πρέπει να ελεγχθούν ώστε να ταιριάζουν με τις προδιαγραφές ροπών σύσφιξης που αναφέρονται στο κεφάλαιο 8 του εγχειριδίου τεχνικών οδηγιών, λειτουργίας και συντήρησης της αντλίας.
- Ο χειριστής θα πρέπει να αποκτήσει το Έντυπο Στοιχείων Ασφαλείας Υλικών από τον προμηθευτή για όλα τα αντλούμενα υλικά με οδηγίες σωστής χρήσης.

1.9 ΧΗΜΙΚΗ ΣΥΜΒΑΤΟΤΗΤΑ

⚠️ ΠΡΟΣΟΧΗ: α. Όταν προδιαγράφετε αντλία για συγκεκριμένη εφαρμογή, τα βρεχόμενα υλικά κατασκευής της αντλίας και τα ελαστομερή υλικά πρέπει να είναι συμβατά με το υγρό.

Παρακαλούμε συμβουλευτείτε τον οδηγό Χημικής Ανθεκτικότητας της WILDEN (E4) ή τον τοπικό εξουσιοδοτημένο αντιπρόσωπο της WILDEN για περισσότερες πληροφορίες.

⚠️ ΠΡΟΣΟΧΗ: β. Εκρηκτική αντίδραση : Μερικά υλικά όπως διαλύτες αλογονωμένων υδρογονανθράκων δεν πρέπει να αντλούνται με αντλία κατασκευασμένη από αλουμίνιο εξαιτίας πιθανής εκρηκτικής αντίδρασης.

⚠️ ΠΡΟΣΟΧΗ: γ. Η χημική συμβατικότητα ορισμένων υλικών με συγκεκριμένης κατασκευής αντλία, ειδικότερα με πλαστικά βρεχόμενα μέρη, πιθανότατα να αλλάξουν καθώς η συγκέντρωση υλικού και η θερμοκρασία ποικίλουν. Παρακαλούμε συμβουλευτείτε τον τοπικό εξουσιοδοτημένο αντιπρόσωπο της WILDEN για περισσότερες πληροφορίες.

2.0 ΛΕΙΤΟΥΡΓΙΑ

⚠️ ΠΡΟΣΟΧΗ : 2.1 Βεβαιωθείτε ότι όλοι οι χειριστές είναι επαρκώς εκπαιδευμένοι και χρησιμοποιούν τις ασφαλείς πρακτικές λειτουργίας και συντήρησης που περιγράφονται στο εγχειρίδιο ασφαλείας, στον οδηγό χρήστη και στο μηχανολογικό εγχειρίδιο λειτουργίας και συντήρησης.

Όρια θερμοκρασίας

Polypropylene	32°F to 175°F	0°C to 79°C
PVDF	10°F to 225°F	-12°C to 107°C
Carbon-Filled		
Acetal	-20°F to 150°F	-28.9°C to 65.6°C
Teflon® PFA	-20°F to 300°F	-28.9°C to 148.9°C
Neoprene	0°F to 200°F	-17.8°C to 93.3°C
Buna-N®	10°F to 180°F	-12.2°C to 82.2°C
Nordel®	-60°F to 280°F	-51.1°C to 137.8°C
Viton®	-40°F to 350°F	-40°C to 176.7°C
Wil-Flex™	-40°F to 225°F	-40°C to 107.2°C
Polyurethane	10°F to 150°F	12.2°C to 65.6°C
Saniflex™	-20°F to 220°F	-28.9°C to 104.4°C
Teflon® PTFE	40°F to 300°F	4.4°C to 148.9°C



EC Declaration of Conformity

Manufacturer Name: Wilden Pump and Engineering Company
Manufacturer Address: 22069 Van Buren Street
Grand Terrace, California 92313-5607 U.S.A.
Tel. (909) 422-1730 Fax (909) 783-3440
www.wildenpump.com

Declare that the machinery described below complies with the relevant essential health and safety requirements of Part 1 of Annex I of the Machinery Directive 98/37/EC.

Description: Wilden Air Operated Double Diaphragm Pump
Model Number:
Size:
Serial Number:

The following standards have either been referred to or been complied with in part or in full as relevant:

EN 60529	Machinery Safety -	Ingress Protection
EN 1299	Machinery Safety -	Mechanical vibration and shock – Vibration isolation of machines – Information for the application of source isolation.
EN 60947	Low Voltage Safety -	Specification for low voltage switchgear and control gear.
EN 954-1	Safety of Machinery -	Safety Related Parts of Control Systems – Part 1: General Principles for Design.
EN 418	Safety of Machinery -	Emergency stop equipment – principles for design.
EN 60204-1	Safety of Machinery-	Electrical equipment of machines.

Full Name of responsible person:

John D. Allen **Position** President / COO
Signature  **Date** November 16, 1999

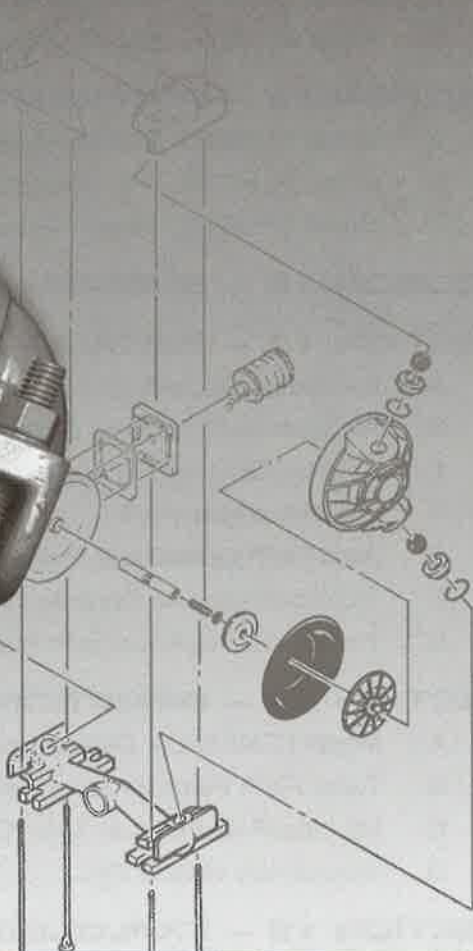
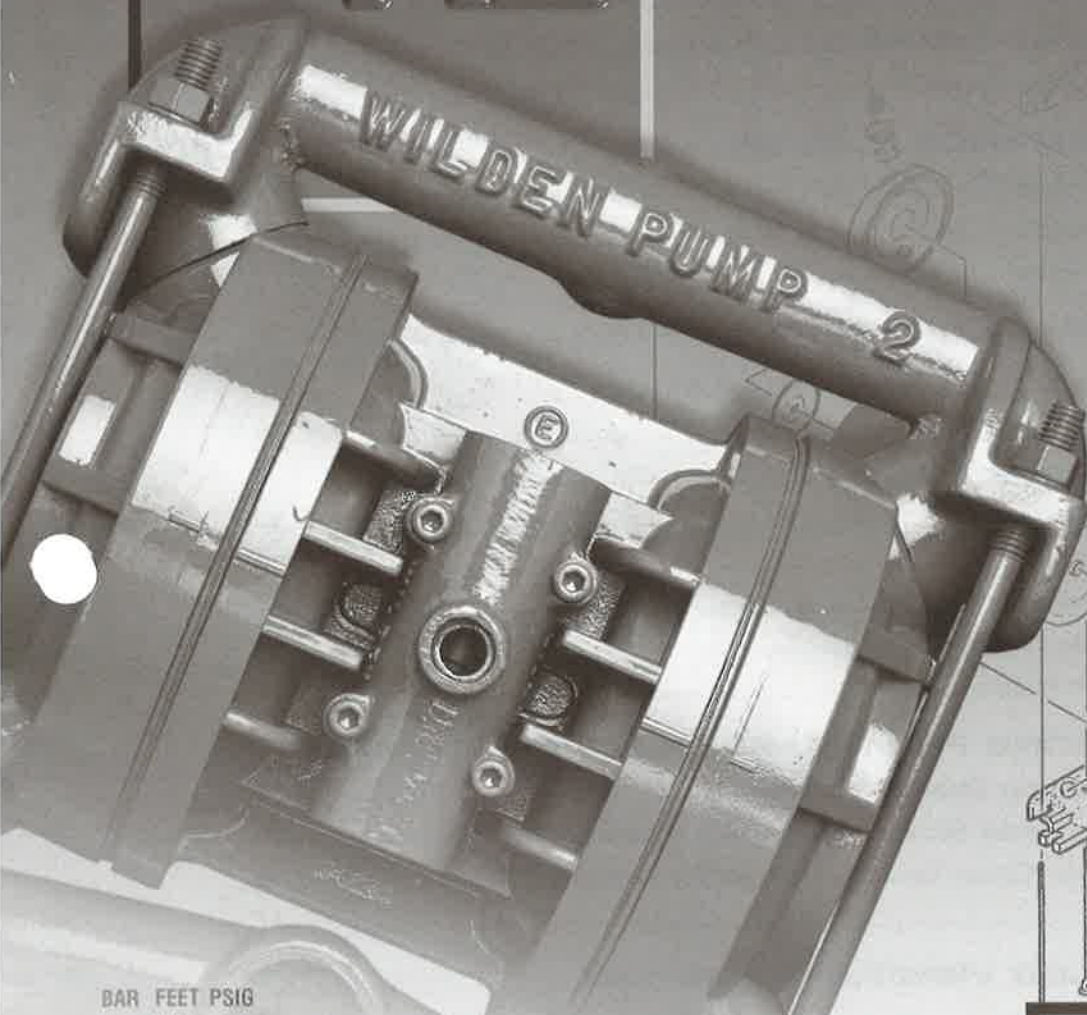
Full Name of Authorized European Representative:

..... (Typed) **Position** (Typed)
Signature **Date**
Address **Phone**
.....

P-260/270/276

T2
A2

Engineering Operation & Maintenance



BAR FEET PSIG



AIR CONSUMPTION
(SCFM) [Nm³/h]



WILDEN®

AIR OPERATED DOUBLE DIAPHRAGM PUMPS

A DOVER RESOURCES COMPANY

5 10 15 20 25 30 35
[14.3] [28.6] [42.9] [57.2] [71.5] [85.8] [100.1] [114.4]

TURBOFLO™
PROGRESSIVE PUMP TECHNOLOGY

ACCUFLO™
SOLENOID PUMP TECHNOLOGY

Metal Pumps

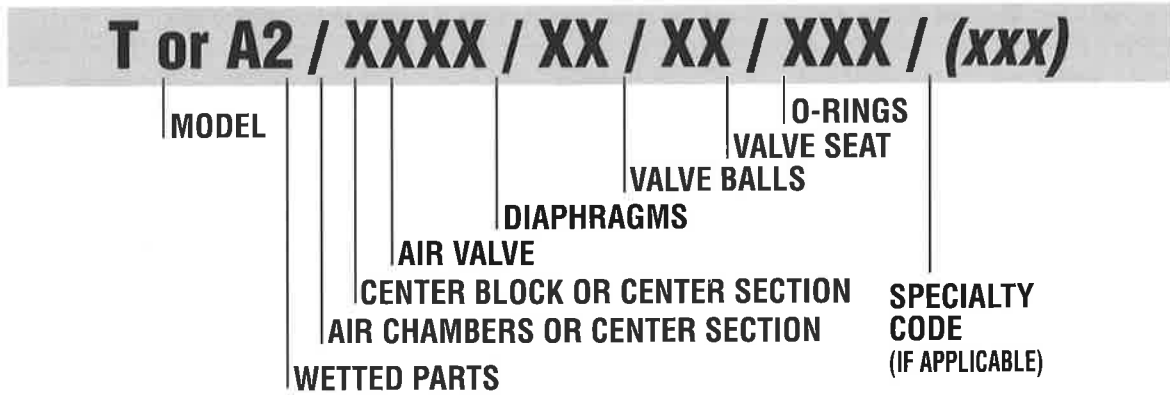
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SECTION 1

WILDEN PUMP DESIGNATION SYSTEM



In the case where a center section is used instead of a center block and air chambers, the designation will be as follows: Aluminum = AA, Teflon®-Coated = CC, Nickel-Plated = NN, Polypropylene = PP

MODEL T2 OR A2 METAL MATERIAL CODES

WETTED PARTS

A = ALUMINUM
H = HASTELLOY
S = STAINLESS STEEL

AIR CHAMBERS

A = ALUMINUM
C = TEFLON®-COATED
N = NICKEL-PLATED
P = POLYPROPYLENE

CENTER SECTION

A = ALUMINUM
C = TEFLON®-COATED
N = NICKEL-PLATED
P = POLYPROPYLENE

AIR VALVE

A = ALUMINUM
(ACCU-FLO™ PUMPS ONLY)
B = BRASS
C = TEFLON®-COATED
N = NICKEL-PLATED
Z = ISOPLAST (LUBE FREE)

DIAPHRAGMS

BN = BUNA-N® (Red Dot)
FG = SANIFLEX™
ND = NORDEL®
NE = NEOPRENE
PU = POLYURETHANE
TF = TEFLON® PTFE
VT = VITON®
WF = WIL-FLEX™ (Orange)

VALVE BALL

BN = BUNA-N® (Red Dot)
FG = SANIFLEX™
FV = FOOD GRADE VITON®
ND = NORDEL
NE = NEOPRENE
PU = POLYURETHANE
SS = STAINLESS STEEL
TF = TEFLON® PTFE (White)
VT = VITON® (Silver or White Dot)
WF = WIL-FLEX™ (Orange)

VALVE SEAT

A = ALUMINUM
H = HASTELLOY
K = KYNAR/PVDF
P = POLYPROPYLENE
S = STAINLESS STEEL

VALVE SEAT O-RING

BN = BUNA-N® (Red Dot)
FG = SANIFLEX™
ND = NORDEL
PU = POLYURETHANE
TF = TEFLON® PTFE
WF = WIL-FLEX™

NOTE: ELASTOMERIC MATERIALS USE COLORED DOTS FOR IDENTIFICATION.

SECTION 2

THE WILDEN PUMP — HOW IT WORKS

The Wilden diaphragm pump is an air-operated, positive displacement, self-priming pump. These drawings show the flow pattern through the pump upon its initial stroke. It is assumed the pump has no fluid in it prior to its initial stroke.

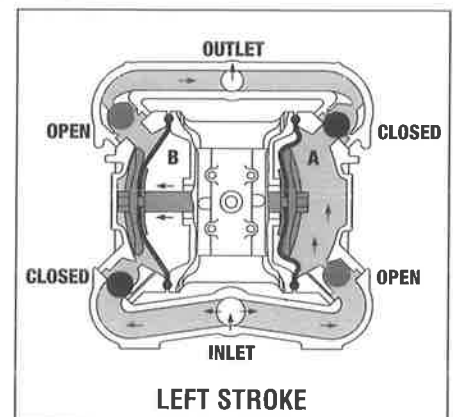
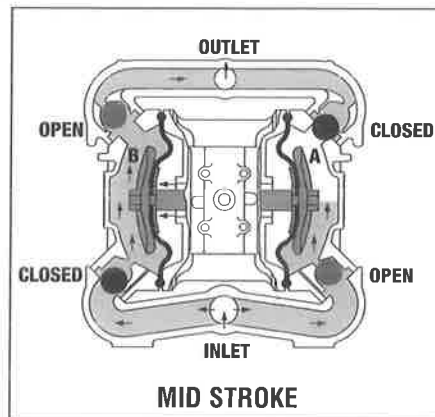
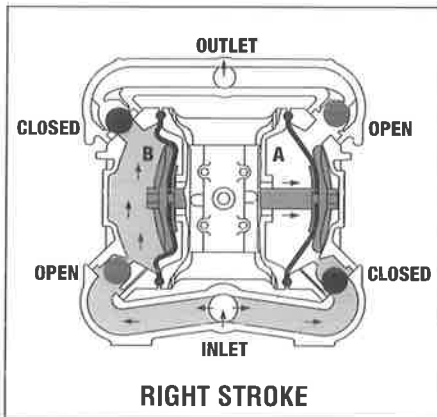


FIGURE 1 The air valve directs pressurized air to the back side of diaphragm A. The compressed air is applied directly to the liquid column separated by elastomeric diaphragms. The diaphragm acts as a separation membrane between the compressed air and liquid, balancing the load and removing mechanical stress from the diaphragm. The compressed air moves the diaphragm away from the center block of the pump. The opposite diaphragm is pulled in by the shaft connected to the pressurized diaphragm. Diaphragm B is on its suction stroke; air behind the diaphragm has been forced out to the atmosphere through the exhaust port of the pump. The movement of diaphragm B toward the center block of the pump creates a vacuum within chamber B. Atmospheric pressure forces fluid into the inlet manifold forcing the inlet valve ball off its seat. Liquid is free to move past the inlet valve ball and fill the liquid chamber (see shaded area).

FIGURE 2 When the pressurized diaphragm, diaphragm A, reaches the limit of its discharge stroke, the air valve redirects pressurized air to the back side of diaphragm B. The pressurized air forces diaphragm B away from the center block while pulling diaphragm A to the center block. Diaphragm B is now on its discharge stroke. Diaphragm B forces the inlet valve ball onto its seat due to the hydraulic forces developed in the liquid chamber and manifold of the pump. These same hydraulic forces lift the discharge valve ball off its seat, while the opposite discharge valve ball is forced onto its seat, forcing fluid to flow through the pump discharge. The movement of diaphragm A toward the center block of the pump creates a vacuum within liquid chamber A. Atmospheric pressure forces fluid into the inlet manifold of the pump. The inlet valve ball is forced off its seat allowing the fluid being pumped to fill the liquid chamber.

FIGURE 3 At completion of the stroke, the air valve again redirects air to the back side of diaphragm A, which starts diaphragm B on its exhaust stroke. As the pump reaches its original starting point, each diaphragm has gone through one exhaust and one discharge stroke. This constitutes one complete pumping cycle. The pump may take several cycles to completely prime depending on the conditions of the application.

SECTION 3

WILDEN MODEL T2 METAL CAUTIONS – READ FIRST!



TEMPERATURE LIMITS:

Polypropylene	+32°F to 175°F	0°C to 79°C
Neoprene	0°F to 200°F	-17.8°C to 93.3°C
Buna-N®	+10°F to +180°F	-12.2°C to 82.2°C
Nordel®	-60°F to 280°F	-51.1°C to 137.8°C
Viton®	-40°F to +350°F	-40°C to 176.7°C
Wil-Flex™	-40°F to +225°F	-40°C to 107.2°C
Polyurethane	10°F to 150°F	12.2°C to 65.6°C
Saniflex™	-20°F to 220°F	-28.9°C to 104.4°C
Teflon® PTFE	+40°F to +300°F	+4.4°C to 148.9°C



CAUTION: When choosing pump materials, be sure to check the temperature limits for all wetted components. Example: Viton® has a maximum limit of 350°F (176.7°C) but polypropylene has a maximum limit of only 175°F (79°C).



CAUTION: Maximum temperature limits are based upon mechanical stress only. Certain chemicals will significantly reduce maximum safe operating temperatures. Consult engineering guide for chemical compatibility and temperature limits.



CAUTION: Always wear safety glasses when operating pump. If diaphragm rupture occurs, material being pumped may be forced out air exhaust.



WARNING: Prevention of static sparking — If static sparking occurs, fire or explosion could result. Pump, valves, and containers must be properly grounded when handling flammable fluids and whenever discharge of static electricity is a hazard.



CAUTION: Do not exceed 125 psig (8.6 Bar) air supply pressure. (50 psig [3.4 Bar] for UL models.)



CAUTION: Before any maintenance or repair is attempted, the compressed air line to the pump should be disconnected and all air pressure allowed to bleed from pump. Disconnect all intake, discharge and air lines. Drain the pump by turning it upside down and allowing any fluid to flow into a suitable container.



CAUTION: Blow out air line for 10 to 20 seconds before attaching to pump to make sure all pipe line debris is clear. Use an in-line air filter. A 5µ (micron) air filter is recommended.



NOTE: Tighten clamp bands and retainers prior to installation. Fittings may loosen during transportation.



NOTE: When installing Teflon® diaphragms, it is important to tighten outer pistons simultaneously (turning in opposite directions) to ensure tight fit.



NOTE: Before starting disassembly, mark a line from each liquid chamber to its corresponding air chamber. This line will assist in proper alignment during reassembly.



CAUTION: Verify the chemical compatibility of the process and cleaning fluid to the pump's component materials in the Chemical Resistance Guide (see RBG E4).



CAUTION: When removing the end cap using compressed air, the air valve end cap may come out with considerable force. Hand protection such as a padded glove or rag should be used to capture the end cap.



CAUTION: Only explosion proof (NEMA 7) solenoid valves should be used in areas where explosion proof equipment is required.



NOTE: All non lube-free air-operated pumps must be lubricated. Wilden suggests an arctic 5 weight oil (ISO grade 15). Do not over-lubricate pump. Over-lubrication will reduce pump performance.



NOTE: UL-listed pumps must not exceed 50 psig (3.4 Bar) air supply pressure.



CAUTION: Do not lubricate lube-free pumps.

SECTION 4A

DIMENSIONAL DRAWING

WILDEN MODEL T2 METAL

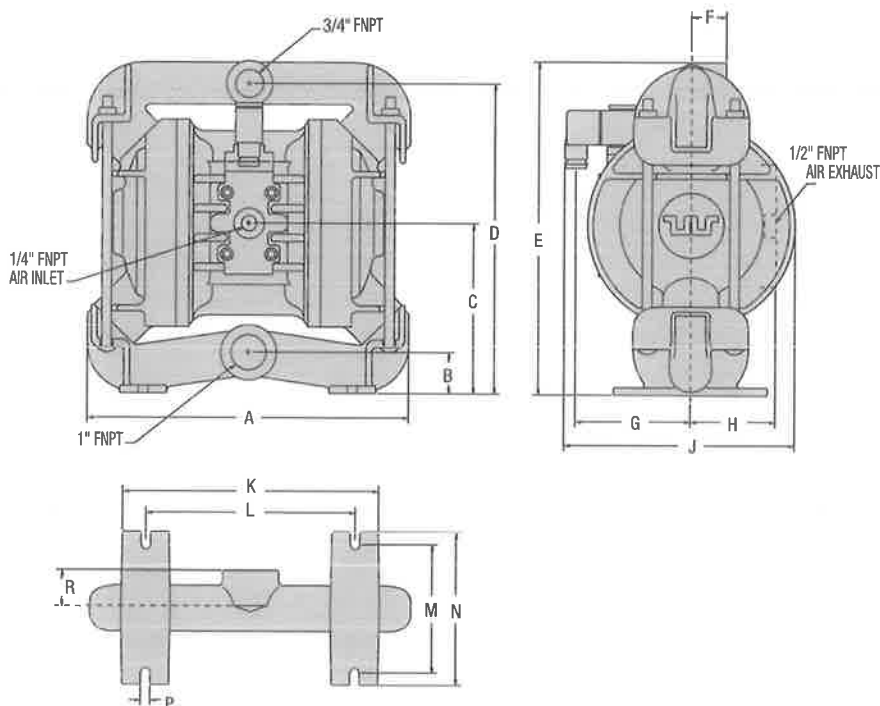
DIMENSIONS - T2 (METAL)		
ITEM	STANDARD (inch)	METRIC (mm)
A	10 17/32	267.5
B	1 7/16	36.5
C	5 7/16	138.0
D	10	254.0
E	11	279.4
F	1 1/8	28.6
G	3 3/4	95.3
H	3 1/32	77.0
J	7 1/4	184.2
K	8 1/4	209.6
L	6 3/4	171.5
M	4 3/16	106.4
N	5	127.0
P	5/16	7.9
R	1 1/4	31.8

BSP threads available.

SECTION 4B

DIMENSIONAL DRAWING

WILDEN MODEL A2 METAL ACCU-FLO™



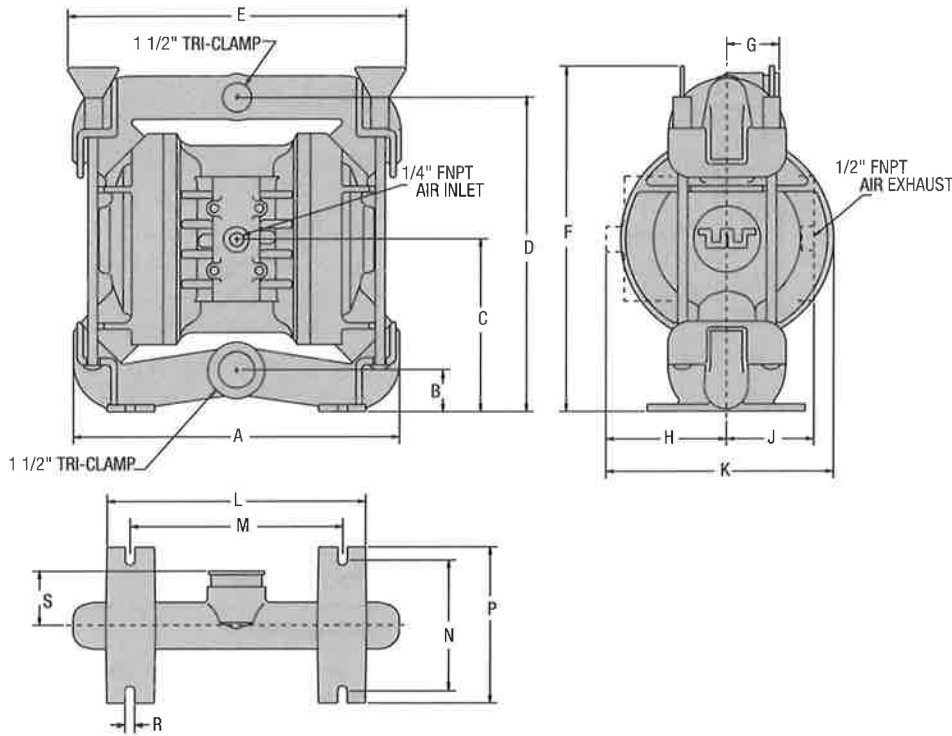
DIMENSIONS - A2 (METAL) SOLENOID-OPERATED		
ITEM	STANDARD (inch)	METRIC (mm)
A	10 17/32	267.5
B	1 7/16	36.5
C	5 7/16	138.0
D	10	254.0
E	11	279.4
F	1 1/8	28.6
G	3 25/32	96.0
H	3 1/32	77.0
J	7 1/2	190.5
K	8 1/4	209.6
L	6 3/4	171.5
M	4 3/16	106.4
N	5	127.0
P	5/16	7.94
R	1 1/4	31.8

BSP threads available.

SECTION 4C

DIMENSIONAL DRAWING

WILDEN MODEL T2 METAL SANIFLO^{FDA}

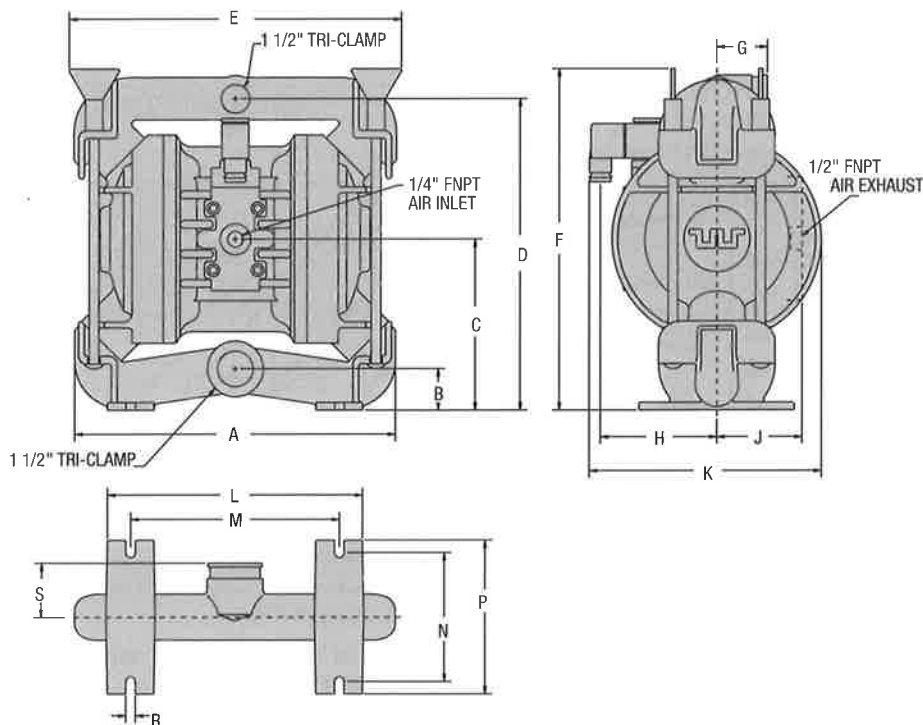


DIMENSIONS - T2 (FOOD PROCESSING)		
ITEM	STANDARD (inch)	METRIC (mm)
A	10 3/8	263.5
B	1 3/8	34.9
C	5 7/16	138.1
D	10 1/16	255.6
E	10 1/2	266.7
F	11 5/8	295.3
G	1 5/8	41.3
H	3 27/32	97.6
J	2 31/32	75.4
K	7 7/32	183.4
L	8 1/4	209.6
M	6 3/4	171.5
N	4 3/16	106.4
P	5	127.0
R	5/16	7.9
S	1 23/32	43.6

SECTION 4D

DIMENSIONAL DRAWING

WILDEN MODEL A2 METAL SANIFLO^{FDA} ACCU-FLOTM



DIMENSIONS - A2 (FOOD PROCESSING) SOLENOID-OPERATED		
ITEM	STANDARD (inch)	METRIC (mm)
A	10 3/8	263.5
B	1 3/8	34.9
C	5 7/16	138.1
D	10 1/16	255.6
E	10 1/2	266.7
F	11 5/8	295.3
G	1 5/8	41.3
H	3 25/32	96.0
J	2 31/32	75.4
K	7 1/2	190.5
L	8 1/4	209.6
M	6 3/4	171.5
N	4 3/16	106.4
P	5	127.0
R	5/16	7.9
S	1 23/32	43.6

SECTION 5A

PERFORMANCE CURVES

MODEL T2 METAL RUBBER-FITTED

Height11" (27.94 cm)
 Width.....10¹/₂" (26.75 cm)
 Depth.....7¹/₄" (18.42 cm)
 Ship WeightAluminum 26 lbs. (12 kg)
 Stainless Steel 36 lbs. (16.6 kg)
 Hastelloy 40 lbs. (16 kg)
 Air Inlet¹/₄" (6.35 mm)
 Inlet.....1" (2.54 cm)
 Outlet.....³/₄" (1.91 cm)
 Suction Lift17' Dry (5.18 m)
 31' Wet (9.45 m)

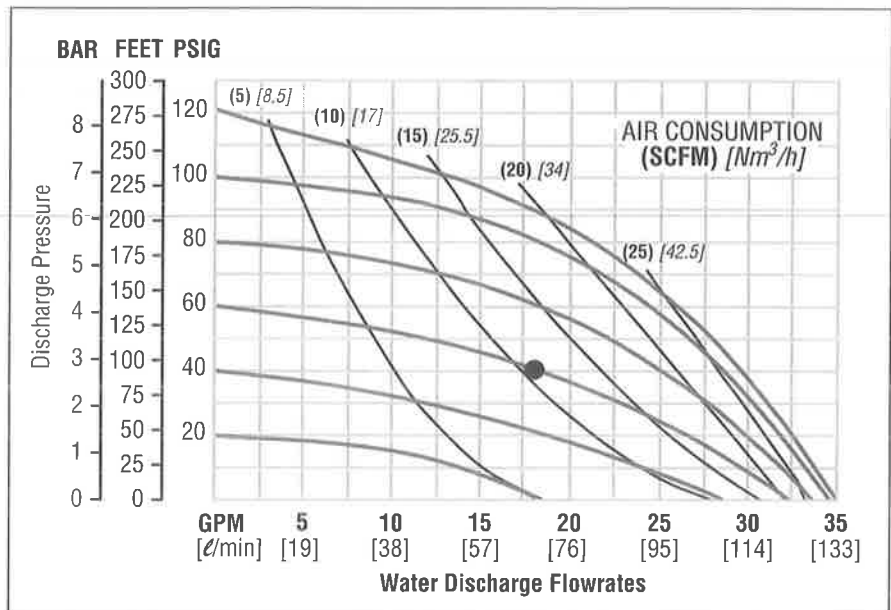
Displacement per

Stroke 0.105 gal. (.41 l)¹
 Max. Flow Rate.....35 gpm (132.49 lpm)
 Max. Size Solids.....¹/₂" (3.18 mm)

¹Displacement per stroke was calculated at 70 psig (4.8 Bar) air inlet pressure against a 30 psig (2 Bar) head pressure.

Example: To pump 18 gpm (68.1 lpm) against a discharge pressure head of 40 psig (2.7 Bar) requires 60 psig (4.1 Bar) and 11 scfm (18.7 Nm³/h) air consumption. (See dot on chart.)

Caution: Do not exceed 125 psig (8.6 Bar) air supply pressure.



Flow rates indicated on chart were determined by pumping water.

For optimum life and performance, pumps should be specified so that daily operation parameters will fall in the center of the pump performance curve.

SECTION 5B

PERFORMANCE CURVES

MODEL T2 METAL TPE-FITTED

Height11" (27.94 cm)
 Width.....10¹/₂" (26.75 cm)
 Depth.....7¹/₄" (18.42 cm)
 Ship WeightAluminum 26 lbs. (12 kg)
 Stainless Steel 36 lbs. (16.6 kg)
 Hastelloy 40 lbs. (16 kg)
 Air Inlet¹/₄" (6.35 mm)
 Inlet.....1" (2.54 cm)
 Outlet.....³/₄" (1.91 cm)
 Suction Lift5' Dry (1.52 m)
 31' Wet (9.45 m)

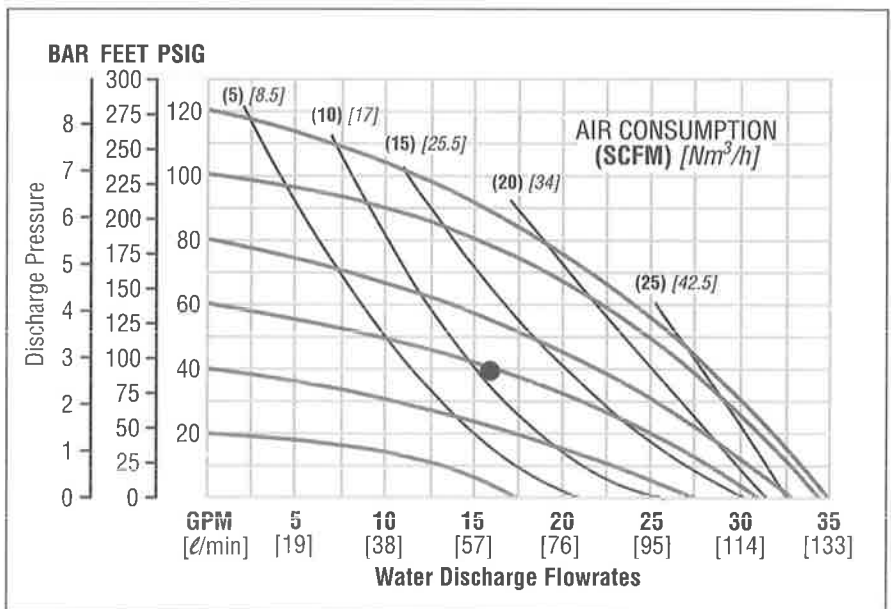
Displacement per

Stroke..... 0.105 gal.(.41 l)¹
 Max. Flow Rate.....35 gpm (132.49 lpm)
 Max. Size Solids.....¹/₂" (3.18 mm)

¹Displacement per stroke was calculated at 70 psig (4.8 Bar) air inlet pressure against a 30 psig (2 Bar) head pressure.

Example: To pump 16 gpm (60.6 lpm) against a discharge pressure head of 40 psig (2.7 Bar) requires 60 psig (4 Bar) and 10 scfm (17 Nm³/h) air consumption. (See dot on chart.)

Caution: Do not exceed 125 psig (8.6 Bar) air supply pressure.



Flow rates indicated on chart were determined by pumping water.

For optimum life and performance, pumps should be specified so that daily operation parameters will fall in the center of the pump performance curve.

SECTION 5C

PERFORMANCE CURVES

MODEL T2 METAL TEFLON®-FITTED

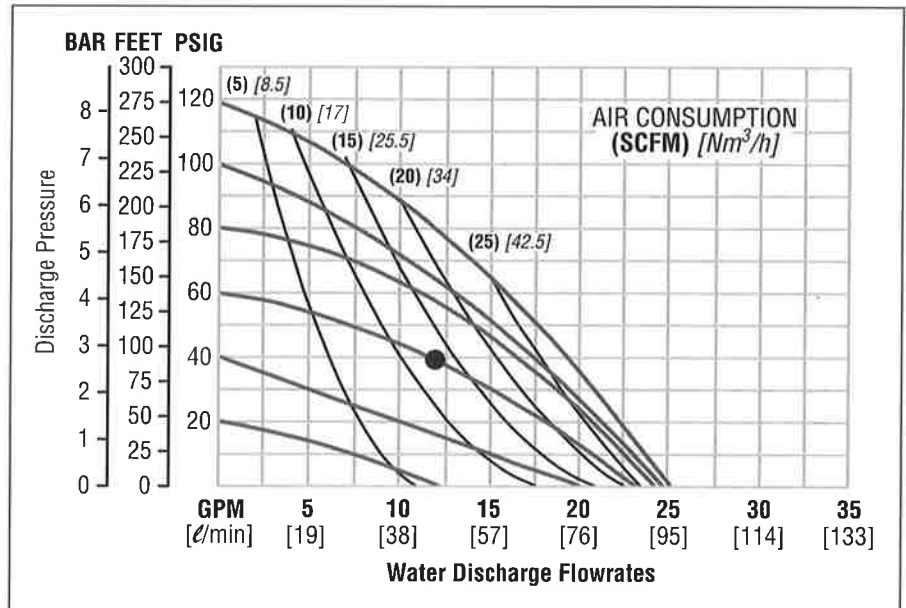
Height11" (27.94 cm)
 Width10¹/₂" (26.75 cm)
 Depth7¹/₄" (18.42 cm)
 Ship WeightAluminum 26 lbs. (12 kg)
 Stainless Steel 36 lbs. (16.6 kg)
 Hastelloy 40 lbs. (16 kg)
 Air Inlet1/4" (6.35 mm)
 Inlet1" (2.54 cm)
 Outlet3/4" (1.91 cm)
 Suction Lift6' Dry (1.83 m)
 31' Wet (9.45 m)

Displacement per

Stroke 0.05 gal. (.19 l)
 Max. Flow Rate25 gpm (94.64 lpm)
 Max. Size Solids1/8" (3.18 mm)
 *Displacement per stroke was calculated at 70 psig (4.8 Bar) air inlet pressure against a 30 psig (2 Bar) head pressure.

Example: To pump 12 gpm (45.4 lpm) against a discharge pressure head of 40 psig (2.7 Bar) requires 60 psig (4.1 Bar) and 13 scfm (22.1 Nm³/h) air consumption. (See dot on chart.)

Caution: Do not exceed 125 psig (8.6 Bar) air supply pressure.

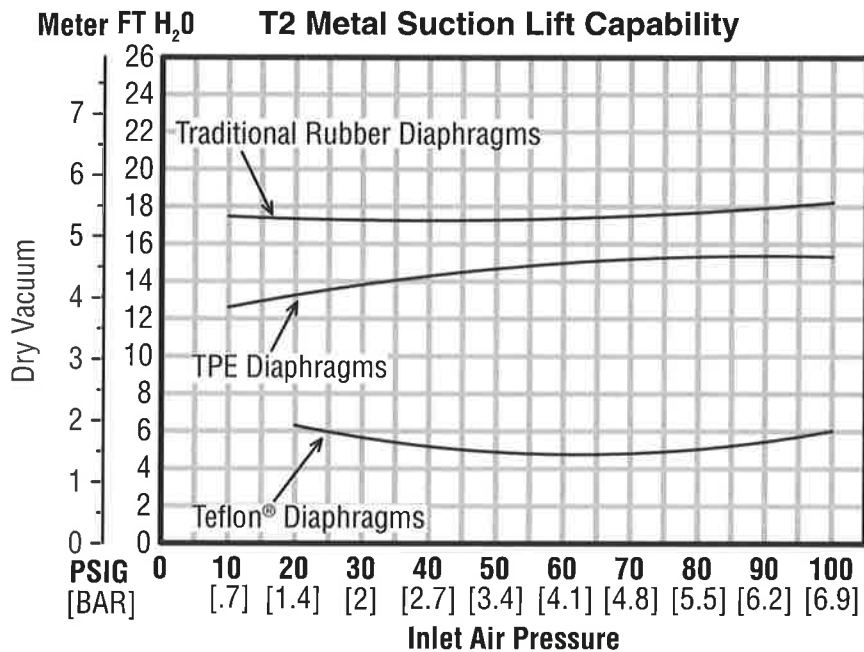


Flow rates indicated on chart were determined by pumping water.

For optimum life and performance, pumps should be specified so that daily operation parameters will fall in the center of the pump performance curve.

SECTION 6

SUCTION LIFT CURVES & DATA



Suction lift curves are calibrated for pumps operating at 1,000' (305 m) above sea level. This chart is meant to be a guide only. There are many variables which can affect your pump's operating characteristics. The number of intake and discharge elbows,

viscosity of pumping fluid, elevation (atmospheric pressure) and pipe friction loss all affect the amount of suction lift your pump will attain.

SECTION 7A

INSTALLATION – T2 METAL AIR-OPERATED PUMPS

The Model T2 Metal pump has a 1" (2.54 cm) inlet and ¾" (1.91 cm) outlet and is designed for flows to 35 gpm (132.49 lpm). The T2 Metal pump is manufactured with wetted parts of aluminum or stainless steel. The center section of the T2 Metal pump is of aluminum or polypropylene construction. Two types of air distribution systems are available: *LUBED AND LUBE-FREE*. The LUBED air distribution system consists of a brass air valve body, aluminum air valve piston, Glyd™ rings and a bronze center section bushing. The LUBE-FREE air distribution system is constructed solely of high-tech, engineered thermoplastics which function together without lubrication. The encircled letters "LF" stamped on the top of the pump's center section denotes that the pump is LUBE-FREE. The lube-free air valve body is off-white in color and also has "LF" molded into the valve body. A variety of diaphragms, valve balls, valve seats, and O-rings are available to satisfy temperature, chemical compatibility, abrasion and flex concerns.

The suction pipe size should be at least 1" (2.54 cm) diameter or larger if highly viscous material is being pumped. The suction hose must be non-collapsible, reinforced type as the T2 is capable of pulling a high vacuum. Discharge piping should be at least ¾" (1.91 cm); larger diameter can be used to reduce friction losses. It is critical that all fittings and connections are airtight or a reduction or loss of pump suction capability will result.

INSTALLATION: Months of careful planning, study, and selection efforts can result in unsatisfactory pump performance if installation details are left to chance.

Premature failure and long term dissatisfaction can be avoided if reasonable care is exercised throughout the installation process.

LOCATION: Noise, safety, and other logistical factors usually dictate that "utility" equipment be situated away from the production floor. Multiple installations with conflicting requirements can result in congestion of utility areas, leaving few choices for siting of additional pumps.

Within the framework of these and other existing conditions, every pump should be located in such a way that four key factors are balanced against each other to maximum advantage.

1. **ACCESS:** First of all, the location should be accessible. If it's easy to reach the pump, maintenance personnel will have an easier time carrying out routine inspections and adjustments. Should major repairs become necessary, ease of access can play a key role in speeding the repair process and reducing total downtime.

2. **AIR SUPPLY:** Every pump location should have an air line large enough to supply the volume of air necessary to achieve the desired pumping rate (see pump performance chart). Use air pressure up to a maximum of 125 psi (8.6 Bar) depending upon pumping requirements. The use of an air filter before the pump will ensure that the majority of any pipeline contaminants will be eliminated. For best results, the pumps should use an air filter, regulator, and lubricator system.

3. **ELEVATION:** Selecting a site that is well within the pump's suction lift capability will assure that loss-of-prime troubles will

be eliminated. In addition, pump efficiency can be adversely affected if proper attention is not given to elevation (see pump performance chart).

4. **PIPING:** Final determination of the pump site should not be made until the piping problems of each possible location have been evaluated. The impact of current and future installations should be considered ahead of time to make sure that inadvertent restrictions are not created for any remaining sites.

The best choice possible will be a site involving the shortest and the straightest hook-up of suction and discharge piping. Unnecessary elbows, bends, and fittings should be avoided. Pipe sizes should be selected so as to keep friction losses within practical limits. All piping should be supported independently of the pump. In addition, it should line up without placing stress on the pump fittings.

Expansion joints can be installed to aid in absorbing the forces created by the natural reciprocating action of the pump. If the pump is to be bolted down to a solid foundation, a mounting pad placed between the pump and foundation will assist in minimizing pump vibration. Flexible connections between the pump and rigid piping will also assist in minimizing pump vibration. If quick-closing valves are installed at any point in the discharge system, or if pulsation within a system becomes a problem, a surge suppressor should be installed to protect the pump, piping and gauges from surges and water hammer.

When pumps are installed in applications involving flooded suction or suction head pressures, a gate valve should be installed in the suction line to permit closing of the line for pump service.

The T2 can be used in submersible applications only when both wetted and non-wetted portions are compatible with the material being pumped. If the pump is to be used in a submersible application, a hose should be attached to the pump's air exhaust and the exhaust air piped above the liquid level.

If the pump is to be used in a self-priming application, be sure that all connections are airtight and that the suction lift is within the pump's ability. Note: Materials of construction and elastomer material have an effect on suction lift parameters. Please refer to pump performance data.

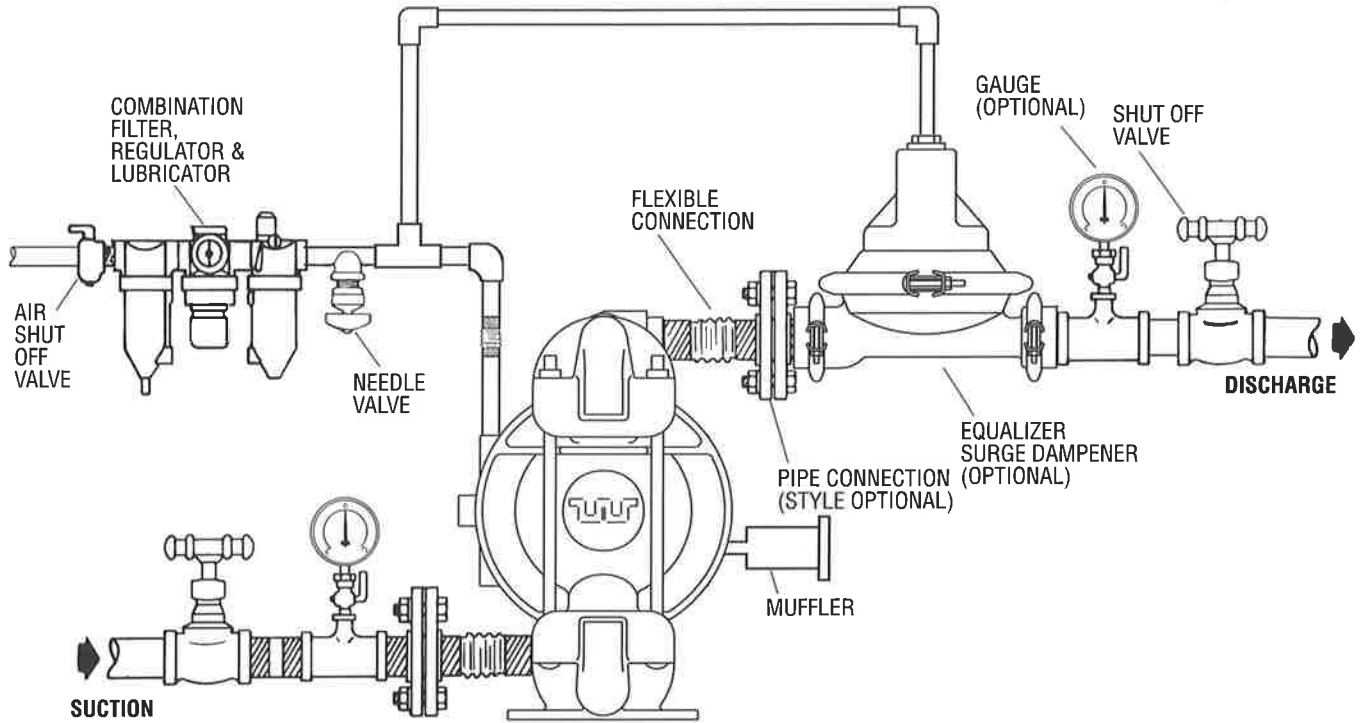
Pumps in service with a positive suction head are most efficient when inlet pressure is limited to 7–10 psig (.5–.7 Bar). Premature diaphragm failure may occur if positive suction is 11 psig (.8 Bar) and higher.

THE MODEL T2 WILL PASS ¼" (3.18 mm) SOLIDS. WHENEVER THE POSSIBILITY EXISTS THAT LARGER SOLID OBJECTS MAY BE SUCKED INTO THE PUMP, A STRAINER SHOULD BE USED ON THE SUCTION LINE.

CAUTION: DO NOT EXCEED 125 PSIG (8.6 BAR) AIR SUPPLY PRESSURE. (50 PSIG [3.4 BAR] FOR UL MODELS.)

BLOW OUT AIR LINE FOR 10 TO 20 SECONDS BEFORE ATTACHING TO PUMP TO MAKE SURE ALL PIPE LINE DEBRIS IS CLEAR. ALWAYS USE AN IN-LINE AIR FILTER.

SUGGESTED INSTALLATION



SECTION 7B – AIR-CONTROLLED SUGGESTED OPERATION AND MAINTENANCE INSTRUCTIONS

OPERATION: Pump discharge rate can be controlled by limiting the volume and/or pressure of the air supply to the pump (preferred method). An air regulator is used to regulate air pressure. A needle valve is used to regulate volume. Pump discharge rate can also be controlled by throttling the pump discharge by partially closing a valve in the discharge line of the pump. This action increases friction loss which reduces flow rate. This is useful when the need exists to control the pump from a remote location. When the pump discharge pressure equals or exceeds the air supply pressure, the pump will stop; no bypass or pressure relief valve is needed, and pump damage will not occur. The pump has reached a "deadhead" situation and can be restarted by reducing the fluid discharge pressure or increasing the air inlet pressure. The Wilden T2 pump runs solely on compressed air and does not generate heat, therefore your process fluid temperature will not be affected.

RECORDS: When service is required, a record should be made of all necessary repairs and replacements. Over a period of time, such records can become a valuable tool for predicting and preventing future maintenance problems and unscheduled downtime. In addition, accurate records make it possible to identify pumps that are poorly suited to their applications.

MAINTENANCE AND INSPECTIONS: Since each application is unique, maintenance schedules may be different for every pump. Frequency of use, line pressure, viscosity and abrasiveness of process fluid all affect the parts life of a Wilden pump. Periodic inspections have been found to offer the best means for preventing unscheduled pump downtime. Personnel familiar with the pump's construction and service should be informed of any abnormalities that are detected during operation.

SECTION 7C

OPERATING PRINCIPLES BEHIND SOLENOID-OPERATED PUMPS

In the solenoid-operated pump models, the standard air valve is replaced with a two position, four-way solenoid valve that has a single operator and spring return. The valve is internally air piloted for longer coil and operator life.

When the solenoid is unpowered, one air chamber is pressurized with air, while the opposite chamber is exhausted. When electric power is applied, the solenoid shifts, and the pressurized air chamber is exhausted while the opposite chamber is pressurized. By alternately applying and removing power, the solenoid-operated pump runs like a standard Wilden pump.

The speed of the pump is controlled electrically. Since each stroke is controlled by an electrical signal, the pump is ideal for batching and other electrically controlled dispensing applications.

Although the speed of the pump is controlled electrically, the air pressure is important. Air pressure displaces the fluid, and if the pressure is insufficient to complete the physical stroke before an electronic impulse signals the pump to shift, the stroke will not be completed, and the displacement per stroke will be reduced. This does not harm the unit in any way, but it may cause inaccuracy when attempting to batch specific quantities with high precision if this effect is not taken into account.

There are three coil voltage options available. One coil allows for 24V DC operation. The second coil option allows for operation with either 12V DC or 24V AC at 60 Hz and the third coil option allows for 110V AC operation.

SECTION 7D

INSTALLATION – A2 METAL ACCU-FLO™ PUMPS

Before installing your A2 Accu-Flo™ pump, review Section 7A for general installation suggestions including Location, Access, Air Supply, Elevation, and Piping.

The Accu-Flo™ Model A2 has a 1" (2.54 cm) inlet and ¾" (1.91 cm) outlet and is designed for flows to 24.5 gpm (94.94 lpm). This maximum flow rate was calculated at 550 strokes per minute with 100 psig air inlet against 0 psig discharge head. The A2 Metal pump is manufactured with wetted parts of aluminum or 316 stainless steel. The center section of the A2 Metal pump is of aluminum or polypropylene construction. A variety of diaphragms, valve balls, and O-rings are available to satisfy temperature, chemical compatibility, abrasion and flex concerns.

All wiring used to operate the pump should be placed and connected according to the proper electrical codes. It is important that the wiring is of adequate gauge to carry the current required to operate the pump. In addition, it is necessary that the electrical power supply is large enough to supply the current required to operate the pump. Wiring should be above ground level if possible (in case of fluid spill or leakage), and all wiring and connections which could become wet or damp should be made watertight.

If the pump is to be used in a self-priming application, be sure that all connections are airtight and that the suction lift is within the pump's ability. Note: Materials of construction and elastomer material have an effect on suction lift parameters. Please refer to pump performance data.

Pumps in service with a positive suction head are most efficient when inlet pressure is limited to 7–10 psig (.5–.7 Bar). Premature diaphragm failure may occur if positive suction head is 11 psig (.8 Bar) and higher.

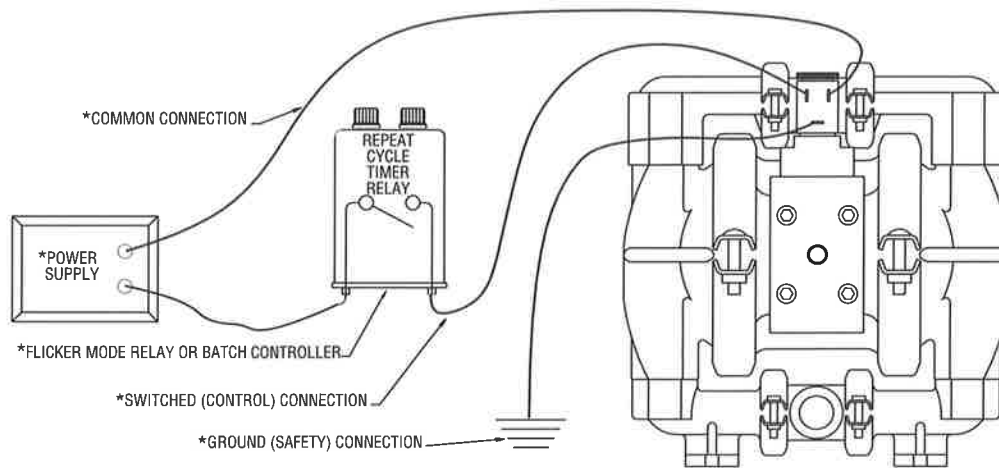
The solenoid valve is rated for continuous duty; however, stopping on an even number stroke count insures that the electrical power is off when pump is stopped. This practice is safer and also eliminates unwanted strokes when the system is shut down and electrical power is off.

THE MODEL A2 WILL PASS ⅛" (3.18 mm) SOLIDS. WHENEVER THE POSSIBILITY EXISTS THAT LARGER SOLID OBJECTS MAY BE SUCKED INTO THE PUMP, A STRAINER SHOULD BE USED ON THE SUCTION LINE.

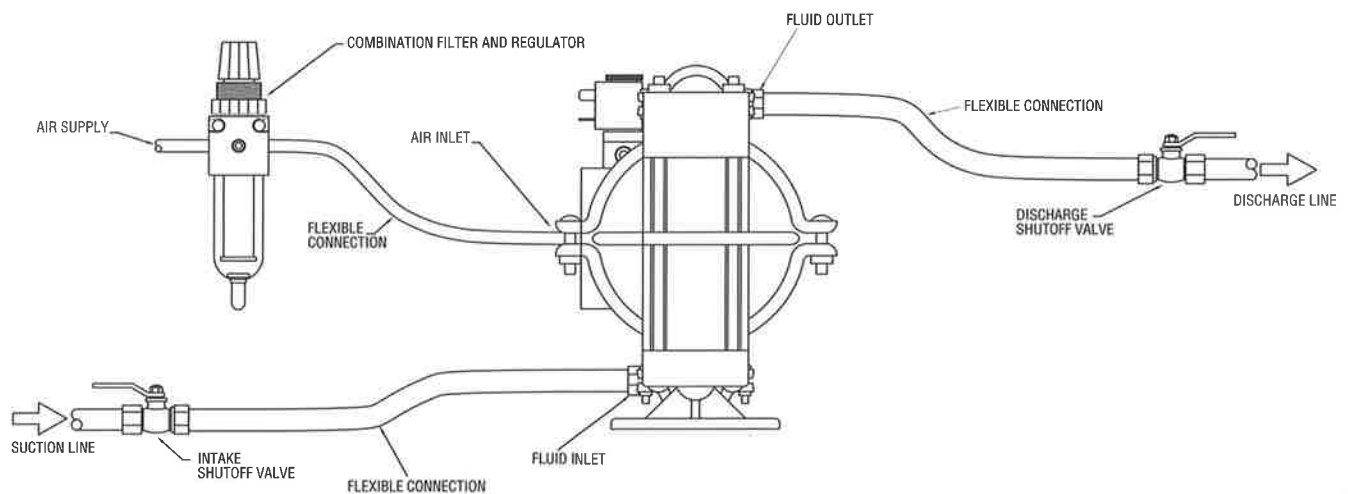
WARNING: The solenoid valve should not be used in an area where explosion proof equipment is required unless NEMA 7 valve is specified.

There are three coil options available in both NEMA 4 and NEMA 7 ratings. One coil allows for 110V AC operation, one allows for 24V DC operation, and the third allows for either 24V AC or 12V DC operation.

ELECTRICAL CONNECTIONS



PLUMBING CONNECTIONS



SECTION 7E - SOLENOID OPERATION

SUGGESTED OPERATION AND MAINTENANCE INSTRUCTIONS

OPERATION: The speed of the pump is controlled electrically. Since each stroke is controlled by an electrical signal, the pump is ideal for batching and other electrically controlled dispensing applications.

Although the speed of the pump is controlled electrically, the air pressure is important. Air pressure displaces the fluid, and if the pressure is insufficient to complete the physical stroke before an electronic impulse signals the pump to shift, the stroke will not be completed, and the displacement per stroke will be reduced. This does not harm the unit in any way, but it may cause inaccuracy when attempting to batch specific quantities with high precision.

The solenoid operated pump is permanently lubricated during assembly, and requires no additional lubrication under normal operation. If the unit runs under extreme conditions (continuous operation at high speeds), it may be necessary to relubricate the center block with a **Buna-N® compatible NLGI Grade 2 grease** every 50 million cycles. Continuous lubrication with a compatible oil is not harmful, and will provide longer seal life, but it may flush all grease out of the unit.

A red button on the side of the air valve is a manual override; when

actuated it will shift the valve as if an electric current had actuated the solenoid.

RECORDS: When service is required, a record should be made of all necessary repairs and replacements. Over a period of time, such records can become a valuable tool for predicting and preventing future maintenance problems and unscheduled downtime. In addition, accurate records make it possible to identify pumps that are poorly suited to their applications.

MAINTENANCE AND INSPECTIONS: Since each application is unique, maintenance schedules may be different for every pump. Frequency of use, line pressure, viscosity and abrasiveness of process fluid all affect the parts life of a Wilden pump. Periodic inspections have been found to offer the best means for preventing unscheduled pump downtime. Personnel familiar with the pump's construction and service should be informed of any abnormalities that are detected during operation. Internal maintenance is not recommended for Accu-Flo™ solenoid air valves. When worn or damaged, a new air valve body, coil or terminal connector must be purchased. Please consult section 9C for part numbers.

SECTION 7F – AIR OPERATION

TROUBLESHOOTING

Pump will not run or runs slowly.

1. Check air inlet screen and air filter for debris.
2. Check for sticking air valve, flush air valve in solvent.
3. Check for worn out air valve. If piston face in air valve is shiny instead of dull, air valve is probably worn beyond working tolerances and must be replaced.
4. Check center block Glyd™ rings. If worn excessively, they will not seal and air will simply flow through pump and out air exhaust. Use only Wilden Glyd™ rings as they are of special construction.
5. Check for rotating piston in air valve.
6. Check type of lubricant being used. A higher viscosity oil than suggested may cause the piston to stick or run erratically. Wilden suggests the use of an oil with arctic characteristics (ISO 15-5 wt.).

Pump runs but little or no product flows.

1. Check for pump cavitation; slow pump speed down to match thickness of material being pumped.

2. Check for sticking ball check valves. If material being pumped is not compatible with pump elastomers, swelling may occur. Replace ball check valves and O-rings with the proper elastomers.

3. Check to make sure all suction connections are air tight, especially clamp bands around intake balls.

Pump air valve freezes.

Check for excessive moisture in compressed air. Either install dryer or hot air generator for compressed air.

Air bubbles in pump discharge.

1. Check for ruptured diaphragm.
2. Check tightness of clamp bands, especially at intake manifold.

Product comes out air exhaust.

1. Check for diaphragm rupture.
2. Check tightness of piston plates to shaft.

SECTION 7G – SOLENOID OPERATION

TROUBLESHOOTING

Pump will not run.

1. Check for pressurized air at the inlet. (Min. 45 psig.)
2. Check air inlet and filter for debris.
3. Connect a test lamp to the two wires which run to pump and ensure that the lamp cycles on and off.
4. Make sure that the air valve manual override (small red knob on front of valve) is switched to the "0" position.
5. Check pilot pressure vent at the top of the operator/coil assembly to ensure that it is not clogged.
6. Check for a worn out air valve. If air continually blows out the exhaust in very large quantities, the air valve seals may be worn beyond their ability to function. In this case, the valve must be replaced.

NOTE: Before the valve is scrapped, it is possible that it may be saved by completely disassembling the valve, cleaning all components and relubricating the valve.

Pump runs but little or no fluid comes out.

1. Check that the discharge isolation valve is not closed.
2. Check that the electronic signal is slow enough that the pump is able to complete each physical stroke before it is signaled to change direction. The time required to complete the stroke is determined by a variety of factors which include fluid viscosity and head pressure. The shaft can be viewed if the muffler is removed to verify that the pump is stroking.
3. Check for pump cavitation; slow pump speed down to match the thickness of the material being pumped.
4. Check for sticking ball check valves. If the material being pumped is not compatible with the pump elastomers, swelling may occur. Replace ball check valves and O-ring with the proper elastomers.
5. Check to make sure that all suction connections are air tight, and that the clamp bands are properly tightened.

Pump air passages blocked with ice.

Check for excessive moisture in compressed air line. As the air expands out the exhaust during the operation of the pump,

water vapor entrapped in the compressed air can freeze and block the air passageways in the pump. If this occurs, it may be necessary to install a coalescing filter, an air dryer, or a hot air generator for the compressed air.

Air bubbles in pump discharge.

1. Check for ruptured diaphragm.
2. Check tightness of clamp bands, and the integrity of the O-rings, especially at intake manifold.

Product comes out air exhaust.

1. Check for diaphragm rupture.
2. Check tightness of piston plates to shaft.

Pump rattles.

1. See RBG E9 Troubleshooting Guide.
2. Create false discharge head or suction lift.

Solenoid buzzes or solenoid burnout.

1. Incorrect voltage, faulty or dirty solenoid.

Solenoid valve fails to shift electrically but shifts with manual override.

1. Incorrect voltage, defective coil or wiring.

Solenoid valve fails to shift electrically or with manual override.

1. Inadequate air supply, contamination, inadequate or improper lubrication, mechanical binding in the valve.

Valve shifts but fails to return.

1. Broken spring, mechanical binding.

Excessive leaking from air valve vent.

1. Worn seals in air valve.

SECTION 8A

MODEL T2 METAL DIRECTIONS FOR DISASSEMBLY/REASSEMBLY

CAUTION: Before any maintenance or repair is attempted, the compressed air line to the pump should be disconnected and all air pressure allowed to bleed from the pump. Disconnect all intake, discharge, and air lines. Drain the pump by turning it upside down and allowing any fluid to flow into a suitable container. Be aware of any hazardous effects of contact with your process fluid.

The Wilden model T2 has a 1" (2.54 cm) inlet and 3/4" (1.91 cm) outlet and is designed for flows up to 35 gpm (132.49 lpm). The single-piece center section, consisting of center block and air chambers, is molded of polypropylene or aluminum. The air valve is manufactured of brass or high-tech, engineered thermoplastics. All O-rings used in the pump are of a special material and shore hardness that should only be replaced with factory-supplied parts.

TOOLS REQUIRED:

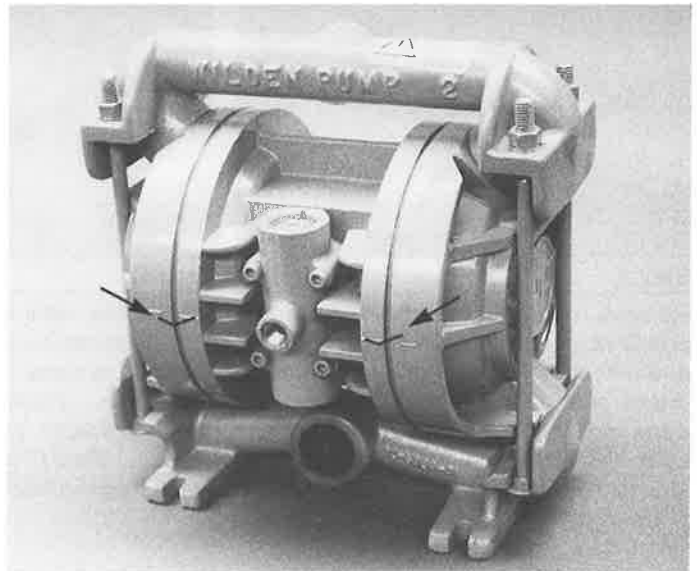
Adjustable Wrench

5/16" Box Wrench

3/4" Box Wrench

Vise equipped with soft jaws (such as plywood, plastic or other suitable material)

NOTE: The model used for these instructions incorporates rubber diaphragms, balls, and seats. Models with Teflon® diaphragms, balls and seats are the same except where noted. The procedures for A2 Accu-Flo™ pumps are the same except for the air distribution system.

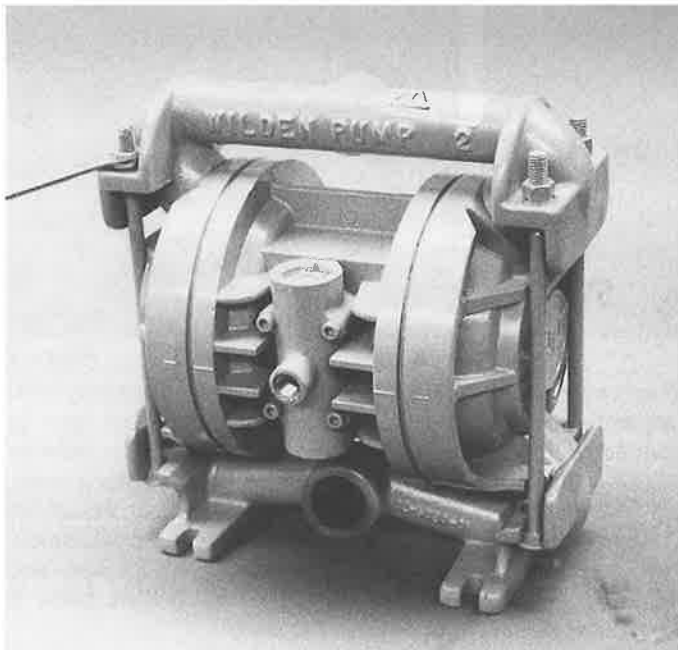


DISASSEMBLY:

Figure 1

Step 1.

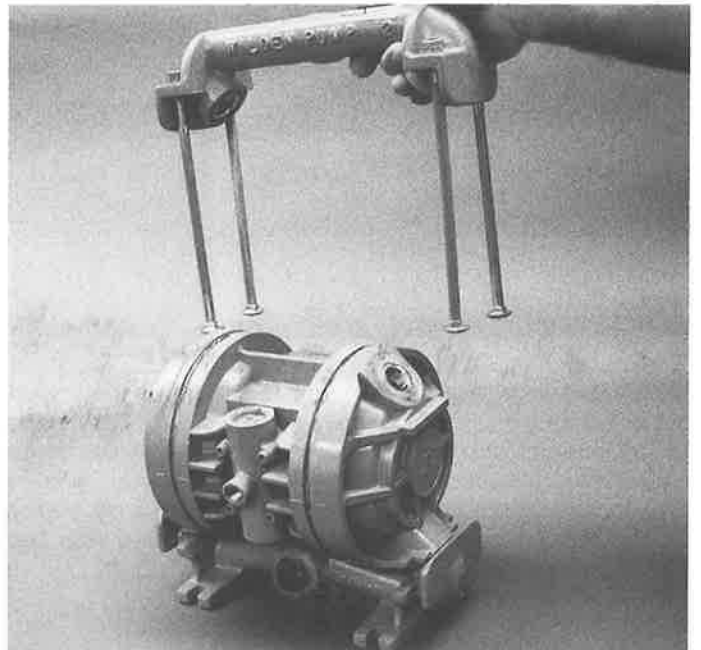
Before starting disassembly, mark a line from each liquid chamber to its corresponding air chamber. This line will assist in proper alignment during reassembly. (Figure 1)



Step 2.

Figure 2

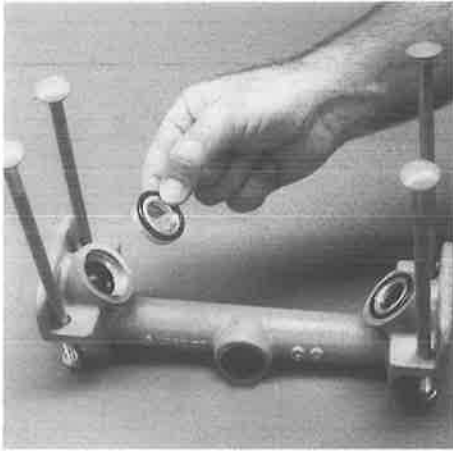
Utilizing the 5/16" box wrench, start by removing the four long carriage bolts that secure the top and bottom manifolds to the center section. (Figure 2)



Step 3.

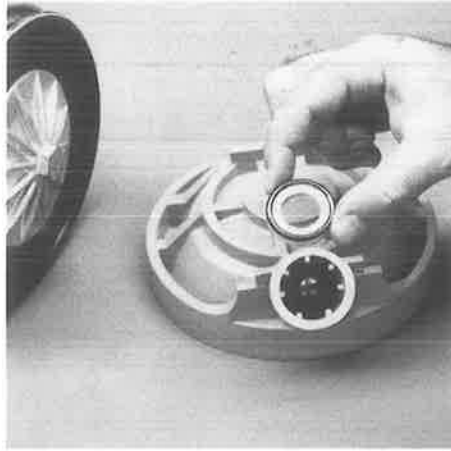
Figure 3

Remove the top manifold and lift the center section off the inlet manifold. (Figure 3)



Step 4. *Figure 4*

Remove the discharge valve balls, seats and O-rings from the discharge manifold and inspect for nicks, gouges, chemical attack or abrasive wear. Replace worn parts with genuine Wilden parts for reliable performance. Teflon® O-rings should be replaced when reassembled. (*Figure 4*)



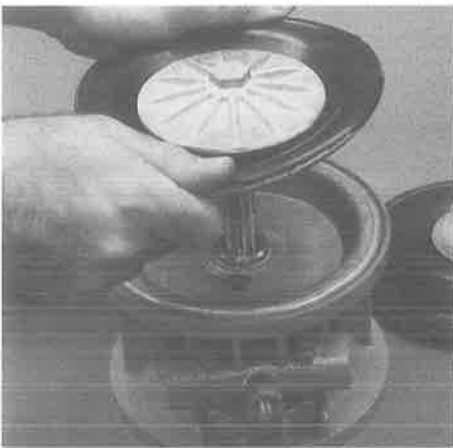
Step 5. *Figure 5*

Inspect the valve seat, valve seat O-ring, and valve ball from intake manifold. Check for nicks, gouges, chemical attack or abrasive wear. Replace worn parts with genuine Wilden parts for reliable performance. Teflon® O-rings should be replaced when reassembled. (*Figure 5*)



Step 6. *Figure 6*

With the $\frac{3}{4}$ " box wrench or by rotating the diaphragm by hand, remove the diaphragm assembly. (*Figure 6*)



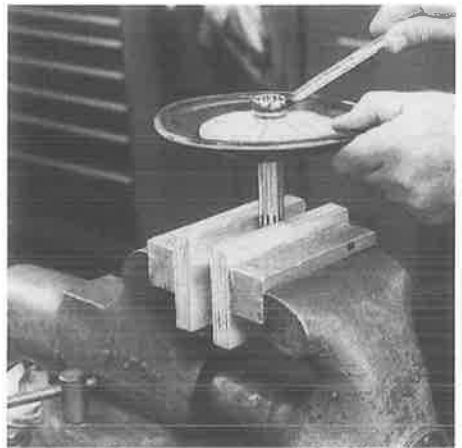
Step 7. *Figure 7*

NOTE: Due to varying torque values, one of the following two situations may occur:
1) The outer piston, diaphragm and inner piston remain attached to the shaft and the entire assembly can be removed from the center section (*Figure 7*).



Step 8. *Figure 8*

2) The outer piston, diaphragm, inner piston, and disc spring separate from the shaft which remains connected to the opposite side diaphragm assembly (*Figure 8*). Teflon®-fitted pumps come standard with back-up diaphragms (not shown).



Step 9. *Figure 9*

To remove the diaphragm assembly from the shaft, secure shaft with soft jaws (a vise fitted with plywood or other suitable material) to ensure shaft is not nicked, scratched, or gouged. Using an adjustable wrench, remove diaphragm assembly from shaft. Inspect all parts for wear and replace with genuine Wilden parts if necessary. (*Figure 9*)

SECTION 8B – TURBO-FLO™ PUMPS

AIR VALVE / CENTER SECTION REPAIR / MAINTENANCE

The air valve assembly consists of the air valve body and piston. The unique design of the air valve relies only on differential pressure to cause the air valve to shift. It is reliable and simple to maintain. The bushing in the center block, along with the diaphragm shaft, provides the “trigger” to tell the air valve to shift. The following procedure will ensure that the air valve on your Wilden pump will provide long trouble-free service.

AIR VALVE BODY AND PISTON ASSEMBLY AND DISASSEMBLY

The air valve body and piston can be disconnected from the pump by removing the four socket-head cap screws which attach it to the center section. The piston in the air valve is aluminum with a dark anodized coating (see *Figure A*). The piston should move freely and the ports in the piston should line up with the ports on the face of the air valve body. The piston should also appear to be dull black in color. If the piston appears to be a shiny aluminum color, the air valve is probably worn beyond working tolerances and should be replaced.

If the piston does not move freely in the air valve, the entire air valve should be immersed in a cleaning solution. (NOTE: Do not

force the piston by inserting a metal object.) This soaking should remove any accumulation of sludge and grit which is preventing the air valve piston from moving freely. If the air valve piston does not move freely after the above cleaning, the air valve should be disassembled as follows: Remove the snap ring from the top end of the air valve and apply an air jet alternately to the two holes located in the face of the air valve until the end cap is blown out. (See *Figure B*, next page) [CAUTION: The air valve end cap may come out with considerable force. Hand protection such as a padded glove or a rag should be used to capture the end cap.] Inspect the piston and cylinder bore for nicks and scoring.

Small nicks can usually be dressed out and the piston returned to service. Inspect the cylinder end caps. Make sure that the guide pin is straight and smooth or the piston will not move freely in the cylinder. Clean out anti-centering pin holes located on each side of the piston. Pin holes are located on each side of the annular groove on the top of the piston and travel to each end. New O-rings should be installed on the end caps. Lubricate the O-rings and install the end caps, assuring that proper alignment of the piston and cylinder ports is maintained. Use an oil with arctic characteristics (ISO 15-5wt).

GLYD™ RING REPLACEMENT/ CENTER SECTION

The pump's center section consists of a molded housing with a bronze bushing. (Bushings is not removable.) This bushing has grooves cut into the inside diameter. Glyd™ rings are installed in these grooves. When the Glyd™ rings become worn, they will no longer seal and must be replaced.

There are two versions of center sections: PRE-ENHANCED (pumps manufactured before March 1, 1992) and ENHANCED (pumps manufactured since March 1, 1992). An encircled letter “E” stamped on the top of the center section denotes the ENHANCED type center section (*Figure C*).

Please contact your local authorized distributor for enhanced air distribution retrofit packages.

If the encircled “E” is present, an enhanced (02-3800-09-07) shaft should be utilized to maximize performance. The center section Glyd™ rings (02-3210-55-225) must be installed in the appropriate grooves as shown (1, 3, 6, 8).

If the encircled “E” is not present, a pre-enhanced shaft (02-3800-09 or 02-3820-09) must be utilized. An enhanced (non-dented) shaft will not function correctly. The center section O-rings (02-3200-52) must be installed in the appropriate grooves as shown (1, 3, 4, 6).

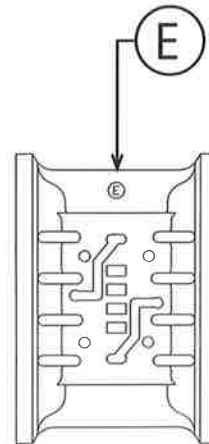
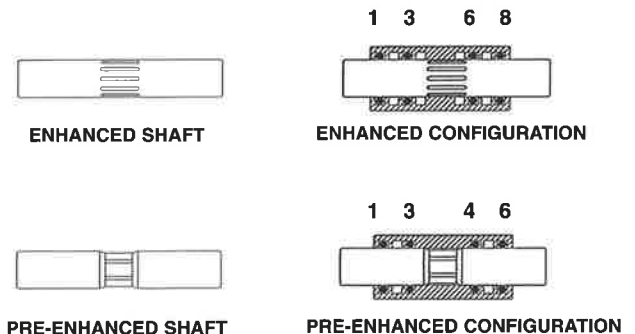


Figure C



SECTION 8C – M2 LUBE-FREE PUMPS

AIR VALVE / CENTER SECTION DISASSEMBLY, CLEANING, INSPECTION

AIR VALVE/CENTER SECTION REPAIR/MAINTENANCE

The center section assembly consists of both the air valve body and piston, and the center section. The lube-free design utilizes high-tech, engineered thermoplastics in place of the brass air valve, aluminum piston, and bronze bushing. This new system also includes slipper seals to reduce the coefficient of friction between the shaft and center section. This lube-free design includes the straight shaft and altered exhaust port configuration utilized in the enhanced M2 air distribution system. Low start-up pressure, on/off reliability, and increased sealing in a dead-head condition are a few of the advantages of the lube-free air distribution system. The selected thermoplastics have the ability to function together without lubrication making the M2 Wilden pump truly lube-free. **The M2 lube-free pumps are not pre-lubed with oil or grease.**

AIR VALVE BODY AND PISTON ASSEMBLY AND DISASSEMBLY

The air valve body and piston (P/N 02-2000-65-200) is externally serviceable by removing the four socket-head cap screws which attach it to the center section. The lube-free air valve body is off-white in color and has an encircled "LF" molded into the exterior. The thermoplastic air valve piston is gray in color like the aluminum lubed style, but is differentiated by a "D-shaped hole" in the top of the piston, and two small holes in the annular groove. (See *Figure B*.)

The piston should move freely and the ports in the piston must line-up with the ports on the face of the air valve body (see *Figure B*). If the piston does not move freely in the valve body, the entire air valve assembly should be immersed in a mild soap solution to remove any accumulation of sludge and/or grit. If the air valve does not move freely after the above cleaning, the air valve should be disassembled as follows: Remove the snap ring from the top of the air valve cylinder and apply an air jet to the 1/8" hole on the opposite end of the air valve face. Caution: The end cap may come out with considerable force. Verify that the guide pin molded into one of the end caps (P/N 02-2340-23-200) is straight and smooth to allow the piston to shift properly. Inspect the piston and cylinder bore for nicks and scoring. Small nicks can be dressed with fine sandpaper and the piston returned to service. Clean and reassemble. **Install air valve to center section and tighten to the required torque specifications*.**

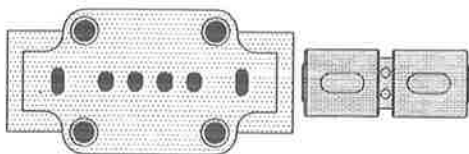


Figure B

O-RING REPLACEMENT/CENTER SECTION

The M2 lube-free Champ series pumps are constructed with a polypropylene center section with a thermoplastic bushing. The M2 lube-free Metal pumps are constructed with a polypropylene center section with a thermoplastic bushing. (Lube-free aluminum center sections are not available.) These center sections are easily distinguished by the encircled letter "LF" stamped on the top of the center section. These bushings are not removable. The bushing has grooves cut into the inside diameter where back-up O-rings and slipper seals are installed. It is important that the correct O-ring is utilized. The back-up O-ring for the lube-free model has a bigger diameter and smaller cross-section in comparison to the "Lubed" model. The straight shaft (P/N 02-3800-09-07) must be utilized in the lube-free pump.

The back-up O-ring is installed first. This is most easily accomplished by using a tool called an O-ring pick, available through most industrial supply companies. The O-rings must be installed in the appropriate grooves as shown in *Figure C* (1, 3, 6, 8). Upon completion of the O-ring installation, the slipper seals (P/N 02-3210-55-200) must be installed in the same grooves (1, 3, 6, 8). This task is accomplished by utilizing long nose pliers and a flat head screw driver covered with tape to ensure seal integrity. Please see *Figures D, E, and F*.

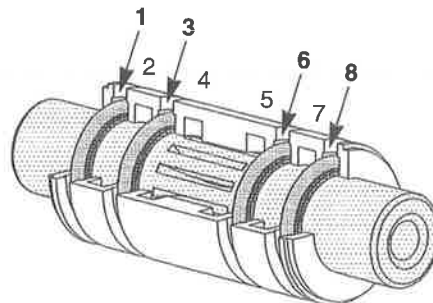


Figure C

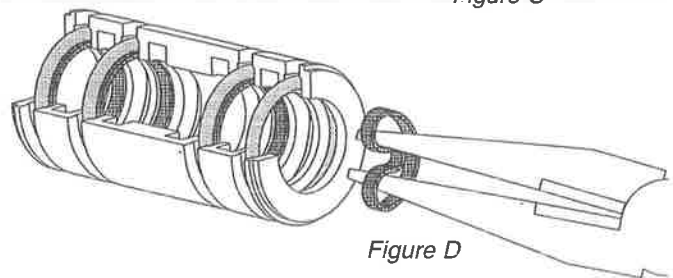


Figure D

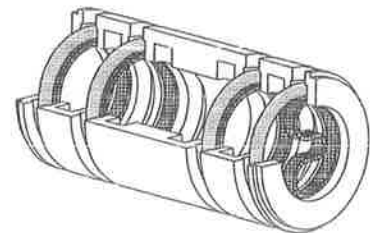


Figure E

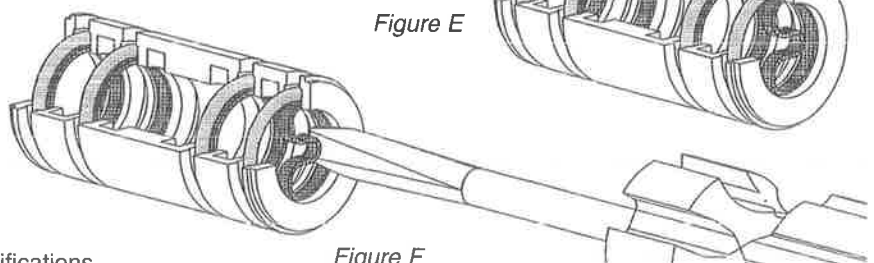


Figure F

*Refer to Section 8D for the required torque specifications.

SECTION 8D

REASSEMBLY HINTS & TIPS

ASSEMBLY:

Upon performing applicable maintenance to the air distribution system, the pump can now be reassembled. Please refer to the disassembly instructions for photos and parts placement. To reassemble the pump, follow the disassembly instructions in reverse order. The air distribution system needs to be assembled first, then the diaphragms and finally the wetted path. Please find the applicable torque specifications on this page. The following tips will assist in the assembly process.

- Clean the inside of the center section shaft bushing to ensure no damage is done to new seals.
- Stainless bolts should be lubed to reduce the possibility of seizing during tightening.
- Level the water chamber side of the intake/discharge manifold to ensure a proper sealing surface. This is most easily accomplished by placing them on a flat surface prior to tightening their clamp bands to the desired torque (see this page for torque specs).

MAXIMUM TORQUE SPECIFICATIONS

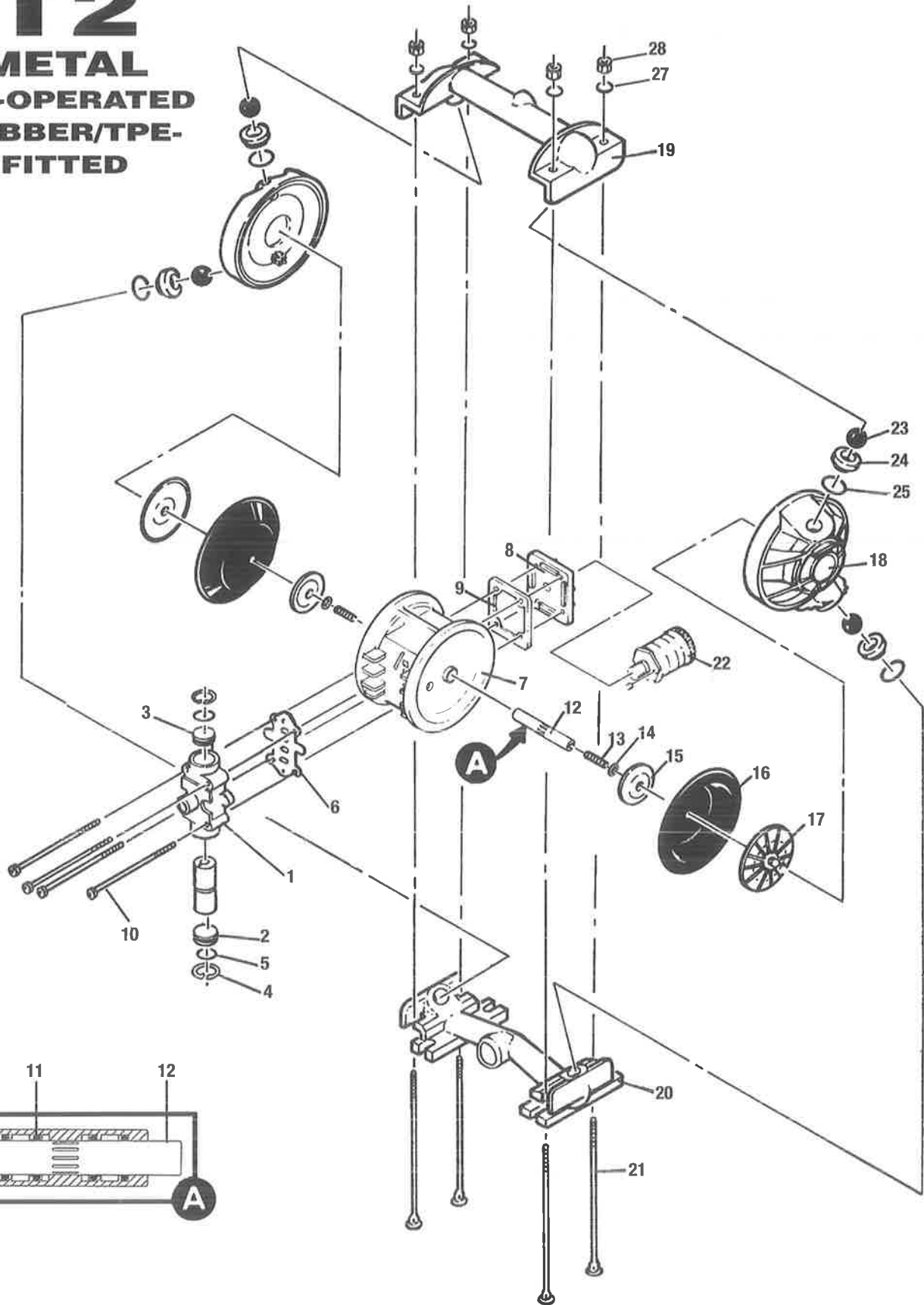
Description of Part	Metal Pumps
Air Valve, Lubed	30 in.-lbs. [3.4 m-N]
Air Valve, Lube-Free	20 in.-lbs. [2.3 m-N]
Outer Piston, Rubber and Teflon®-Fitted	28 ft.-lbs. [38 m-N]
Vertical Bolts	115 in.-lbs. [13.0 m-N]

- Be sure to tighten outer pistons simultaneously on Teflon®-fitted pumps to ensure proper torque values.
- Place one liquid chamber on its side and align center section with chamber using alignment marks made during disassembly. Push down on diaphragm assembly until diaphragm is inverted. Place opposite liquid chamber on center section and align.
- Position valve balls, seats, and O-rings in discharge manifold. Place vertical through discharge manifold with threads pointing up. Install washer and start threads of bolt (about 1½ turns).
- Place center section and liquid chambers on intake manifold.
- Position discharge manifold and bolt assembly on liquid chambers. Ensure proper alignment of mating surfaces between liquid chambers and manifolds before tightening bolts.
- Apply a small amount of Loctite 242 to the steel bore of the shaft from the diaphragm assembly.

SECTION 9A

EXPLODED VIEW/PARTS LISTING

T2
METAL
AIR-OPERATED
RUBBER/TPE-
FITTED



Model T2 Metal Air-Operated Rubber/TPE-Fitted Pumps

Item	Description	Qty. Per Pump	T2/	T2/	T2/	T2/	T2/	T2	T2/	T2/	T2/	T2/
			APPB	APPB-003	SPPB	HPPB	SPPN-070	AAAB	AAAB-003	SAAB	HNNB	
			P/N	P/N	P/N	P/N	P/N	P/N	P/N	P/N	P/N	P/N
1	Air Valve Assembly ¹	1	02-2000-07	02-2000-07	02-2000-07	02-2000-07	02-2000-07	02-2000-06	02-2000-07	02-2000-07	02-2000-07	02-2000-07
2	Air Valve Cap w/ Guide (Bottom)	1	02-2331-23	02-2331-23	02-2331-23	02-2331-23	02-2331-23	02-2331-23	02-2331-23	02-2331-23	02-2331-23	02-2331-23
3	Air Valve Cap w/ Guide (Top)	1	02-2301-23	02-2301-23	02-2301-23	02-2301-23	02-2301-23	02-2301-23	02-2301-23	02-2301-23	02-2301-23	02-2301-23
4	Snap Ring	2	02-2650-03	02-2650-03	02-2650-03	02-2650-03	02-2650-03	02-2650-03	02-2650-03	02-2650-03	02-2650-03	02-2650-03
5	Air Valve Cap O-Ring	2	02-3200-52-200	02-3200-52-200	02-3200-52-200	02-3200-52-200	02-3200-52-200	02-3200-52-200	02-3200-52-200	02-3200-52-200	02-3200-52-200	02-3200-52-200
6	Air Valve Gasket — Buna-N [®]	1	02-2600-52	02-2600-52	02-2600-52	02-2600-52	02-2600-52	02-2600-52	02-2600-52	02-2600-52	02-2600-52	02-2600-52
7	Center Section ¹	1	02-3151-20	02-3151-20	02-3151-20	02-3151-20	02-3151-20	02-3151-20	02-3150-01	02-3150-01	02-3150-01	02-3150-06
8	Muffler Plate	1	02-3180-20	02-3180-20	02-3180-20	02-3180-20	02-3180-20	02-3180-20	02-3180-01	02-3180-01	02-3180-01	02-3180-01
9	Muffler Plate Gasket — Buna-N [®]	1	02-3500-52-500	02-3500-52-500	02-3500-52-500	02-3500-52-500	02-3500-52-500	02-3500-52-500	02-3500-52-110	02-3500-52-110	02-3500-52-110	02-3500-52-110
10	Air Valve Screws 1/20 x 6"	4	02-6000-08	02-6000-03	02-6000-03	02-6000-03	02-6000-03	02-6000-03	02-6000-08	02-6000-03	02-6000-03	02-6000-03
11	Center Section Glyd™ Ring	4	02-3210-55-225	02-3210-55-225	02-3210-55-225	02-3210-55-225	02-3210-55-225	02-3210-55-225	02-3210-55-225	02-3210-55-225	02-3210-55-225	02-3210-55-225
12	Shaft	1	02-3800-09-07	02-3800-09-07	02-3800-09-07	02-3800-09-07	02-3800-09-07	02-3800-09-07	02-3800-09-07	02-3800-09-07	02-3800-09-07	02-3800-09-07
13	Stud 3/8"-16 x 1 1/4"	2	N/R	N/R	02-6150-08	02-6150-08	02-6150-08	02-6150-08	N/R	N/R	02-6150-08	02-6150-08
14	Disc Spring	2	02-6802-08	02-6802-08	02-6802-08	02-6802-08	02-6802-08	02-6802-08	02-6802-08	02-6802-08	02-6802-08	02-6802-08
15	Pistons — Inner	2	02-3700-08	02-3700-08	02-3700-08	02-3700-08	02-3700-08	02-3700-08	02-3700-08	02-3700-08	02-3700-08	02-3700-08
16	Diaphragm*	2	*	*	*	*	02-1010-56	*	*	*	*	*
17	Pistons — Outer	2	02-4550-01	02-4550-01	02-4550-03	02-4550-04	02-4550-03	02-4550-01	02-4550-01	02-4550-03	02-4550-03	02-4550-04
18	Liquid Chamber	2	02-5000-01	02-5000-01	02-5000-03	02-5000-04	02-5000-03	02-5000-01	02-5000-01	02-5000-03	02-5000-03	02-5000-04
19	Discharge Manifold	1	02-5020-01	02-5020-01-03	02-5020-03	02-5020-04	02-5020-03-70	02-5020-01	02-5020-01-03	02-5020-03	02-5020-03	02-5020-04
20	Inlet Housing	1	02-5080-01	02-5080-01-03	02-5080-03	02-5080-04	02-5080-03-70	02-5080-01	02-5080-01-03	02-5080-03	02-5080-03	02-5080-04
21	Manifold Bolt 1/2"-16 x 8 1/2"	4	02-6080-08	02-6080-03	02-6080-03	02-6080-03	02-6080-03	02-6080-08	02-6080-03	02-6080-03	02-6080-03	02-6080-03
22	Muffler	1	02-3510-99	02-3510-99	02-3510-99	02-3510-99	02-3510-99	02-3510-99	02-3510-99	02-3510-99	02-3510-99	02-3510-99
23	Valve Balls*	4	*	*	*	*	02-1080-56	*	*	*	*	*
24	Valve Seat	4	02-1120-01	02-1120-01	02-1120-03	02-1120-04	02-1120-03	02-1120-01	02-1120-01	02-1120-03	02-1120-03	02-1120-04
25	Valve Seat O-Ring*	4	*	*	*	*	02-1200-56	*	*	*	*	*
26	Hex Nut 1/20, S.S.** (Not Shown)	4	04-6400-08	04-6400-03	04-6400-03	04-6400-03	04-6400-03	N/A	N/A	N/A	N/A	N/A
27	Manifold Bolt Washer 3/8"	4	15-6720-08	02-6730-03	02-6730-03	02-6730-03	08-6720-07-70	15-6720-08	02-6730-03	02-6730-03	02-6730-03	02-6730-03
28	Manifold Bolt Nut 3/8"-16	4	02-6430-08	02-6430-03	02-6430-03	02-6430-03	02-6430-03	02-6430-08	02-6430-03	02-6430-03	02-6430-03	02-6430-03

Lube-Free Model M2 Metal Air-Operated Rubber/TPE-Fitted Pumps

Item	Description	Qty. Per Pump	M2/	M2/	M2/	M2/	M2/
			APPZ	APPZ-003	SPPZ	HPPZ	SPPZ-070
			LF P/N	LF P/N	LF P/N	LF P/N	LF P/N
1	Air Valve Assembly — Lube-free ¹	1	02-2000-65-200	02-2000-65-200	02-2000-65-200	02-2000-65-200	02-2000-65-200
2	Air Valve Cap w/o Guide (Bottom)	1	02-2331-23	02-2331-23	02-2331-23	02-2331-23	02-2331-23
3	Air Valve Cap w/ Plastic Guide (Top)	1	02-2301-23-200	02-2301-23-200	02-2301-23-200	02-2301-23-200	02-2301-23-200
4	Snap Ring	2	02-2650-03	02-2650-03	02-2650-03	02-2650-03	02-2650-03
5	Air Valve Cap O-Ring	2	02-3200-52-200	02-3200-52-200	02-3200-52-200	02-3200-52-200	02-3200-52-200
6	Air Valve Gasket — Buna-N [®]	1	02-2600-52	02-2600-52	02-2600-52	02-2600-52	02-2600-52
7	Center Section — Lube-free ¹	1	02-3151-20-200	02-3151-20-200	02-3151-20-200	02-3151-20-200	02-3151-20-200
8	Muffler Plate	1	02-3180-20	02-3180-20	02-3180-20	02-3180-20	02-3180-20
9	Muffler Plate Gasket — Buna-N [®]	1	02-3500-52-500	02-3500-52-500	02-3500-52-500	02-3500-52-500	02-3500-52-500
10	Air Valve Bolts 1/2"-20 x 6 1/2"	4	02-6000-03-200	02-6000-03-200	02-6000-03-200	02-6000-03-200	02-6000-03-200
11	Center Section 115 70 Shore O-Ring — Buna-N [®]	4	02-3200-52-200	02-3200-52-200	02-3200-52-200	02-3200-52-200	02-3200-52-200
	Slipper Seal (See page 24)	4	02-3210-55-200	02-3210-55-200	02-3210-55-200	02-3210-55-200	02-3210-55-200
12	Shaft ¹	1	02-3800-09-07	02-3800-09-07	02-3800-09-07	02-3800-09-07	02-3800-09-07
13	Stud 3/8"-16 x 1 1/4"	2	N/R	N/R	02-6150-08	02-6150-08	02-6150-08
14	Disc Spring	2	02-6802-08	02-6802-08	02-6802-08	02-6802-08	02-6802-08
15	Pistons — Inner	2	02-3700-08	02-3700-08	02-3700-08	02-3700-08	02-3700-08
16	Diaphragm*	2	*	*	*	*	02-1010-56
17	Pistons — Outer	2	02-4550-01	02-4550-01	02-4550-03	02-4550-04	02-4550-03
18	Liquid Chamber	2	02-5000-01	02-5000-01	02-5000-03	02-5000-04	02-5000-03
19	Discharge Manifold	1	02-5020-01	02-5020-01-03	02-5020-03	02-5020-04	02-5020-03-70
20	Inlet Housing	1	02-5080-01	02-5080-01-03	02-5080-03	02-5080-04	02-5080-03-70
21	Manifold Bolt 1/2"-16 x 8 1/2"	4	02-6080-08	02-6080-03	02-6080-03	02-6080-03	02-6080-03
22	Muffler	1	02-3510-99	02-3510-99	02-3510-99	02-3510-99	02-3510-99
23	Valve Balls*	4	*	*	*	*	02-1080-56
24	Valve Seat	4	02-1120-01	02-1120-01	02-1120-03	02-1120-04	02-1120-03
25	Valve Seat O-Ring*	4	*	*	*	*	02-1200-56
26	Hex Nut 1/20, S.S.** (Not shown)	4	01-6470-03-200	01-6470-03-200	01-6470-03-200	01-6470-03-200	01-6470-03-200
27	Manifold Bolt Washer 3/8"	4	15-6720-08	02-6730-03	02-6730-03	02-6730-03	08-6720-07-70
28	Manifold Bolt Nut 3/8"-16	4	02-6430-08	02-6430-03	02-6430-03	02-6430-03	02-6430-03

-003 Specialty Code = Alloy-Fitted
-005 Specialty Code = Lube-Free, Alloy-Fitted
-070 Specialty Code = Saniflo FDA

¹Air Valve Assembly includes items 2, 3, 4 and 5.

*Refer to corresponding elastomer chart for metal pumps in Section 8.

**Part to be used with P/N 02-6000-03 to secure air valve and muffler plate.

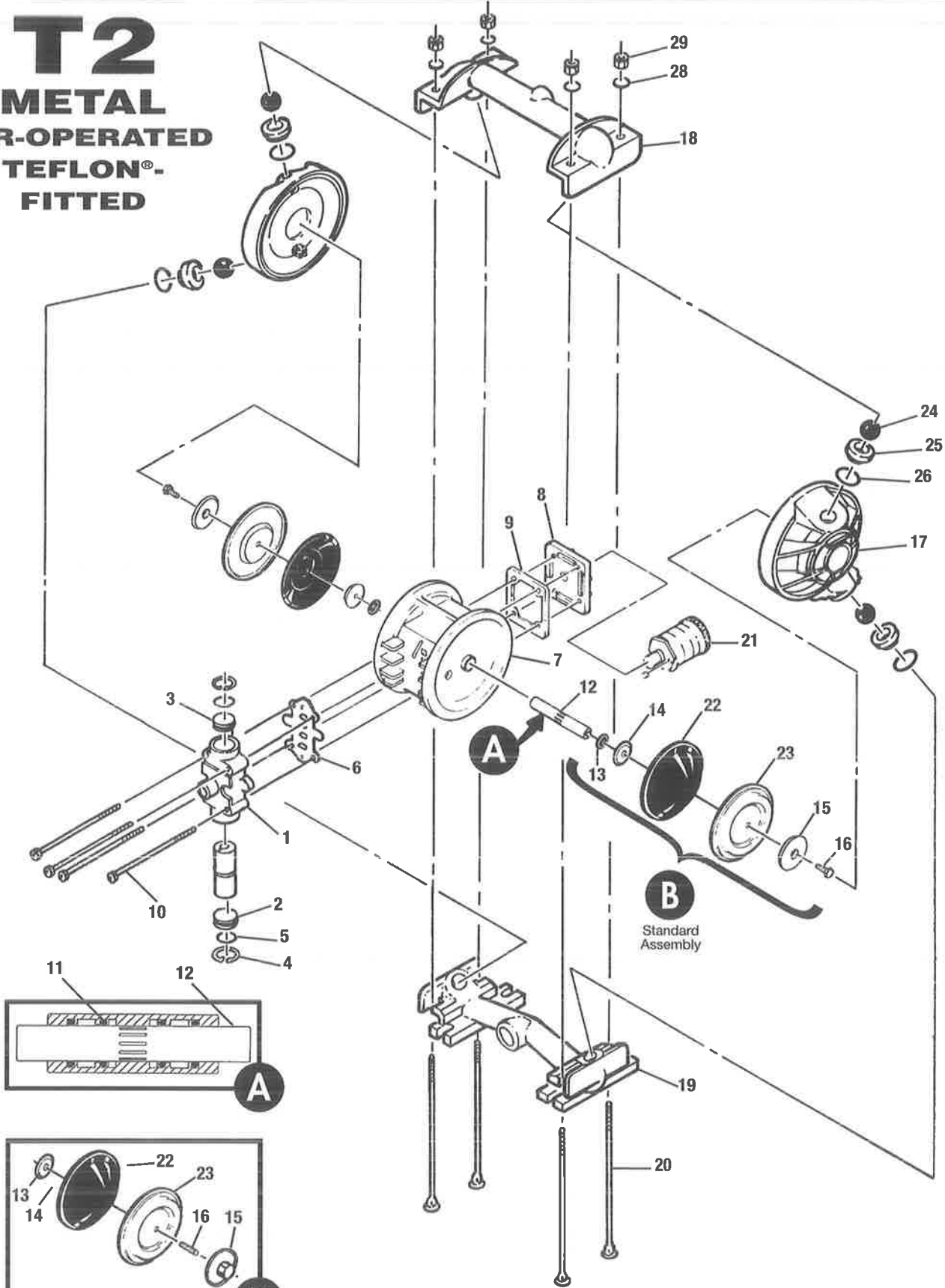
NOTE: Models T2/SPPN-070 and M2/SPPZ-070 have 1.5" cast tri-clamp inlet and outlet ports and use wing nut type fasteners on manifold bolts.

All boldface items are primary wear parts.

SECTION 9B

EXPLODED VIEW/PARTS LISTING

T2
METAL
AIR-OPERATED
TEFLON®-
FITTED



STAINLESS STEEL PUMP
DIAPHRAGM & PISTON ASSEMBLY

Model T2 Metal Air-Operated Teflon®-Fitted Pumps

Item	Description	Qty. Per Pump	T2/APPB/TF/TF/ATF	T2/APPB/TF/TF/ATF-003	T2/SPPB/TF/TF/STF	T2/HPPB/TF/TF/HTF	T2/SPPN/TF/TF/STF-070	T2/AAAB/TF/TF/ATF	T2/AAAB/TF/TF/ATF-003	T2/SAAB/TF/TF/STF	T2/HAAB/TF/TF/HTF
			P/N	P/N	P/N	P/N	P/N	P/N	P/N	P/N	P/N
1	Air Valve Assembly ¹	1	02-2000-07	02-2000-07	02-2000-07	02-2000-07	02-2000-07	02-2000-06	02-2000-07	02-2000-07	02-2000-07
2	Air Valve Cap w/ Guide (Bottom)	1	02-2331-23	02-2331-23	02-2331-23	02-2331-23	02-2331-23	02-2331-23	02-2331-23	02-2331-23	02-2331-23
3	Air Valve Cap w/ Guide (Top)	1	02-2301-23	02-2301-23	02-2301-23	02-2301-23	02-2301-23	02-2301-23	02-2301-23	02-2301-23	02-2301-23
4	Snap Ring	2	02-2650-03	02-2650-03	02-2650-03	02-2650-03	02-2650-03	02-2650-03	02-2650-03	02-2650-03	02-2650-03
5	Air Valve Cap O-Ring	2	02-3200-52-200	02-3200-52-200	02-3200-52-200	02-3200-52-200	02-3200-52-200	02-3200-52-200	02-3200-52-200	02-3200-52-200	02-3200-52-200
6	Air Valve Gasket — Buna-N [®]	1	02-2600-52	02-2600-52	02-2600-52	02-2600-52	02-2600-52	02-2600-52	02-2600-52	02-2600-52	02-2600-52
7	Center Section	1	02-3151-20	02-3151-20	02-3151-20	02-3151-20	02-3151-20	02-3150-01	02-3150-01	02-3150-01	02-3150-01
8	Muffler Plate	1	02-3180-20	02-3180-20	02-3180-20	02-3180-20	02-3180-20	02-3180-01	02-3180-01	02-3180-01	02-3180-01
9	Muffler Plate Gasket — Buna-N [®]	1	02-3500-52-500	02-3500-52-500	02-3500-52-500	02-3500-52-500	02-3500-52-500	02-3500-52-110	02-3500-52-110	02-3500-52-110	02-3500-52-110
10	Air Valve Screws	4	02-6000-08	02-6000-03	02-6000-03	02-6000-03	02-6000-03	02-6000-08	02-6000-03	02-6000-03	02-6000-03
11	Center Section Glyd™ Ring	4	02-3210-55-225	02-3210-55-225	02-3210-55-225	02-3210-55-225	02-3210-55-225	02-3210-55-225	02-3210-55-225	02-3210-55-225	02-3210-55-225
12	Shaft	1	02-3820-09-07	02-3820-09-07	02-3820-09-07	02-3820-09-07	02-3820-09-07	02-3820-09-07	02-3820-09-07	02-3820-09-07	02-3820-09-07
13	Disc Spring	2	02-6802-08	02-6802-08	02-6802-08	02-6802-08	02-6802-08	02-6802-08	02-6802-08	02-6802-08	02-6802-08
14	Pistons — Inner	2	02-3750-01	02-3750-01	02-3750-01	02-3750-01	02-3750-01	02-3750-01	02-3750-01	02-3750-01	02-3750-01
15	Pistons — Outer	2	02-4600-01	02-4600-03	02-4600-03	02-4600-04	02-4600-03	02-4600-01	02-4600-03	02-4600-03	02-4600-04
16	Stud/Bolt	2	15-6130-08	02-6150-08	02-6150-08	02-6150-08	02-6150-08	15-6130-08	02-6150-08	02-6150-08	02-6150-08
17	Liquid Chamber	2	02-5000-01	02-5000-01	02-5000-03	02-5000-04	02-5000-03	02-5000-01	02-5000-01	02-5000-03	02-5000-04
18	Discharge Manifold	1	02-5020-01	02-5020-01-03	02-5020-03	02-5020-04	02-5020-03-70	02-5020-01	02-5020-01-03	02-5020-03	02-5020-04
19	Inlet Housing	1	02-5080-01	02-5080-01-03	02-5080-03	02-5080-04	02-5080-03-70	02-5080-01	02-5080-01-03	02-5080-03	02-5080-04
20	Manifold Bolt 3/8"-16 x 8 1/2"	4	02-6080-03	02-6080-03	02-6080-03	02-6080-03	02-6080-03	02-6080-03	02-6080-03	02-6080-03	02-6080-03
21	Muffler	1	02-3510-99	02-3510-99	02-3510-99	02-3510-99	02-3510-99	02-3510-99	02-3510-99	02-3510-99	02-3510-99
22	Back-up Diaphragm*	2	02-1060-51	02-1060-51	02-1060-51	02-1060-51	02-1060-51	02-1060-51	02-1060-51	02-1060-51	02-1060-51
23	Diaphragm	2	02-1010-55	02-1010-55	02-1010-55	02-1010-55	02-1010-55	02-1010-55	02-1010-55	02-1010-55	02-1010-55
24	Valve Balls	4	02-1080-55	02-1080-55	02-1080-55	02-1080-55	02-1080-55	02-1080-55	02-1080-55	02-1080-55	02-1080-55
25	Valve Seat	4	02-1120-01	02-1120-03	02-1120-03	02-1120-04	02-1120-03	02-1120-01	02-1120-01	02-1120-03	02-1120-04
26	Valve Seat O-Ring	4	02-1200-55	02-1200-55	02-1200-55	02-1200-55	02-1200-55	02-1200-55	02-1200-55	02-1200-55	02-1200-55
27	Hex Nut 1/2-20, S.S.** (Not shown)	4	04-6400-03	04-6400-03	04-6400-03	04-6400-03	04-6400-03	N/A	N/A	N/A	N/A
28	Manifold Bolt Washer 3/8"	4	15-6720-08	02-6730-03	02-6730-03	02-6730-03	08-6720-07-70	15-6720-08	02-6730-03	02-6730-03	02-6730-03
29	Manifold Bolt Nut 3/8"-16	4	02-6430-03	02-6430-03	02-6430-03	02-6430-03	02-6680-03-70	02-6430-03	02-6430-03	02-6430-03	02-6430-03

Lube-Free Model M2 Metal Air-Operated Teflon®-Fitted Pumps

Item	Description	Qty. Per Pump	M2/APPZ	M2/APPZ-003	M2/SPPZ	M2/HPPZ	M2/SPPZ-070
			LF P/N	LF P/N	LF P/N	LF P/N	LF P/N
1	Air Valve Assembly — Lube-free ¹	1	02-2000-65-200	02-2000-65-200	02-2000-65-200	02-2000-65-200	02-2000-65-200
2	Air Valve Cap w/o Guide (Bottom)	1	02-2331-23	02-2331-23	02-2331-23	02-2331-23	02-2331-23
3	Air Valve Cap w/ Plastic Guide (Top)	1	02-2301-23-200	02-2301-23-200	02-2301-23-200	02-2301-23-200	02-2301-23-200
4	Snap Ring	2	02-2650-03	02-2650-03	02-2650-03	02-2650-03	02-2650-03
5	Air Valve Cap O-Ring	2	02-3200-52-200	02-3200-52-200	02-3200-52-200	02-3200-52-200	02-3200-52-200
6	Air Valve Gasket — Buna-N [®]	1	02-2600-52	02-2600-52	02-2600-52	02-2600-52	02-2600-52
7	Center Section — Lube-free ¹	1	02-3151-20-200	02-3151-20-200	02-3151-20-200	02-3151-20-200	02-3151-20-200
8	Muffler Plate	1	02-3180-20	02-3180-20	02-3180-20	02-3180-20	02-3180-20
9	Muffler Plate Gasket — Buna-N [®]	1	02-3500-52-500	02-3500-52-500	02-3500-52-500	02-3500-52-500	02-3500-52-500
10	Air Valve Bolts 1/2"-20 x 6 1/2"	4	02-6000-03-200	02-6000-03-200	02-6000-03-200	02-6000-03-200	02-6000-03-200
11	Center Section 115 70 Shore O-Ring — Buna-N [®]	4	02-3200-52-200	02-3200-52-200	02-3200-52-200	02-3200-52-200	02-3200-52-200
	Slipper Seal	4	02-3210-55-200	02-3210-55-200	02-3210-55-200	02-3210-55-200	02-3210-55-200
12	Shaft ¹	1	02-3820-09-07	02-3820-09-07	02-3820-09-07	02-3820-09-07	02-3820-09-07
13	Disc Spring	2	02-6802-08	02-6802-08	02-6802-08	02-6802-08	02-6802-08
14	Pistons — Inner	2	02-3750-01	02-3750-01	02-3750-01	02-3750-01	02-3750-01
15	Pistons — Outer	2	02-4600-01	02-4600-03	02-4600-03	02-4600-04	02-4600-03
16	Stud/Bolt	2	15-6130-08	02-6150-08	02-6150-08	02-6150-08	02-6150-08
17	Liquid Chamber	2	02-5000-01	02-5000-01	02-5000-03	02-5000-04	02-5000-03
18	Discharge Manifold	1	02-5020-01	02-5020-01-03	02-5020-03	02-5020-04	02-5020-03-70
19	Inlet Housing	1	02-5080-01	02-5080-01-03	02-5080-03	02-5080-04	02-5080-03-70
20	Manifold Bolt 3/8"-16 x 8 1/2"	4	02-6080-03	02-6080-03	02-6080-03	02-6080-03	02-6080-03
21	Muffler	1	02-3510-99	02-3510-99	02-3510-99	02-3510-99	02-3510-99
22	Back-up Diaphragm*	2	02-1060-51	02-1060-51	02-1060-51	02-1060-51	02-1060-51
23	Diaphragm	2	02-1010-55	02-1010-55	02-1010-55	02-1010-55	02-1010-55
24	Valve Balls	4	02-1080-55	02-1080-55	02-1080-55	02-1080-55	02-1080-55
25	Valve Seat	4	02-1120-01	02-1120-03	02-1120-03	02-1120-04	02-1120-03
26	Valve Seat O-Ring	4	02-1200-55	02-1200-55	02-1200-55	02-1200-55	02-1200-55
27	Hex Nut 1/2-20, S.S.** (Not shown)	4	01-6470-03-200	01-6470-03-200	01-6470-03-200	01-6470-03-200	01-6470-03-200
28	Manifold Bolt Washer 3/8"	4	15-6720-08	02-6730-03	02-6730-03	02-6730-03	08-6720-07-70
29	Manifold Bolt Nut 3/8"-16	4	02-6430-03	02-6430-03	02-6430-03	02-6430-03	02-6680-03-70

- 003 Specialty Code = Alloy-Fitted
- 005 Specialty Code = Spark-Free, Lube-Free/Turbo
- 070 Specialty Code = Saniflo FDA
- 073 Specialty Code = Saniflo FDA, Lube-Free/Turbo
- 200 Specialty Code = Lube-Free

¹Air Valve Assembly includes items 2, 3, 4 and 5.

*Required only for Teflon®-fitted pumps. Saniflex™ back-up diaphragms, P/N 02-1060-56, are available upon request. Please consult your local distributor.

**Part to be used with P/N 02-6000-03 to secure air valve and muffler plate.

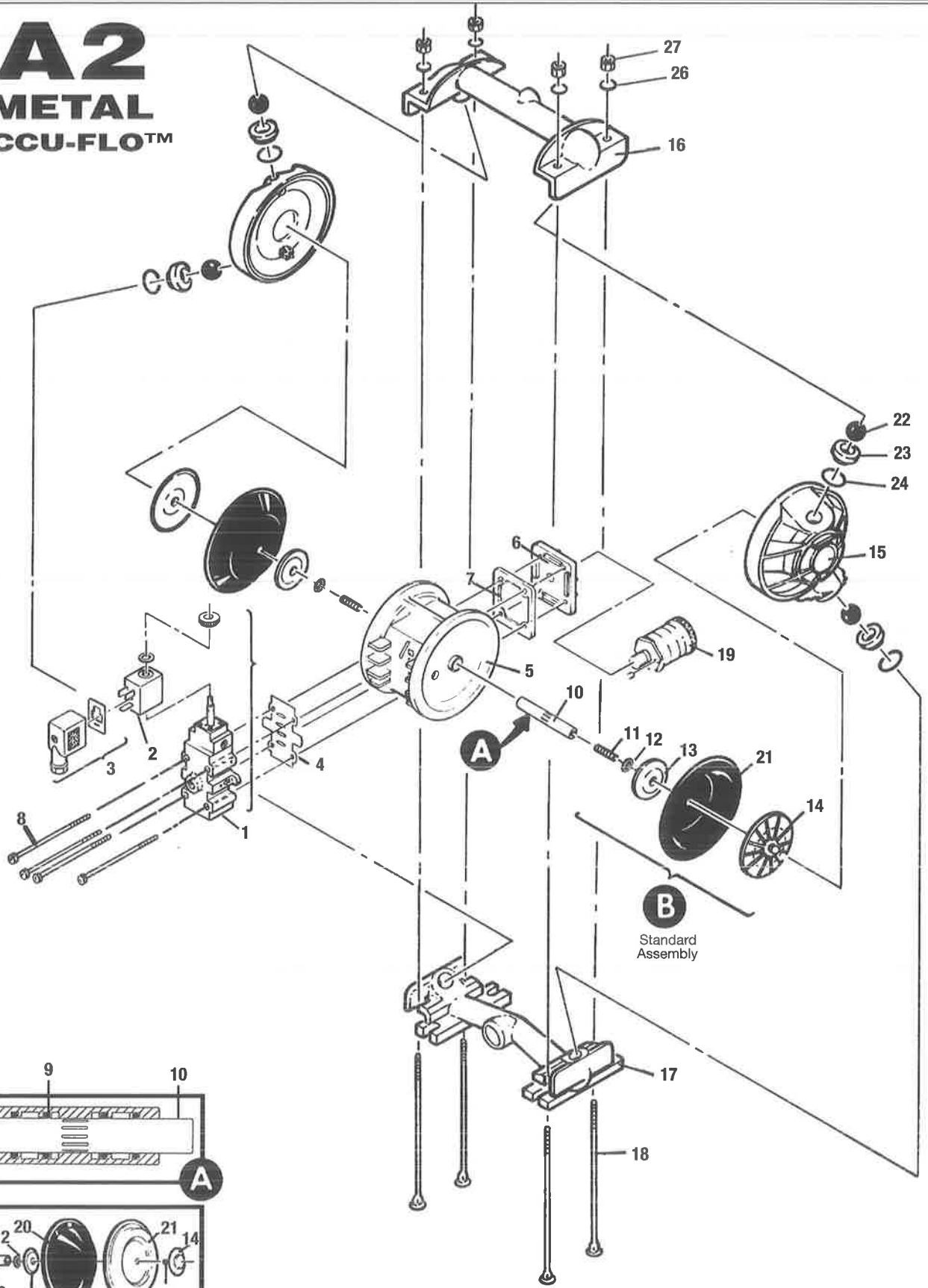
NOTE: Model T2/SPPN-070 has 1.5" cast tri-clamp inlet and outlet ports and uses wing nut type fasteners on manifold bolts.

All boldface items are primary wear parts.

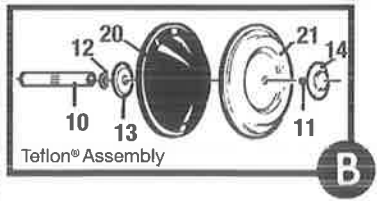
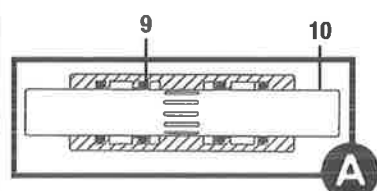
SECTION 9C

EXPLODED VIEW/PARTS LISTING

A2
METAL
ACCU-FLO™



B
 Standard
 Assembly



NOTE: Teflon® Diaphragm Models Assembled With Teflon® Gasket Kit At Factory (Not Shown)

Model A2 Metal Accu-Flo™ Rubber/TPE-Fitted Pumps

Item	Description	Qty. Per Pump	Teflon®-Fitted Pumps											
			A2/ APPA-150 P/N	A2/ APPA-194 P/N	A2/ SPPA-150 P/N	A2/ HPPA150 P/N	A2/ SPPA-125 P/N	A2/ APPA-150 P/N	A2/ APPA-194 P/N	A2/ SPPA-150 P/N	A2/ HPPA-150 P/N	A2/ SPPA-125 P/N		
1	Solenoid Valve Assembly	1	02-2000-99-150	02-2000-99-150	02-2000-99-150	02-2000-99-150	02-2000-99-150	02-2000-99-150	02-2000-99-150	02-2000-99-150	02-2000-99-150	02-2000-99-150	02-2000-99-150	02-2000-99-150
1	Main Valve Assembly	1	02-2000-01-150	02-2000-01-150	02-2000-01-150	02-2000-01-150	02-2000-01-150	02-2000-01-150	02-2000-01-150	02-2000-01-150	02-2000-01-150	02-2000-01-150	02-2000-01-150	02-2000-01-150
2	Coil	1	02-2110-99-150	02-2110-99-150	02-2110-99-150	02-2110-99-150	02-2110-99-150	02-2110-99-150	02-2110-99-150	02-2110-99-150	02-2110-99-150	02-2110-99-150	02-2110-99-150	02-2110-99-150
3	Terminal Connector	1	00-2130-99	00-2130-99	00-2130-99	00-2130-99	00-2130-99	00-2130-99	00-2130-99	00-2130-99	00-2130-99	00-2130-99	00-2130-99	00-2130-99
4	Air Valve Gasket — Buna-N®	1	02-2600-52	02-2600-52	02-2600-52	02-2600-52	02-2600-52	02-2600-52	02-2600-52	02-2600-52	02-2600-52	02-2600-52	02-2600-52	02-2600-52
5	Center Section	1	02-3151-20	02-3151-20	02-3151-20	02-3151-20	02-3151-20	02-3151-20	02-3151-20	02-3151-20	02-3151-20	02-3151-20	02-3151-20	02-3151-20
6	Muffler Plate	1	02-3180-20	02-3180-20	02-3180-20	02-3180-20	02-3180-20	02-3180-20	02-3180-20	02-3180-20	02-3180-20	02-3180-20	02-3180-20	02-3180-20
7	Muffler Plate Gasket — Buna-N®	1	02-3500-52-500	02-3500-52-500	02-3500-52-500	02-3500-52-500	02-3500-52-500	02-3500-52-500	02-3500-52-500	02-3500-52-500	02-3500-52-500	02-3500-52-500	02-3500-52-500	02-3500-52-500
8	Air Valve Screws	4	02-6000-08	02-6000-03	02-6000-03	02-6000-03	02-6000-03	02-6000-03	02-6000-08	02-6000-03	02-6000-03	02-6000-03	02-6000-03	02-6000-03
9	Center Section Glyd™ Ring	4	02-3210-55-225	02-3210-55-225	02-3210-55-225	02-3210-55-225	02-3210-55-225	02-3210-55-225	02-3210-55-225	02-3210-55-225	02-3210-55-225	02-3210-55-225	02-3210-55-225	02-3210-55-225
10	Shaft	1	02-3820-09-07	02-3820-09-07	02-3820-09-07	02-3820-09-07	02-3820-09-07	02-3820-09-07	02-3820-09-07	02-3820-09-07	02-3820-09-07	02-3820-09-07	02-3820-09-07	02-3820-09-07
11	Stud	2	N/R	N/R	02-6150-08	02-6150-08	02-6150-08	02-6090-08	02-6150-08	02-6150-08	02-6150-08	02-6150-08	02-6150-08	02-6150-08
12	Disc Spring	2	02-6802-08	02-6802-08	02-6802-08	02-6802-08	02-6802-08	02-6802-08	02-6802-08	02-6802-08	02-6802-08	02-6802-08	02-6802-08	02-6802-08
13	Pistons — Inner	2	02-3750-01	02-3750-01	02-3750-01	02-3750-01	02-3750-01	02-3750-01	02-3750-01	02-3750-01	02-3750-01	02-3750-01	02-3750-01	02-3750-01
14	Pistons — Outer	2	02-4550-01	02-4550-01	02-4550-03	02-4550-03	02-4550-04	02-4550-03	02-4600-01	02-4600-03	02-4600-03	02-4600-04	02-4600-03	02-4600-03
15	Liquid Chamber	2	02-5000-01	02-5000-01	02-5000-03	02-5000-04	02-5000-03	02-5000-01	02-5000-01	02-5000-03	02-5000-04	02-5000-03	02-5000-03	02-5000-03
16	Discharge Manifold	1	02-5020-01	02-5020-01-03	02-5020-03	02-5020-04	02-5020-03-70	02-5020-01	02-5020-01-03	02-5020-03	02-5020-04	02-5020-03-70	02-5020-03-70	02-5020-03-70
17	Inlet Housing	1	02-5080-01	02-5080-01-03	02-5080-03	02-5080-04	02-5080-03-70	02-5080-01	02-5080-01-03	02-5080-03	02-5080-04	02-5080-03-70	02-5080-03-70	02-5080-03-70
18	Manifold Bolt	4	02-6080-08	02-6080-03	02-6080-03	02-6080-03	02-6080-03	02-6080-03	02-6080-03	02-6080-03	02-6080-03	02-6080-03	02-6080-03	02-6080-03
19	Muffler	1	02-3510-99	02-3510-99	02-3510-99	02-3510-99	02-3510-99	02-3510-99	02-3510-99	02-3510-99	02-3510-99	02-3510-99	02-3510-99	02-3510-99
20	Back-up Diaphragm**	2	N/R	N/R	N/R	N/R	N/R	02-1060-51	02-1060-51	02-1060-51	02-1060-51	02-1060-51	02-1060-51	02-1060-51
21	Diaphragm*	2	*	*	*	*	02-1010-56	02-1010-55	02-1010-55	02-1010-55	02-1010-55	02-1010-55	02-1010-55	02-1010-55
22	Valve Balls*	4	*	*	*	*	02-1080-56	02-1080-55	02-1080-55	02-1080-55	02-1080-55	02-1080-55	02-1080-55	02-1080-55
23	Valve Seat	4	02-1120-01	02-1120-01	02-1120-03	02-1120-04	02-1120-03	02-1120-01	02-1120-01	02-1120-03	02-1120-04	02-1120-03	02-1120-03	02-1120-03
24	Valve Seat O-Ring*	4	*	*	*	*	02-1200-56	02-1200-55	02-1200-55	02-1200-55	02-1200-55	02-1200-55	02-1200-55	02-1200-55
25	Hex Nut X-20, S.S.*** (Not Shown)	4	04-6400-08	04-6400-08	04-6400-03	04-6400-03	04-6400-03	04-6400-08	04-6400-08	04-6400-03	04-6400-03	04-6400-03	04-6400-03	04-6400-03
26	Manifold Bolt Washer	4	15-6720-08	15-6720-08	02-6730-03	02-6730-03	08-6720-07-70	15-6720-08	15-6720-08	02-6730-03	02-6730-03	08-6720-07-70	02-6730-03	08-6720-07-70
27	Manifold Bolt Nut	4	02-6430-08	02-6430-08	02-6430-03	02-6430-03	02-6680-03-70	02-6430-08	02-6430-03	02-6430-03	02-6430-03	02-6430-03	02-6680-03-70	02-6680-03-70

*Refer to corresponding elastomer chart for metal pumps in Section 10.

**Required only for Teflon® fitted pumps.

***Part to be used with P/N 02-6000-03 to secure air valve and muffler plate.

NOTE: Models A2/SPPE-125 rubber-fitted and A2/SPPE-125 Teflon®-fitted have 1.5" cast tri-clamp inlet and outlet ports and use wing nut type fasteners on manifold bolts. (Food Processing pumps.)

-125 Specialty Code = Saniflo USDA with Solenoid, 24V DC -150 Specialty Code = Solenoid-Operated, 24V DC -194 Specialty Code = Solenoid-Operated, 24V DC, Spark-Free

All boldface items are primary wear parts.

Valve Assembly Options (CONSISTS OF VALVE BODY, COIL AND CONNECTOR)

Pump Models Designating Specialty Code #	Part Number	Description
151	02-2000-99-151	24V AC / 12V DC Valve Assembly
153	02-2000-99-153	24V AC / 12V DC Valve Assembly (NEMA 7)
150	02-2000-99-150	24V DC Valve Assembly
154	02-2000-99-154	24V DC Valve Assembly (NEMA 7)
157	02-2000-99-157	24V DC Valve Assembly ¹
155	02-2000-99-155	110V AC Valve Assembly
156	02-2000-99-156	110V AC Valve Assembly (NEMA 7)

Item 1 Main Valve Body Options

Part Number	Description
02-2040-01-150	Main Valve Body
02-2040-01-154	Main Valve Body (NEMA 7)

Item 2 Coil Options

Pump Models Designating Specialty Code #	Part Number	Description
151	00-2110-99-151	24V AC / 12V DC Coil
153	00-2110-99-153	24V AC / 12V DC Coil (NEMA 7)
150	00-2110-99-150	24V DC Coil
154	00-2110-99-154	24V DC Coil (NEMA 7)
155	00-2110-99-155	110V AC Coil
156	00-2110-99-156	110V AC Coil (NEMA 7)
157	00-2110-99-157	International 24V DC Coil ¹

¹Meet European standards and regulations; CENELEC/PTB file # EX-9.C.2027.

SECTION 10A

ELASTOMER OPTIONS

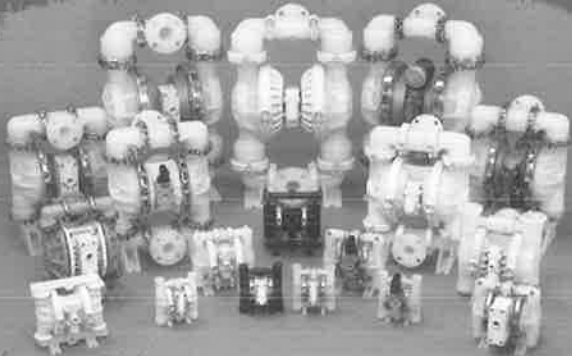
Elastomer Options for Model T2 Metal Pumps

Material	Diaphragm P/N	Valve Ball P/N	Valve Seat P/N	Valve Seat O-Ring* P/N
Polyurethane	02-1010-50	02-1080-50	N/A	02-1200-50
Buna-N®	02-1010-52	02-1080-52	N/A	02-1200-52
Neoprene	02-1010-51	02-1080-51	N/A	N/A
Nordel (EPDM)	02-1010-54	02-1080-54	N/A	02-1200-54
Viton®	02-1010-53	02-1080-53	N/A	N/A
Wil-Flex™	02-1010-58	02-1080-58	N/A	02-1200-58
Saniflex™	02-1010-56	02-1080-56	N/A	02-1200-56
Teflon® PTFE	02-1010-55	02-1080-55	N/A	02-1200-55
Stainless Steel	N/A	N/A	02-1120-03	N/A
Aluminum	N/A	N/A	02-1120-01	N/A
Hastelloy	N/A	N/A	02-1120-04	N/A

*NOTE: Rubber valve seats do not require an O-ring.

ENGINEERED REVOLUTION

"Revolutionizing the way you solve your toughest pumping problems"



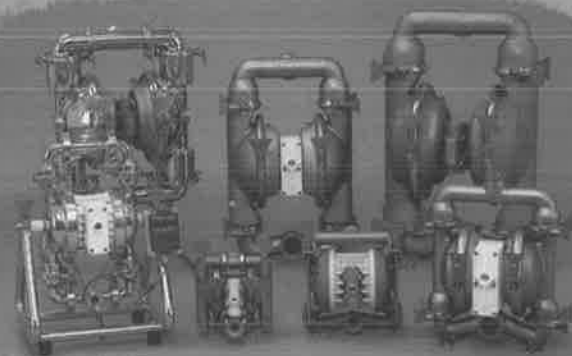
Plastic

- Polypropylene
- Carbon-Filled Acetal
- PVDF
- Teflon® PTFE
- Teflon® PFA



Metal

- Aluminum
- 316 S.S.
- Cast Iron
- Hastelloy



SANIFLO™
SANITARY PUMP TECHNOLOGY

FDA USDA 3A

HYTEC
BELLOWS TECHNOLOGY



ULTRAPURE
TEFLON PROCESS PUMPS

- Teflon® PFA
- Teflon® PTFE



Accessories

- SPCI
- Wil-Gard
- FCSI
- Equalizers
- Drum Pump Kits
- APV



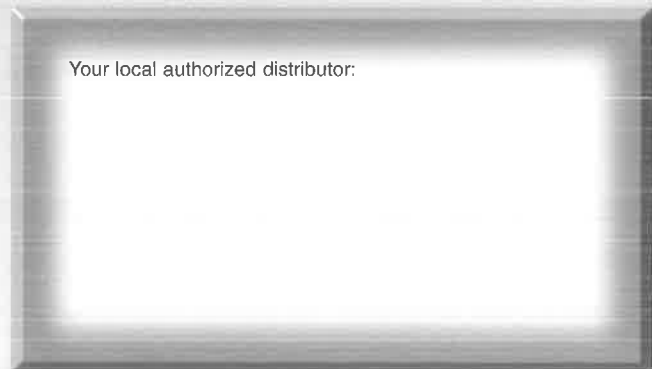
WILDEN®

AIR OPERATED DOUBLE DIAPHRAGM PUMPS

22069 Van Buren St., Grand Terrace, CA 92313-5607
Telephone (909) 422-1730 • Fax (909) 783-3440
www.wildenpump.com

A **DOVER** RESOURCES COMPANY

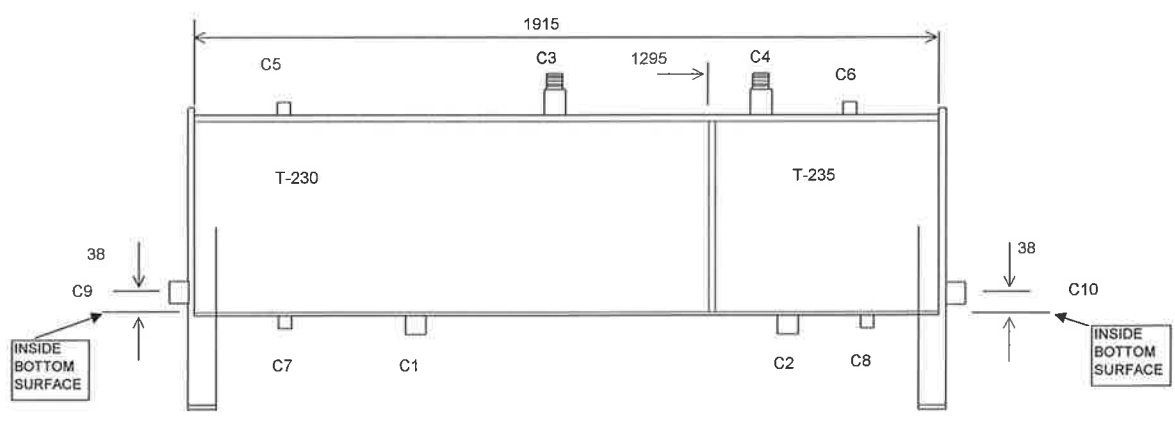
Your local authorized distributor:



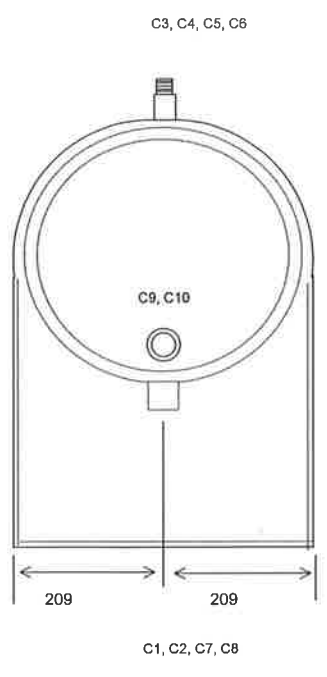
PROPAK SYSTEMS LTD POSTAL BAG # 2, AIRDRIE, ALBERTA, CANADA T4B 2C3				TANK			SHEET 1 OF 2	FILE NO: 11.7.T	REQ.#
CUSTOMER	STOCK UNIT	REV	BY	DATE	REVISION	DESCRIPTION			
PLANT	STOCK 1380 HP COMPRESSOR	0	TK	01/25/00	ISSUED TO DRAFTING				
SERVICE	JACKET / AUXILIARY WATER SURGE TANKS	1	DP	03/20/00	REVISED TO STD SIZE FOR 12 CYL WAUK. VHP ENGINE				
JOB NO.	99420 TAG NO: T-235A/B								
MFR.	PROPAK MODEL NO:								
1	PART	REQ'D(THICKNESS)	MATERIAL (SPEC)	MK	SERVICE	SIZE	RATING	FLANGE	PROJECT
2	SHELL	6.35 mm	SA-53- B SMLS	N1					
3	HEADS	6.35 mm	SA-36	N2					
4	FLOOR		---	N3					
5	SUPPORT / STAND		SA-36	N4					
6	PIPE		SA-106 B	N5					
7	PIPE FITTINGS		SA-234 WPB SMLS	N6					
8	FLANGES		---	N7					
9	COUPLINGS		SA-105	N8					
10	BOLTS		SA-193-B7	N9					
11	NUTS		SA-194-2H	N10					
12	GASKETS		---	N11					
13	COIL		---	N12					
14	RISER		---						
15	BAFFLES		SA-36	C1	BALANCE LINE JW	48	3000#	CPLG	
16	INTERNAL LADDER		---	C2	BALANCE LINE AW	48	3000#	CPLG	
17	SUMP		---	C3	PRESSURE CAP / FILL JW	60	3000#	CPLG	
18	SYPHON DRAIN		---	C4	PRESSURE CAP / FILL AW	60	3000#	CPLG	
19	VORTEX BREAKER		---	C5	LG - VAPOUR SIDE JW	21	3000#	CPLG	
20	DISTRIB SPIDER		---	C6	LG - VAPOUR SIDE AW	21	3000#	CPLG	
21	LADDER		---	C7	LG- LIQUID SIDE JW	21	3000#	CPLG	
22	PLATFORMS		---	C8	LG- LIQUID SIDE AW	21	3000#	CPLG	
23	LADDER CLIPS		---	C9	LSL - JW	48	3000#	CPLG	
24	PLATFORM CLIPS		---	C10	LSL - AW	48	3000#	CPLG	
25	PIPE CLIPS		---	C11					
26	FIREPROOF CLIPS		---	C12					
27	INSULATION RINGS		---						
28	LIFTING LUGS		---	M1					
29	LEVEL INDICATOR		---	M2					
30	THIEF HATCH		---						
31	PRESS / VAC RELIEF		---						
32	EXTENDED MANWAY		---						
33									
34									
35									
36									
37	DESIGN DATA								
38	SIZE: ID (mm)		OD: (mm)	406	NOTES: [1] SEE PAGE 2 FOR SKETCH				
39	S/S (mm)	1295 / 620							
40	DES. PRESS. (kPa)	ATM.	OPER. PRESS. (kPa)	70					
41	DES. TEMP. ° C	100	OPER. TEMP. ° C	93					
42	HYDROTEST (kPag)	130	CORR. ALLOW. (mm)	0.0					
43	MDMT	-28	CYCLIC LOAD	NO					
44	X-RAY	NO	STRESS RELIEVE	NO					
45	WIND LOAD (km / h)	---	EARTHQUAKE ZONE	NO					
46	SOUR SERVICE	NO	INSUL. THK (mm)	NONE					
47	FIREPROOF	NONE	REFACTORY THK (mm)	NONE					
48	INT. SURFACE PREP.	NONE	EXT. SURFACE PREP.	PNT-11					
49	INT. COATING	NONE	PRIMER COAT	PNT-11					
50	ASME SEC. VIII DIV.	NO	FINISH COAT	PNT-11					
51	'U' STAMP REQ'D	NO	FINISH COLOR	C705 (CARBOLINE GREY)					
52									
53	WEIGHT EMPTY (kg)		HYDRO WEIGHT (kg)						
54	LSD	NO							
55									
56									
57									
58									
59									

CUSTOMER : PROPAK	REV	BY	DATE	REVISION DESCRIPTION
PLANT : STOCK 1380 HP COMPRESSOR	1	DCP	06.03.00	ISSUED FOR CONSTRUCTION
SERVICE : ENGINE JW / AW SURGE TANK				
JOB NO. : 99420 TAG NO: T-230 / 235				
MFR. : PROPAK MODEL NO: W1380-6HOS-3				

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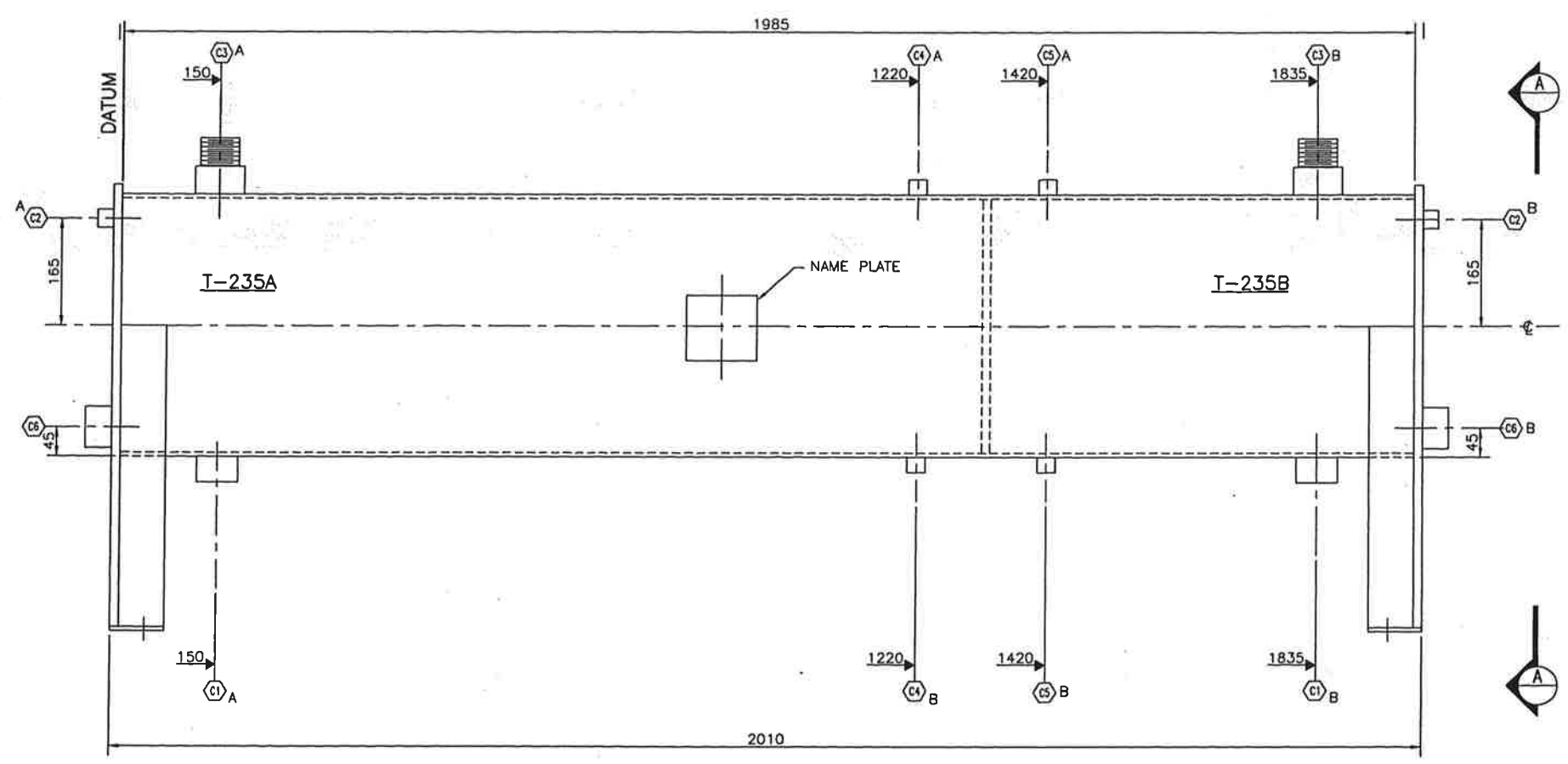


- NOTE
- [1] C5 AND C7 ALIGNED WITH ONE ANOTHER
C6 AND C8 ALIGNED WITH ONE ANOTHER
 - [2] THIS TANK DRAWING CAN BE APPLIED TO ANY 12 CYLINDER WAUKESHA VHP ENGINE

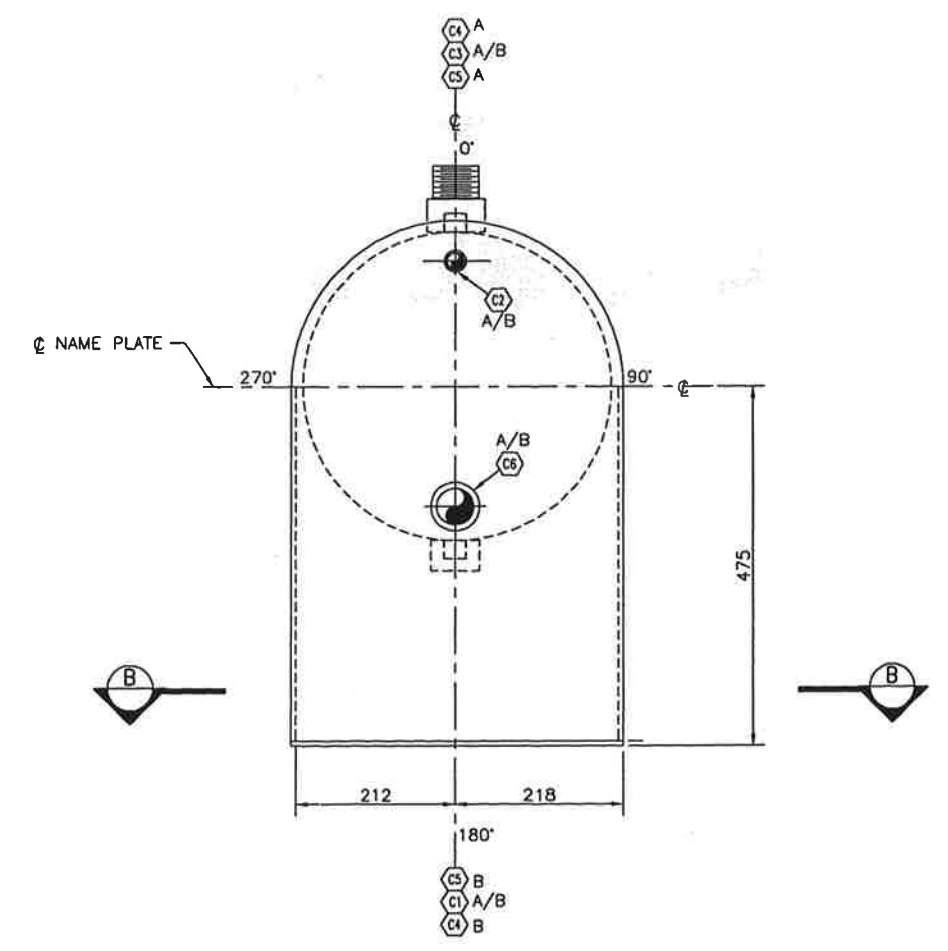


THE DESIGN IT COVERS ARE CONFIDENTIAL AND THE PROPERTY OF PROPAK SYSTEMS LTD., AND SHALL NOT BE DISCLOSED TO OTHERS OR REPRODUCED IN ANY MANNER OR USED FOR ANY PURPOSE WHATSOEVER EXCEPT BY WRITTEN CONSENT OF PROPAK.

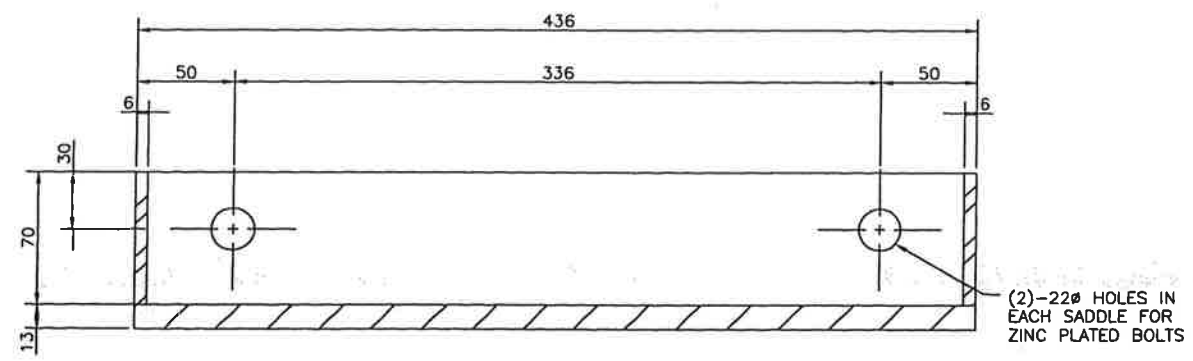
NOZZLE SCHEDULE									
MK	SIZE	RATING	FACING	SCH	SERVICE	INT. PROJ	EXT. PROJ	WELD	
A/B	C1	48	3000#	HALF CPLG	--	SHUNT LINE	--	--	--
A/B	C2	21	3000#	HALF CPLG	--	VENT	--	--	--
A/B	C3	60	3000#	HALF CPLG	--	PRV VENT/FILL	--	--	--
A/B	C4	21	3000#	HALF CPLG	--	LG	--	--	--
A/B	C5	21	3000#	HALF CPLG	--	LG	--	--	--
A/B	C6	48	3000#	HALF CPLG	--	LSL-235 A/B	--	--	--



ELEVATION
SCALE: 1:5



VIEW 'A-A'
SCALE: 1:5



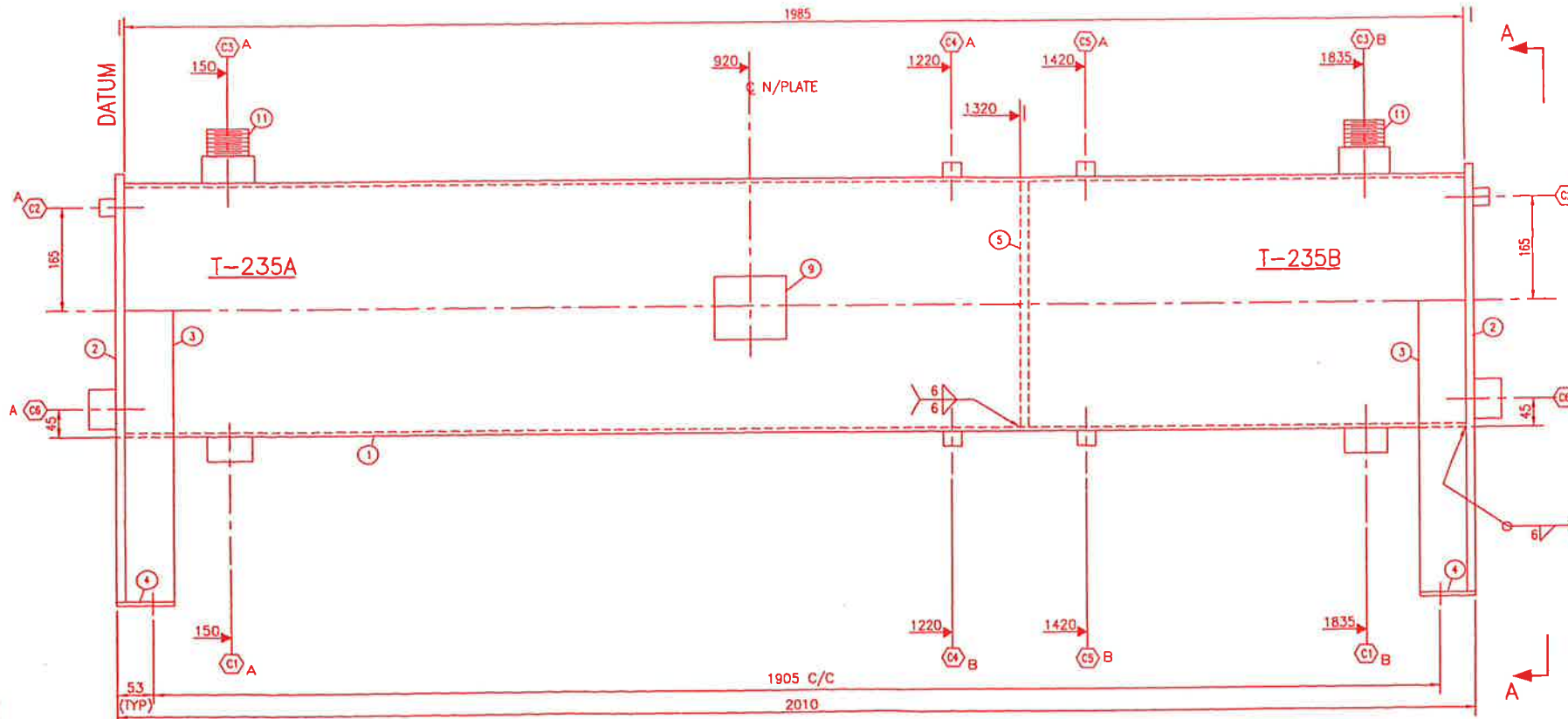
VIEW 'B-B'
SCALE: 1:2

CAPACITY: T-235A: 0.161 m ³ T-235B: 0.079 m ³	SERIAL NO: 99420-112 CRN: N/A
WEIGHT EMPTY: 237 kg	TAG NO: T-235A/B YEAR BUILT: 2000
WEIGHT FULL OF WATER: 477 kg	LSL #: -
SURFACE PREPARATION: PNT-11	CODE: NON CODE
PRIMER: PNT-11	DESIGN PRESS: 101 kPag
FINISH PAINT: PNT-11	DESIGN TEMP: 100 °C
INSULATION: NONE	HYDROTEST: 150 kPag
SERVICE: GLYCOL	MATERIAL: HEAD: SA-36
	SHELL: SA-53-B (MIN)
	RADIOGRAPHY:
	LONG L: N/A
	CIRC: N/A
	P.W.H.T.:
	<input checked="" type="checkbox"/> YES <input type="checkbox"/> NO
	CORR. ALLOW: NIL

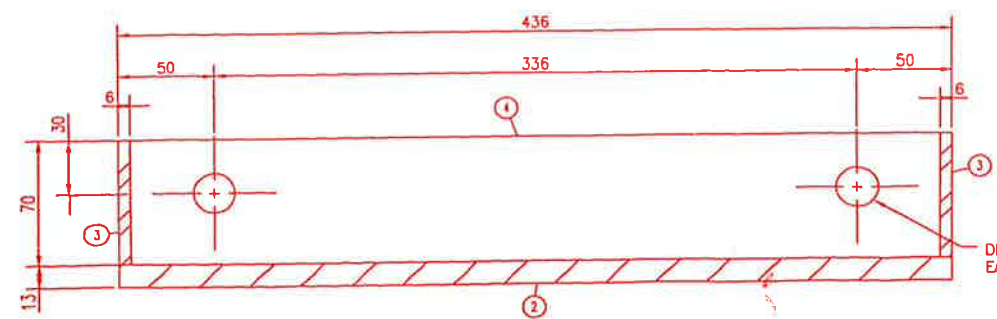
GENERAL NOTES		GENERAL NOTES		SKT	ISSUED FOR DOCUMENTATION	H. LE	00/09/15	VK	SW	APPROVED	DRAWN	APACHE CANADA LIMITED	
DATE: 2000.09.26 8:28am	FILE NAME: J:\jobs99\DWG\99420\Comp\Misc\TNK-99420-112-SKT-01.dwg	No.	REVISION	BY	DATE	CKD	ENG			MECH./STRUCT.	BY	DATE	1478 HP HAMBURG COMPRESSOR PACKAGE
										ELECTRICAL	CHECKED	406 O/D x 1985 LG.	440 East Lake Road,
										PROJECT	DATE	DWG. No.: D-TNK-99420-112-SKT	Postal Bag #2
										DATE	SCALE AS NOTED	SHT. 1 OF 1	Airdrie, Alberta
												REV. SKT	Canada T4B 2C3

OTHERS OR REPRODUCED IN ANY MANNER OR USED FOR ANY PURPOSE WHATSOEVER EXCEPT BY WRITTEN CONSENT

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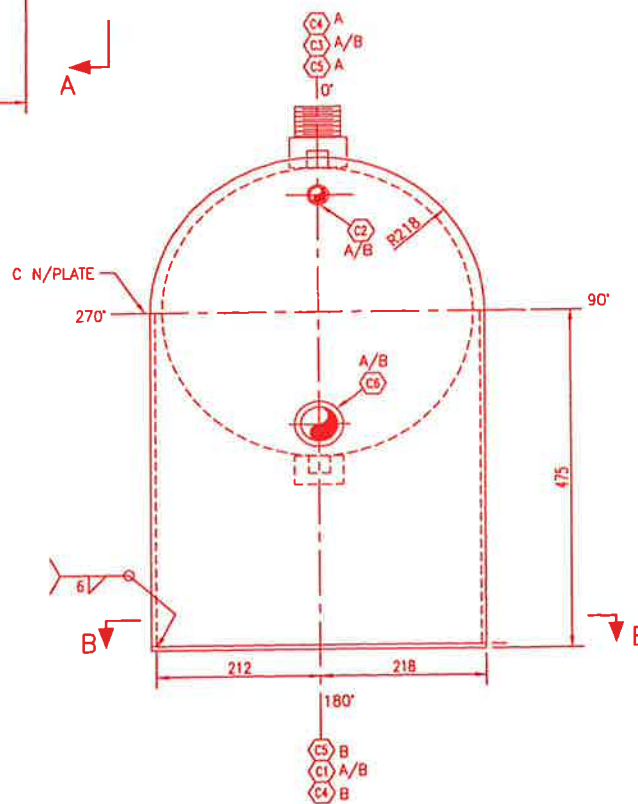


ELEVATION
SCALE: 1:5



VIEW 'B-B'
SCALE: 1:2

DRILL (2)-22Ø HOLES IN EACH SADDLE FOR ITEM #10



VIEW 'A-A'
SCALE: 1:5

NOZZLE SCHEDULE									
MK	SIZE	RATING	FACING	SCH	SERVICE	INT.	PROJ	EXT. PROJ	WELD
A/B	C1	48	3000#	HALF CPLG	—	SHUNT LINE	—	—	S
A/B	C2	21	3000#	HALF CPLG	—	VENT	—	—	S
A/B	C3	60	3000#	HALF CPLG	—	PRV VENT/FILL	—	—	S
A/B	C4	21	3000#	HALF CPLG	—	LG	—	—	S
A/B	C5	21	3000#	HALF CPLG	—	LG	—	—	S
A/B	C6	48	3000#	HALF CPLG	—	LSL-235 A/B	—	—	S

BILL OF MATERIAL			DESCRIPTION	SA-53-B (MIN)
1	1	PIPE: 406 O/D x 6.35 W.T. x 1985 LG.		SA-53-B (MIN)
2	2	PLATE: 12.70 THK. x 436 WD. x 693 LG. (CTS)		SA-36
3	4	PLATE: 6 THK. x 70 WD. x 469 LG.		SA-36
4	2	FLAT BAR: 6 THK. x 83 WD. x 436 LG.		SA-36
5	1	PLATE: 12.70 THK. x 390 O/D		SA-36
6	2	HALF CPLG: 60 - 3000# NPT		SA-105
7	4	HALF CPLG: 48 - 3000# NPT		SA-105
8	6	HALF CPLG: 21 - 3000# NPT		SA-105
9	1	NAMEPLATE c/w MOUNTING BRACKET		SS/SA-36
10	4	ZINC PLATED BOLTS: 19Ø x 50 LG. c/w (1) HEXNUT & WASHER EACH		SA-325
11	2	NIPPLE: 60 O/D SCH. STD. x 76 LG. (T.B.E.) SMLS		SA-106-B

CAPACITY: T-235A: 0.161 m³
T-235B: 0.079 m³

WEIGHT EMPTY: 237 kg
WEIGHT FULL OF WATER: 477 kg

SURFACE PREPARATION: PNT-11
PRIMER: PNT-11
FINISH PAINT: PNT-11
INSULATION: NONE

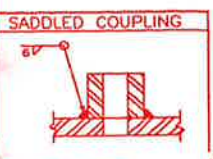
SERVICE: GLYCOL
LONG & CIRC. WELDS TYPE 1
QWP: 590.2
QCP: AQP-1050(S) AQP-1227(S)
TACK WELDS: WPS# 101
PRESS. TO STRUCT. WELD WPS# 101,105,109

SERIAL NO: 99420-112 CRN: N/A
TAG NO: T-235A/B YEAR BUILT: 2000
LSD #: -
CODE: **NON CODE**

DESIGN PRESS: 101 kPag
DESIGN TEMP: 100 °C
HYDROTEST: 150 kPag

MATERIAL: HEAD: SA-36
SHELL: SA-53-B (MIN)

RADIOGRAPHY:
LONG: N/A
CIRC: N/A
P.W.H.T.:
 YES NO
CORR. ALLOW: NIL



S. WPS# 101,107,109

APPROVED				DRAWN			
MECH./STRUCT.	DATE	BY	DATE	D. SMITH	DATE	00/04/28	
ELECTRICAL	DATE	BY	DATE	M. IWANILUK	DATE	00/05/10	
PROJECT	DATE	S. WARD	DATE		DATE		
	00/05/10						

PROPAC SYSTEMS LTD.
1380 STOCK COMPRESSOR
JACKET WATER EXPANSION TANK
406 O/D x 1985 LG.

DWG. No.: **D-TNK-99420-112**

PROPAC
440 East Lake Road,
Postal Bag #2
Airdrie, Alberta
Canada T4B 2C3

GENERAL NOTES		GENERAL NOTES		REVISION		BY DATE CKD ENG	
1	ISSUED FOR CONSTRUCTION			D. SMITH	00/05/10	M.I.	S.W.

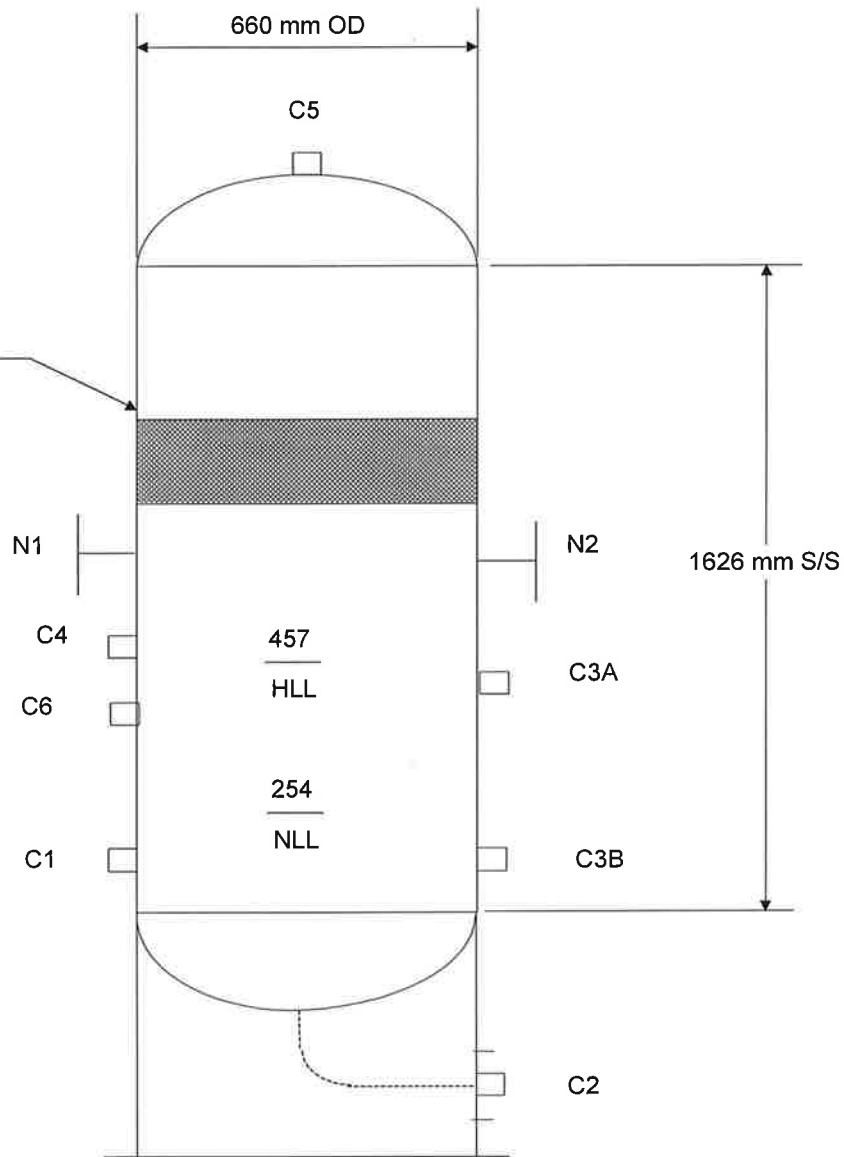
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PROPAK SYSTEMS LTD POSTAL BAG # 2, AIRDRIE, ALBERTA, CANADA T4B 2C3				PRESSURE VESSEL				SHEET 1 OF 2 FILE NO: 11.7.V REQ #	
CUSTOMER : STOCK UNIT				REV	BY	DATE	REVISION DESCRIPTION		
PLANT : STOCK 1380 HP COMPRESSOR				0	TK	01/24/00	ISSUED TO DRAFTING		
SERVICE : STAGE-2 INLET SCRUBBER - SOUR GAS				1	DP	03/21/00	GENERAL REVISION		
JOB NO. : 99420 TAG NO: V-110									
MFR. : PROPAK MODEL NO:									
1	PART	REQ'D(THICKNESS)	MATERIAL (SPEC)	MK	SERVICE	SIZE	RATING	FLANGE	PROJECT
2	SHELL		SA-516 GR. 70N	N1	INLET	168	300#	RFWN	
3	HEADS		SA-516 GR. 70N	N2	OUTLET	168	300#	RFWN	
4	SKIRTS		SA-36	N3					
5	SADDLES		-	N4					
6	PIPE		SA-106 GR. B	N5					
7	PIPE FITTINGS		SA-234-WPB	N6					
8	FLANGES		SA-105N	N7					
9	COUPLINGS		SA-105N	N8					
10	BOLTS		SA-193-B7M	N9					
11	NUTS		SA-194-2HM	N10					
12	GASKETS		316L SS	N11					
13	COIL		-	N12					
14	RISER		-						
15	PACKING SUPPORT		-	C1	LEVEL CONTROL VALVE	33	6000#	CPLG	
16	TRAY SUPPORTS		-	C2	DRAIN	33	6000#	CPLG	
17	BAFFLES		-	C3A/B	LEVEL GAUGE	27	6000#	CPLG	
18	INLET BAFFLE		-	C4	LEVEL SWITCH	48	6000#	CPLG	
19	VORTEX BREAKER		-	C5	INSPECTION	60	6000#	CPLG	
20	SYPHON DRAIN		-	C6	LEVEL CONTROL	60	6000#	CPLG	
21	DEMISTER	152mm	316LSS 144kg/m3	C7					
22	DEMISTER SUPPORTS		SA-516-70	C8	NOTE: Plus any inspection openings if required under ASME Section VIII code				
23	PACKING		-	C9					
24	TRAYS		-	C10					
25	PLATFORM		-	C11					
26	LADDER		-	C12					
27	DAVIT		-						
28	INSULATION RINGS		-	M1					
29	LIFTING LUGS	YES	SA-516-70N	M2					
30	PIPE CLIPS								
31	PIPE SUPPORTS		SA-516-70N						
32	REINFORCEMENT PADS	AS PER CODE	SA-516-70N						
33									
34									
35	DESIGN DATA								
36	SIZE: ID (mm)		OD: (mm)	660	NOTES: {1} UT ALL CATEGORY "D" WELDS				
37	S/S (mm)	1626							
38	DES PRESS (kPa)	4516	OPER. PRESS (kPag)						
39	DES TEMP ° C	149	OPER. TEMP ° C						
40	HYDROTEST	6774	CORR. ALLOW. (mm)	3.2					
41	MDMT ° C	-28	CYCLIC LOAD	NO					
42	X-RAY	FULL (RT1) [NOTE1]	STRESS RELIEVE	YES					
43	WIND LOAD (km / h)	NO	EARTHQUAKE ZONE	NO					
44	SOUR SERVICE	YES	INSUL THK (mm)	NO					
45	FIREPROOF	NO	REFRACTORY THK (mm)	NO					
46	INT. SURFACE PREP.	SHOP FLUSH	EXT. SURFACE PREP.	PNT-11					
47	INT. COATING	OIL	PRIMER COAT	PNT-11					
48	ASME SEC. VIII DIV.	Div. 1, 95 Ed., 97 Add.	FINISH COAT	PNT-11					
49	STAMP REQ'D	YES	FINISH COLOR	C705 GREY					
50									
51	WEIGHT EMPTY ((kg)		HYDRO WEIGHT (kg)						
52	LSD	ALBERTA (TBA)							
53									
54									
55									
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57									

PROPAK SYSTEMS LTD POSTAL BAG # 2, AIRDRIE, ALBERTA, CANADA T4B 2C3		SHEET 2 OF 2	
		FILE NO:	REQ.# 1
CUSTOMER : STOCK UNIT	REV	BY	DATE
PLANT : STOCK 1380 HP COMPRESSOR	0	TK	01/24/00
SERVICE : STAGE-2 INLET SCRUBBER - SOUR GAS	1	DP	03/21/00
JOB NO. : 99420 TAG NO: V-110			REVISION DESCRIPTION
MFR. : PROPAK MODEL NO:			ISSUED TO DRAFTING
			GENERAL REVISION

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152 mm THICK 316L SS
MESH PAD
144 kg/m³ DENSITY

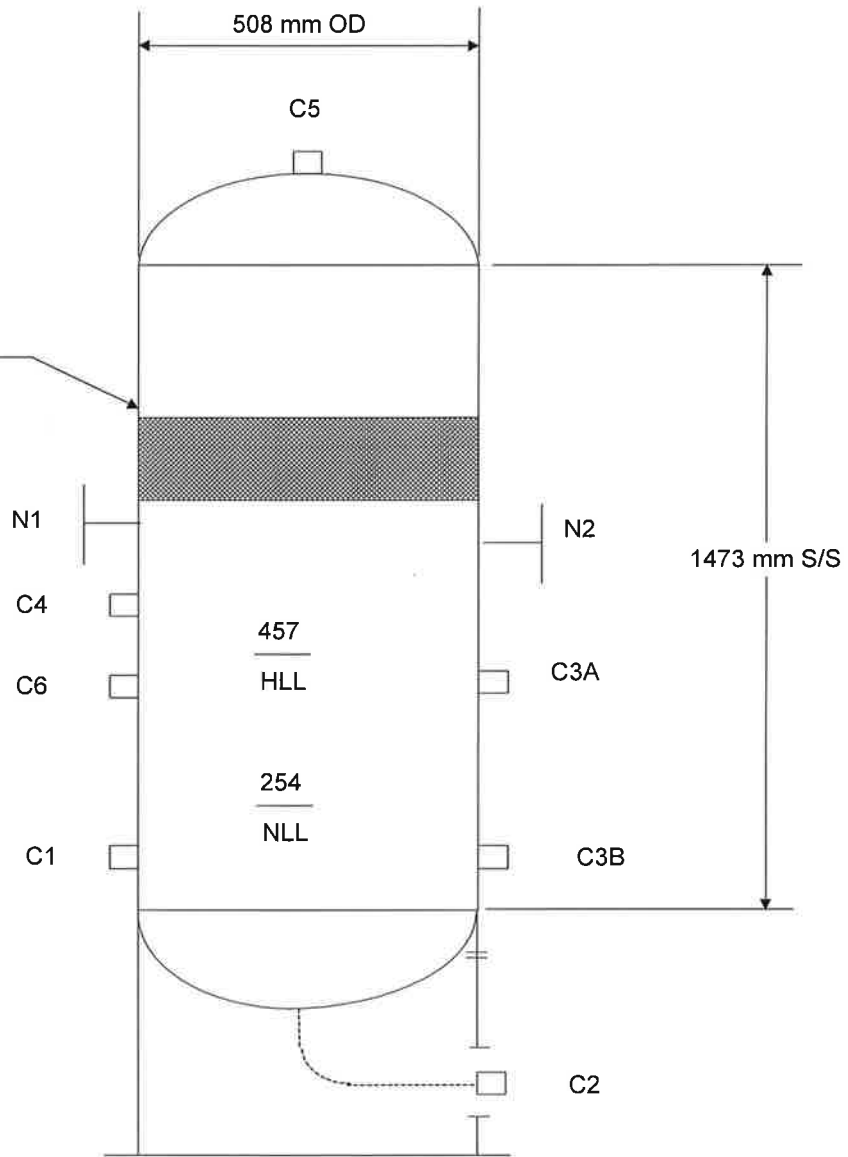


PROPAK SYSTEMS LTD POSTAL BAG # 2, AIRDRIE, ALBERTA, CANADA T4B 2C3				PRESSURE VESSEL				SHEET 1 OF 2	
				REV	BY	DATE	REVISION DESCRIPTION		
CUSTOMER : STOCK UNIT				0	TK	01/24/00	ISSUED TO DRAFTING		
PLANT : STOCK 1380 HP COMPRESSOR				1	DP	03/21/00	GENERAL REVISION		
SERVICE : STAGE-3 INLET SCRUBBER - SOUR GAS									
JOB NO. : 99420 TAG NO: V-120									
MFR. : PROPAK MODEL NO:									
1	PART	REQ'D(THICKNESS)	MATERIAL (SPEC)	MK	SERVICE	SIZE	RATING	FLANGE	PROJECT
2	SHELL		SA-516 GR. 70N	N1	INLET	114	600#	RFWN	
3	HEADS		SA-516 GR. 70N	N2	OUTLET	114	600#	RFWN	
4	SKIRTS		SA-36	N3					
5	SADDLES		-	N4					
6	PIPE		SA-106 GR. B	N5					
7	PIPE FITTINGS		SA-234-WPB	N6					
8	FLANGES		SA-105N	N7					
9	COUPLINGS		SA-105N	N8					
10	BOLTS		SA-193-B7M	N9					
11	NUTS		SA-194-2HM	N10					
12	GASKETS		316L SS	N11					
13	COIL		-	N12					
14	RISER		-						
15	PACKING SUPPORT		-	C1	LEVEL CONTROL VALVE	33	6000#	CPLG	
16	TRAY SUPPORTS		-	C2	DRAIN	33	6000#	CPLG	
17	BAFFLES		-	C3A/B	LEVEL GAUGE	27	6000#	CPLG	
18	INLET BAFFLE		-	C4	LEVEL SWITCH	48	6000#	CPLG	
19	VORTEX BREAKER		-	C5	INSPECTION	60	6000#	CPLG	
20	SYPHON DRAIN		-	C6	LEVEL CONTROL	60	6000#	CPLG	
21	DEMISTER	152mm	316LSS 144kg/m3	C7					
22	DEMISTER SUPPORTS		SA-516-70	C8	NOTE: Plus any inspection openings if required under ASME Section VIII code				
23	PACKING		-	C9					
24	TRAYS		-	C10					
25	PLATFORM		-	C11					
26	LADDER		-	C12					
27	DAVIT		-						
28	INSULATION RINGS		-	M1					
29	LIFTING LUGS	YES	SA-516-70N	M2					
30	PIPE CLIPS								
31	PIPE SUPPORTS		SA-516-70N						
32	REINFORCEMENT PADS	AS PER CODE	SA-516-70N						
33									
34									
35	DESIGN DATA								
36	SIZE: ID (mm)		OD : (mm)	508	NOTES: [1] UT ALL CATEGORY "D" WELDS				
37	S/S (mm)	1473							
38	DES PRESS (kPa)	9067	OPER. PRESS (kPag)						
39	DES TEMP ° C	149	OPER. TEMP ° C						
40	HYDROTEST	13601	CORR. ALLOW. (mm)	3.2					
41	MDMT ° C	-28	CYCLIC LOAD	NO					
42	X-RAY	FULL (RT1) [NOTE 1]	STRESS RELIEVE	YES					
43	WIND LOAD (km / h)	NO	EARTHQUAKE ZONE	NO					
44	SOUR SERVICE	YES	INSUL THK (mm)	NO					
45	FIREPROOF	NO	REFRACTORY THK (mm)	NO					
46	INT. SURFACE PREP.	SHOP FLUSH	EXT. SURFACE PREP.	PNT-11					
47	INT. COATING	OIL	PRIMER COAT	PNT-11					
48	ASME SEC. VIII DIV.	Div. 1, 95 Ed., 97 Add.	FINISH COAT	PNT-11					
49	STAMP REQ'D	YES	FINISH COLOR	C705 GREY					
50									
51	WEIGHT EMPTY ((kg)		HYDRO WEIGHT (kg)						
52	LSD	ALBERTA (TBA)							
53									
54									
55									
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PROPAK SYSTEMS LTD POSTAL BAG # 2, AIRDRIE, ALBERTA, CANADA T4B 2C3		SHEET 2 OF 2	
		FILE NO:	REQ.# 1
CUSTOMER : STOCK UNIT	REV	BY	DATE
PLANT : STOCK 1380 HP COMPRESSOR	0	TK	01/24/00
SERVICE : STAGE-3 INLET SCRUBBER - SOUR GAS	1	DP	03/21/00
JOB NO. : 99420 TAG NO: V-120			REVISION DESCRIPTION
MFR. : PROPAK MODEL NO:			ISSUED TO DRAFTING
			GENERAL REVISION

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152 mm THICK 316L SS
MESH PAD
144 kg/m³ DENSITY

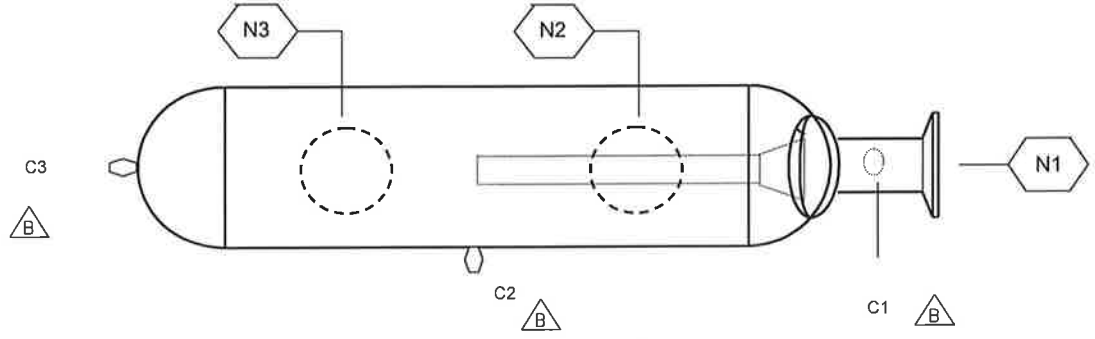


PROPAK SYSTEMS LTD POSTAL BAG # 2, AIRDRIE, ALBERTA, CANADA T4B 2C3				SUCTION BOTTLE				SHEET 1 OF 2	
CUSTOMER : STOCK UNIT PLANT : STOCK 1380 HP COMPRESSOR SERVICE : STAGE-1 SUCTION BOTTLE - SOUR SERVICE JOB NO. : 99420 TAG NO: V-121 MFR. : PROPAK MODEL NO:				REV	BY	DATE	REVISION DESCRIPTION		
				0	TK	01/24/00	ISSUED TO DRAFTING		
				1	DP	03/21/00	GENERAL REVISIONS		
				2	DP	04/12/00	ADDED CHOKE TUBE		
1	PART	REQ'D(THICKNESS)	MATERIAL (SPEC)	MK	SERVICE	SIZE	RATING	FLANGE	PROJECT
2	SHELL		SA-516 GR. 70N	N1	INLET PROCESS GAS	219	300#	RFWN	
3	HEADS		SA-516 GR. 70N	N2	OUTLET NOZZLE - CYL 1	219	300#	RFWN	
4	SKIRTS		-	N3	OUTLET NOZZLE - CYL 2	219	300#	RFWN	
5	SADDLES		-	N4					
6	PIPE		SA-106 GR. B	N5					
7	PIPE FITTINGS		SA-234 WPB	N6					
8	FLANGES		SA-105N	N7					
9	COUPLINGS		SA-105N	N8					
10	BOLTS		SA-193-B7M	N9					
11	NUTS		SA-194-2HM	N10					
12	GASKETS		316SS FLEXITALLIC	N11					
13	COIL		-	N12					
14	RISER		-						
15	PACKING SUPPORT		-	C1	NOTE: Plus any inspection openings if required under ASME Section VIII code.				
16	TRAY SUPPORTS		-	C2					
17	BAFFLES		-	C3					
18	INLET BAFFLE		-	C4					
19	VORTEX BREAKER		-	C5					
20	SYPHON DRAIN		-	C6					
21	DEMISTER		-	C7					
22	DISTRIB. SPIDER		-	C8					
23	PACKING		-	C9					
24	TRAYS		-	C10					
25	PLATFORM		-	C11					
26	LADDER		-	C12					
27	DAVIT		-						
28	INSULATION RINGS		-		CHOKE TUBE				LENGTH
29	LIFTING LUGS		-		6"SCH 40				1219mm
30	PIPE CLIPS		-						
31	PIPE SUPPORTS		-						
32	RE-PADS/GUSSETS	YES, SEE SKETCH	SA-516 GR. 70N						
33	CHOKE TUBE	N/A							
34	BELL MOUTH	N/A							
35	DESIGN DATA								
36	SIZE: ID (mm)		OD (mm)	610	NOTES: [1] SEE PAGE 2 FOR SKETCH [2] INTERNAL CHEMICAL CLEANING & OILING [3] UT ALL CATEGORY "D" WELDS				
37	S/S (mm)	1778							
38	DES. PRESS (kPag)	4516	OPER. PRESS (kPag)						
39	DES. TEMP (° C)	149	OPER. TEMP (° C)						
40	HYDROTEST (kPag)	6774	CORR. ALLOW. (mm)	3.2					
41	MDMT (° C)	-28	CYCLIC LOAD	NO					
42	X-RAY	FULL (RT1) [NOTE 3]	STRESS RELIEVE	YES					
43	WIND LOAD	NO	EARTHQUAKE ZONE	NO					
44	SOUR SERVICE	YES	INSUL. THK. (mm)	NO					
45	FIREPROOF	NO	REFRACTORY THK (mm)	NO					
46	INT. SURFACE PREP.	NOTE 2	EXT. SURFACE PREP.	PNT-11					
47	INT. COATING	NOTE 2	PRIMER COAT	PNT-11					
48	ASME SEC. VIII DIV.	Div. 1,95 Ed.,97 Add.	FINISH COAT	PNT-11					
49	STAMP REQ'D	YES	FINISH COLOR	C705 GREY					
50									
51	WEIGHT EMPTY (kg)		HYDRO WEIGHT (kg)						
52	LSD	ALBERTA (TBA)							
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56									
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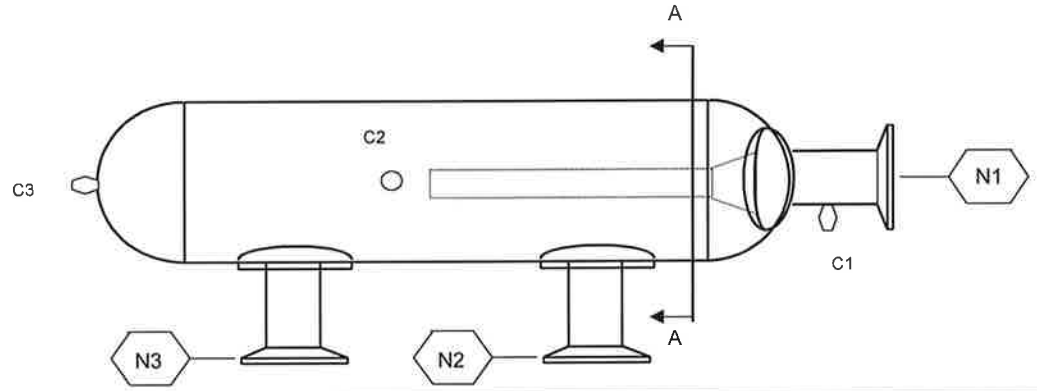
PROPAK SYSTEMS LTD POSTAL BAG #2, ARDRIE, CANADA, T4B 2C3				SHEET 2 OF 2	
				FILE #	REQ.#
CUSTOMER :	STOCK UNIT	REV	BY	DATE	REVISION DESCRIPTION
PLANT :	STOCK 1380 HP COMPRESSOR	0	TK	01/24/00	ISSUED TO DRAFTING
SERVICE :	STAGE-1 SUCTION BOTTLE	1	DP	03/21/00	GENERAL REVISION
JOB NO. :	99420	TAG NO. :	V-121		
MFR	PROPAK	MODEL NO. :			

SUCTION BOTTLE

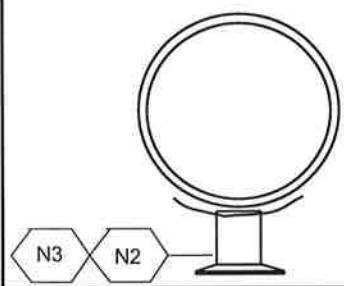
TOP VIEW



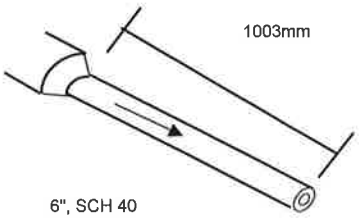
SIDE VIEW



SECTION AA



CHOKE TUBE



NOTES

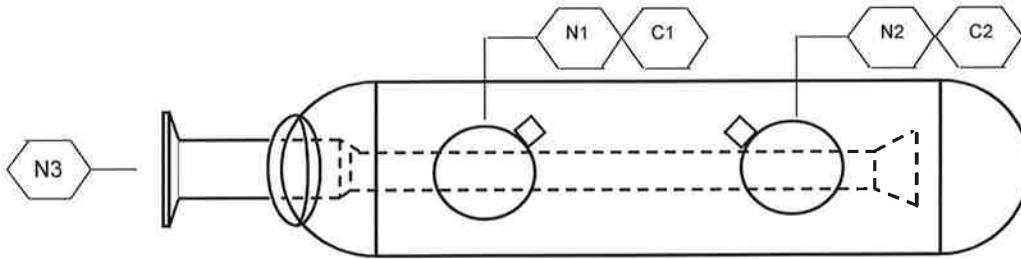
1. VIEW FROM SKID EDGE

PROPAK SYSTEMS LTD POSTAL BAG # 2, AIRDRIE, ALBERTA, CANADA T4B 2C3				DISCHARGE BOTTLE			SHEET 1	OF 2	
CUSTOMER : STOCK UNIT PLANT : STOCK 1380 HP COMPRESSOR SERVICE : STAGE-1 DISCHARGE BOTTLE - SOUR SERVICE JOB NO. : 99420 TAG NO: V-122 MFR. : PROPAK MODEL NO:				REV	BY	DATE	REVISION DESCRIPTION		
				0	TK	01/24/00	ISSUED TO DRAFTING		
				1	DP	03/21/00	GENERAL REVISIONS		
				2	DP	03/28/00	VESSEL OD		
3	DP	12/04/00	VESSEL OD, CHOKE TUBE TO SUIT LAYOUT						
1	PART	REQ'D(THICKNESS)	MATERIAL (SPEC)	MK	SERVICE	SIZE	RATING	FLANGE	PROJECT
2	SHELL		SA-516 GR. 70N	N1	INLET NOZZLE - CYL 1	219	300#	RFWN	
3	HEADS		SA-516 GR. 70N	N2	INLET NOZZLE - CYL 2	219	300#	RFWN	
4	SKIRTS		-	N3	PROCESS GAS OUTLET	168	300#	RFWN	
5	SADDLES		-	N4					
6	PIPE		SA-106 GR. B	N5					
7	PIPE FITTINGS		SA-234 WPB	N6					
8	FLANGES		SA-105N	N7					
9	COUPLINGS		SA-105N	N8					
10	BOLTS		SA-193-B7M	N9					
11	NUTS		SA-194-2HM	N10					
12	GASKETS		316 SS FLEXITALLIC	N11					
13	COIL		-	N12					
14	RISER		-						
15	PACKING SUPPORT		-	C1	THERMOWELL	27	6000#	CPLG	
16	TRAY SUPPORTS		-	C2	THERMOWELL	27	6000#	CPLG	
17	BAFFLES		-	C3	DRAIN	27	6000#	CPLG	
18	INLET BAFFLE		-	C4	NOTE: Plus any inspection openings if required under ASME Section VIII code.				
19	VORTEX BREAKER		-	C5					
20	SYPHON DRAIN		-	C6					
21	DEMISTER		-	C7					
22	DISTRIB. SPIDER		-	C8					
23	PACKING		-	C9					
24	TRAYS		-	C10					
25	PLATFORM		-	C11					
26	LADDER		-	C12					
27	DAVIT		-						LENGTH
28	INSULATION RINGS		-		CHOKE TUBE	114 SCH 40			1270 mm
29	LIFTING LUGS		-						
30	PIPE CLIPS		-						
31	PIPE SUPPORTS	YES	SA-516 GR. 70N						
32	RE-PADS/GUSSETS	YES, SEE SKETCH	SA-516 GR. 70N						
33	CHOKE TUBE	YES	SA-106 GR. B						
34	BELL MOUTH	YES	SA-234 WPB						
35	DESIGN DATA								
36	SIZE: ID		OD :	(mm)	457	NOTES: [1] SEE PAGE 2 FOR SKETCH. [2] UT ALL CAT "D" WELDS			
37	S/S	(mm) 2235							
38	DES. PRESS	(kPag) 4447	OPER. PRESS	(kPag)					
39	DES. TEMP	° C 176	OPER. TEMP	° C					
40	HYDROTEST	(kPag) 6671	CORR. ALLOW.	(mm) 3.2					
41	MDMT	° C -28	CYCLIC LOAD		NO				
42	X-RAY	FULL (RT1) [NOTE 2]	STRESS RELIEVE		YES				
43	WIND LOAD	NO	EARTHQUAKE ZONE		NO				
44	SOUR SERVICE	YES	INSUL. THK.	(mm)	NO				
45	FIREPROOF	NO	REFRACTORY THK	(mm)	NO				
46	INT. SURFACE PREP.	SHOP FLUSH	EXT. SURFACE PREP.		PNT-12				
47	INT. COATING	OIL	PRIMER COAT		PNT-12				
48	ASME SEC. VIII DIV.	Div. 1,95 Ed.,97 Add.	FINISH COAT		PNT-12				
49	STAMP REQ'D	YES	FINISH COLOR		C705 GREY				
50									
51	WEIGHT EMPTY	(kg)	HYDRO WEIGHT	(kg)					
52	LSD	ALBERTA (TBA)							
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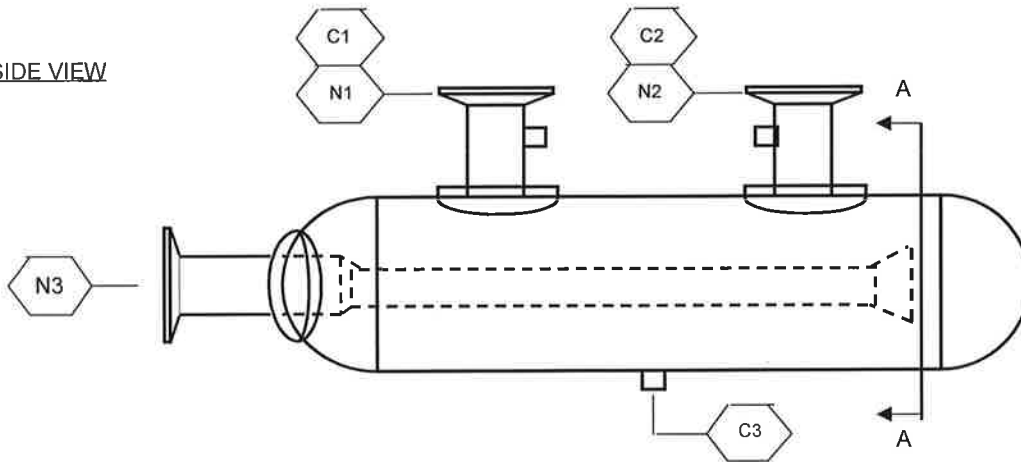
PROPAK SYSTEMS LTD POSTAL BAG #2, ARDRIE, CANADA, T4B 2C3				SHEET 2 OF 2			
				FILE #	REQ.#		
CUSTOMER :	STOCK UNIT	REV	BY	DATE	REVISION DESCRIPTION		
PLANT :	STOCK 1380 HP COMPRESSOR	0	TK	12/29/99	ISSUED TO DRAFTING		
SERVICE :	STAGE-1 DISCHARGE BOTTLE	1	DP	03/21/00	GENERAL REVISION		
JOB NO. :	99420	TAG NO. :	V-122	3	DP	12/04/00	VESSEL OD, CHOKE TUBE TO SUIT LAYOUT
MFR	PROPAK	MODEL NO. :					

DISCHARGE BOTTLE

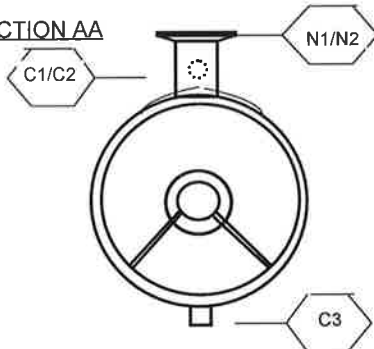
TOP VIEW



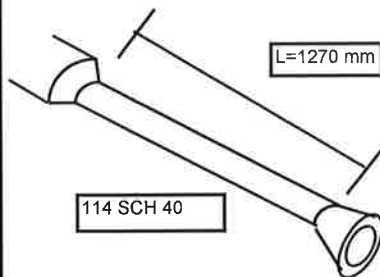
SIDE VIEW



SECTION AA



CHOKE TUBE



NOTES

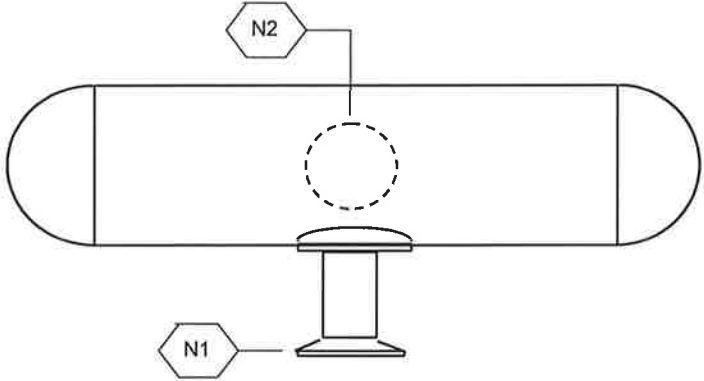
1. VIEW FROM SKID EDGE
2. SEE TOP VIEW FOR C1/C2 ORIENT

PROPAK SYSTEMS LTD POSTAL BAG # 2, AIRDRIE, ALBERTA, CANADA T4B 2C3				SUCTION BOTTLE				SHEET 1 OF 2	
CUSTOMER : STOCK UNIT PLANT : STOCK 1380 HP COMPRESSOR SERVICE : STAGE-2 SUCTION BOTTLE - SOUR SERVICE JOB NO. : 99420 TAG NO: V-123 MFR. : PROPAK MODEL NO:				REV	BY	DATE	REVISION DESCRIPTION		
				0	TK	01/24/00	ISSUED TO DRAFTING		
				1	DP	03/21/00	GENERAL REVISIONS		
1	PART	REQ'D(THICKNESS)	MATERIAL (SPEC)	MK	SERVICE	SIZE	RATING	FLANGE	PROJECT
2	SHELL		SA-516 GR. 70N	N1	INLET PROCESS GAS	168	300#	RFWN	
3	HEADS		SA-516 GR. 70N	N2	OUTLET NOZZLE	168	600#	RFWN	
4	SKIRTS		-	N3					
5	SADDLES		-	N4					
6	PIPE		SA-106 GR. B	N5					
7	PIPE FITTINGS		SA-234 WPB	N6					
8	FLANGES		SA-105N	N7					
9	COUPLINGS		SA-105N	N8					
10	BOLTS		SA-193-B7M	N9					
11	NUTS		SA-194-2HM	N10					
12	GASKETS		316SS FLEXITALLIC	N11					
13	COIL		-	N12					
14	RISER		-						
15	PACKING SUPPORT		-	C1	NOTE: Plus any inspection openings if required under ASME Section VIII code.				
16	TRAY SUPPORTS		-	C2					
17	BAFFLES		-	C3					
18	INLET BAFFLE		-	C4					
19	VORTEX BREAKER		-	C5					
20	SYPHON DRAIN		-	C6					
21	DEMISTER		-	C7					
22	DISTRIB. SPIDER		-	C8					
23	PACKING		-	C9					
24	TRAYS		-	C10					
25	PLATFORM		-	C11					
26	LADDER		-	C12					
27	DAVIT		-						
28	INSULATION RINGS		-						
29	LIFTING LUGS		-						
30	PIPE CLIPS		-						
31	PIPE SUPPORTS		-						
32	RE-PADS/GUSSETS	YES, SEE SKETCH	SA-516 GR. 70N						
33	CHOKE TUBE	N/A							
34	BELL MOUTH	N/A							
35	DESIGN DATA								
36	SIZE: ID (mm)		OD (mm)	457	NOTES: [1] SEE PAGE 2 FOR SKETCH [2] INTERNAL CHEMICAL CLEANING & OILING [3] UT ALL CATEGORY "D" WELDS				
37	S/S (mm)	914							
38	DES. PRESS (kPag)	4516	OPER. PRESS (kPag)						
39	DES. TEMP (° C)	149	OPER. TEMP (° C)						
40	HYDROTEST (kPag)	6774	CORR. ALLOW. (mm)	3.2					
41	MDMT (° C)	-28	CYCLIC LOAD	NO					
42	X-RAY	FULL (RT1) [NOTE 3]	STRESS RELIEVE	YES					
43	WIND LOAD	NO	EARTHQUAKE ZONE	NO					
44	SOUR SERVICE	YES	INSUL. THK. (mm)	NO					
45	FIREPROOF	NO	REFRACTORY THK (mm)	NO					
46	INT. SURFACE PREP.	NOTE 2	EXT. SURFACE PREP.	PNT-11					
47	INT. COATING	NOTE 2	PRIMER COAT	PNT-11					
48	ASME SEC. VIII DIV.	Div. 1,95 Ed.,97 Add.	FINISH COAT	PNT-11					
49	STAMP REQ'D	YES	FINISH COLOR	C705 GREY					
50									
51	WEIGHT EMPTY (kg)		HYDRO WEIGHT (kg)						
52	LSD	ALBERTA (TBA)							
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54									
55									
56									
57									

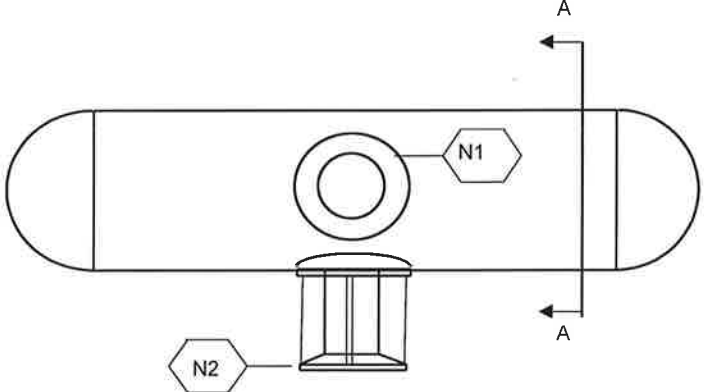
PROPAK SYSTEMS LTD POSTAL BAG #2, ARDRIE, CANADA, T4B 2C3				SHEET 2 OF 2	
CUSTOMER :	STOCK UNIT	REV	BY	DATE	REVISION DESCRIPTION
PLANT :	STOCK 1380 HP COMPRESSOR	0	TK	01/24/00	ISSUED TO DRAFTING
SERVICE :	STAGE-2 SUCTION BOTTLE	1	DP	03/21/00	GENERAL REVISION
JOB NO. :	99420	TAG NO. :	V-123		
MFR	PROPAK	MODEL NO. :			

SUCTION BOTTLE

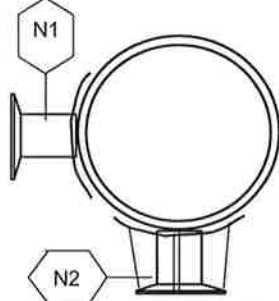
TOP VIEW



SIDE VIEW



SECTION AA



CHOKE TUBE

NO CHOKE TUBE

NOTES

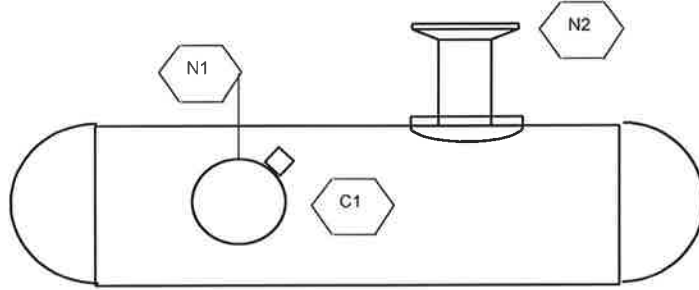
1. SIDE VIEW FROM V-110 LOOKING AT V-123

PROPAK SYSTEMS LTD POSTAL BAG # 2, AIRDRIE, ALBERTA, CANADA T4B 2C3				DISCHARGE BOTTLE			SHEET 1 OF 2		
CUSTOMER : STOCK UNIT PLANT : STOCK 1380 HP COMPRESSOR SERVICE : STAGE-2 DISCHARGE BOTTLE - SOUR SERVICE JOB NO. : 99420 TAG NO: V-124 MFR. : PROPAK MODEL NO:				REV	BY	DATE	REVISION DESCRIPTION		
				0	TK	01/24/00	ISSUED TO DRAFTING		
				1	DP	03/21/00	GENERAL REVISIONS		
1	PART	REQ'D(THICKNESS)	MATERIAL (SPEC)	MK	SERVICE	SIZE	RATING	FLANGE	PROJECT
2	SHELL		SA-106 GR. B	N1	INLET NOZZLE	168	600#	RFWN	
3	HEADS		SA-516 GR. 70N	N2	PROCESS GAS OUTLET	114	600#	RFWN	
4	SKIRTS		-	N3					
5	SADDLES		-	N4					
6	PIPE		SA-106 GR. B	N5					
7	PIPE FITTINGS		SA-234 WPB	N6					
8	FLANGES		SA-105N	N7					
9	COUPLINGS		SA-105N	N8					
10	BOLTS		SA-193-B7M	N9					
11	NUTS		SA-194-2HM	N10					
12	GASKETS		316 SS FLEXITALLIC	N11					
13	COIL		-	N12					
14	RISER		-						
15	PACKING SUPPORT		-	C1	THERMOWELL	27	6000#	CPLG	
16	TRAY SUPPORTS		-	C2	DRAIN	27	6000#	CPLG	
17	BAFFLES		-	C3	NOTE: Plus any inspection openings if required under ASME Section VIII code.				
18	INLET BAFFLE		-	C4					
19	VORTEX BREAKER		-	C5					
20	SYPHON DRAIN		-	C6					
21	DEMISTER		-	C7					
22	DISTRIB. SPIDER		-	C8					
23	PACKING		-	C9					
24	TRAYS		-	C10					
25	PLATFORM		-	C11					
26	LADDER		-	C12					
27	DAVIT		-						
28	INSULATION RINGS		-						
29	LIFTING LUGS		-						
30	PIPE CLIPS		-						
31	PIPE SUPPORTS		-						
32	RE-PADS/GUSSETS	YES, SEE SKETCH	SA-516 GR. 70N						
33	CHOKE TUBE	N/A							
34	BELL MOUTH	N/A							
35	DESIGN DATA								
36	SIZE: ID		OD :	(mm)	406	NOTES: [1] SEE PAGE 2 FOR SKETCH. [2] UT ALL CAT "D" WELDS			
37	S/S (mm)	1016							
38	DES. PRESS (kPag)	8908	OPER. PRESS (kPag)						
39	DES. TEMP (° C)	176	OPER. TEMP (° C)						
40	HYDROTEST (kPag)	13362	CORR. ALLOW. (mm)	3.2					
41	MDMT (° C)	-28	CYCLIC LOAD	NO					
42	X-RAY	FULL (RT1) [NOTE 2]	STRESS RELIEVE	YES					
43	WIND LOAD	NO	EARTHQUAKE ZONE	NO					
44	SOUR SERVICE	YES	INSUL. THK. (mm)	NO					
45	FIREPROOF	NO	REFRACTORY THK (mm)	NO					
46	INT. SURFACE PREP.	SHOP FLUSH	EXT. SURFACE PREP.	PNT-12					
47	INT. COATING	OIL	PRIMER COAT	PNT-12					
48	ASME SEC. VIII DIV.	Div. 1,95 Ed.,97 Add.	FINISH COAT	PNT-12					
49	STAMP REQ'D	YES	FINISH COLOR	C705 GREY					
50									
51	WEIGHT EMPTY (kg)		HYDRO WEIGHT (kg)						
52	LSD	ALBERTA (TBA)							
53									
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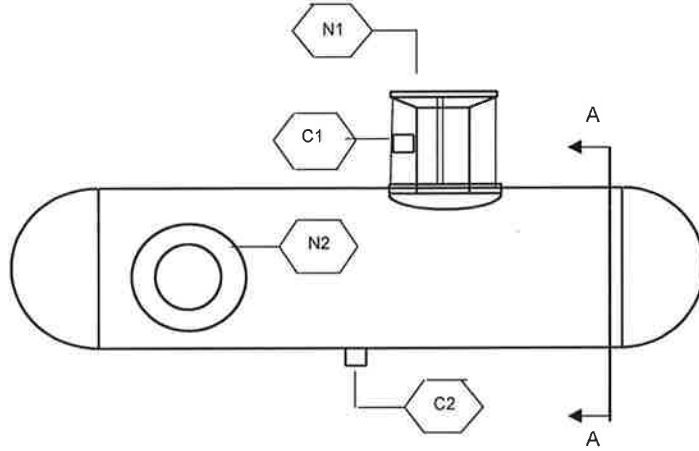
PROPAK SYSTEMS LTD POSTAL BAG #2, ARDRIE, CANADA, T4B 2C3				SHEET 2 OF 2	
				FILE #	REQ.#
CUSTOMER :	STOCK UNIT	REV	BY	DATE	REVISION DESCRIPTION
PLANT :	STOCK 1380 HP COMPRESSOR	0	TK	01/24/00	ISSUED TO DRAFTING
SERVICE :	STAGE-2 DISCHARGE BOTTLE	1	DP	03/21/00	GENERAL REVISION
JOB NO. :	99420	TAG NO. :	V-124		
MFR	PROPAK	MODEL NO. :			

DISCHARGE BOTTLE

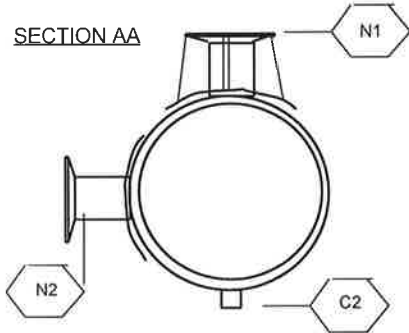
TOP VIEW



SIDE VIEW



SECTION AA



CHOKE TUBE

NO CHOKE TUBE

NOTES

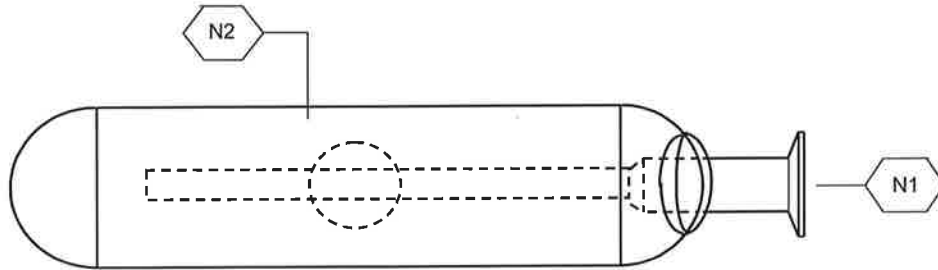
1. SIDE VIEW VIEWED FROM SKID EDGE
2. SEE TOP VIEW FOR C1 ORIENT

PROPAK SYSTEMS LTD POSTAL BAG # 2, AIRDRIE, ALBERTA, CANADA T4B 2C3				SUCTION BOTTLE			SHEET 1 OF 2		
CUSTOMER : STOCK UNIT PLANT : STOCK 1380 HP COMPRESSOR SERVICE : STAGE-3 SUCTION BOTTLE - SOUR SERVICE JOB NO. : 99420 TAG NO: V-125 MFR. : PROPAK MODEL NO:				REV	BY	DATE	REVISION DESCRIPTION		
				0	TK	01/24/00	ISSUED TO DRAFTING		
				1	DP	03/21/00	GENERAL REVISIONS		
1	PART	REQ'D(THICKNESS)	MATERIAL (SPEC)	MK	SERVICE	SIZE	RATING	FLANGE	PROJECT
2	SHELL		SA-106 GR. B	N1	INLET PROCESS GAS	114	600#	RFWN	
3	HEADS		SA-516 GR. 70N	N2	OUTLET NOZZLE	114	900#	RFWN	
4	SKIRTS		-	N3					
5	SADDLES		-	N4					
6	PIPE		SA-106 GR. B	N5					
7	PIPE FITTINGS		SA-234 WPB	N6					
8	FLANGES		SA-105N	N7					
9	COUPLINGS		SA-105N	N8					
10	BOLTS		SA-193-B7M	N9					
11	NUTS		SA-194-2HM	N10					
12	GASKETS		316SS FLEXITALLIC	N11					
13	COIL		-	N12					
14	RISER		-						
15	PACKING SUPPORT		-	C1	NOTE: Plus any inspection openings if required under ASME Section VIII code.				
16	TRAY SUPPORTS		-	C2					
17	BAFFLES		-	C3					
18	INLET BAFFLE		-	C4					
19	VORTEX BREAKER		-	C5					
20	SYPHON DRAIN		-	C6					
21	DEMISTER		-	C7					
22	DISTRIB. SPIDER		-	C8					
23	PACKING		-	C9					
24	TRAYS		-	C10					
25	PLATFORM		-	C11					
26	LADDER		-	C12					
27	DAVIT		-						LENGTH
28	INSULATION RINGS		-		CHOKE TUBE	73 SCH 160			737 mm
29	LIFTING LUGS		-						
30	PIPE CLIPS		-						
31	PIPE SUPPORTS		-						
32	RE-PADS/GUSSETS	YES, SEE SKETCH	SA-516 GR. 70N						
33	CHOKE TUBE	YES	SA-106 GR. B						
34	BELL MOUTH								
35	DESIGN DATA								
36	SIZE: ID (mm)		OD: (mm)	406	NOTES: [1] SEE PAGE 2 FOR SKETCH [2] INTERNAL CHEMICAL CLEANING & OILING [3] UT ALL CATEGORY "D" WELDS				
37	S/S (mm)	Ø14							
38	DES. PRESS (kPag)	9067	OPER. PRESS (kPag)						
39	DES. TEMP (°C)	149	OPER. TEMP (°C)						
40	HYDROTEST (kPag)	13601	CORR. ALLOW. (mm)	3.2					
41	MDMT (°C)	-28	CYCLIC LOAD	NO					
42	X-RAY	FULL (RT1) [NOTE 3]	STRESS RELIEVE	YES					
43	WIND LOAD	NO	EARTHQUAKE ZONE	NO					
44	SOUR SERVICE	YES	INSUL. THK. (mm)	NO					
45	FIREPROOF	NO	REFRACTORY THK (mm)	NO					
46	INT. SURFACE PREP.	NOTE 2	EXT. SURFACE PREP.	PNT-11					
47	INT. COATING	NOTE 2	PRIMER COAT	PNT-11					
48	ASME SEC. VIII DIV.	Div. 1,95 Ed.,97 Add.	FINISH COAT	PNT-11					
49	STAMP REQ'D	YES	FINISH COLOR	C705 GREY					
50									
51	WEIGHT EMPTY (kg)		HYDRO WEIGHT (kg)						
52	LSD	ALBERTA (TBA)							
53									
54									
55									
56									
57									

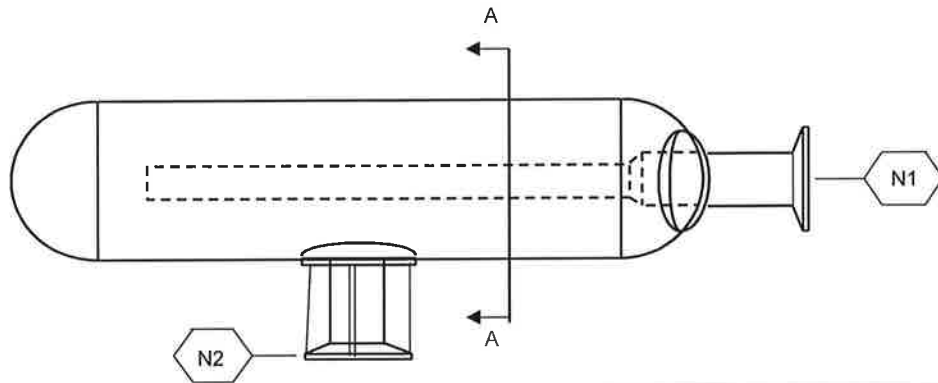
PROPAK SYSTEMS LTD POSTAL BAG #2, ARDRIE, CANADA, T4B 2C3				SHEET 2 OF 2	
CUSTOMER :	STOCK UNIT	REV	BY	DATE	REVISION DESCRIPTION
PLANT :	STOCK 1380 HP COMPRESSOR	0	TK	01/24/00	ISSUED TO DRAFTING
SERVICE :	STAGE-3 SUCTION BOTTLE	1	DP	03/21/00	GENERAL REVISION
JOB NO. :	99420	TAG NO. :	V-125		
MFR	PROPAK	MODEL NO. :			

SUCTION BOTTLE

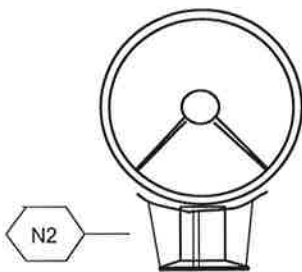
TOP VIEW



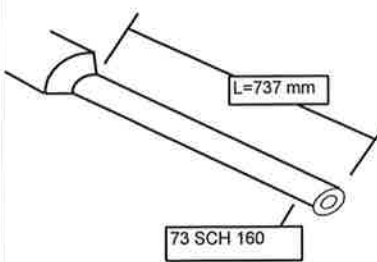
SIDE VIEW



SECTION AA



CHOKE TUBE



NOTES

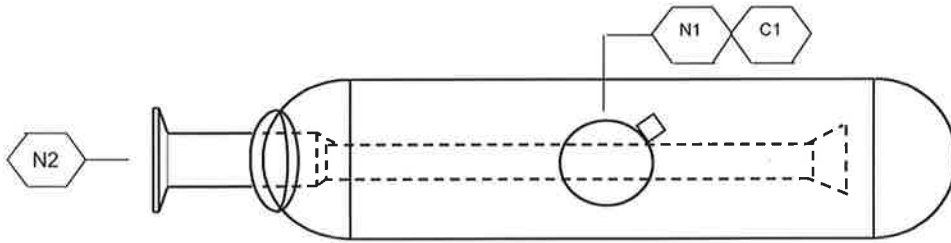
1. VIEW FROM SKID EDGE

PROPAK SYSTEMS LTD POSTAL BAG # 2, AIRDRIE, ALBERTA, CANADA T4B 2C3				DISCHARGE BOTTLE			SHEET 1 OF 2		
CUSTOMER : STOCK UNIT PLANT : STOCK 1380 HP COMPRESSOR SERVICE : STAGE-3 DISCHARGE BOTTLE - SOUR SERVICE JOB NO. : 99420 TAG NO: V-126 MFR. : PROPAK MODEL NO:				REV	BY	DATE	REVISION DESCRIPTION		
				0	TK	01/24/00	ISSUED TO DRAFTING		
				1	DP	03/21/00	GENERAL REVISIONS		
1	PART	REQ'D(THICKNESS)	MATERIAL (SPEC)	MK	SERVICE	SIZE	RATING	FLANGE	PROJECT
2	SHELL		SA-106 GR. B	N1	INLET NOZZLE	114	900#	RFWN	
3	HEADS		SA-516 GR. 70N	N2	PROCESS GAS OUTLET	89	900#	RFWN	
4	SKIRTS		-	N3					
5	SADDLES		-	N4					
6	PIPE		SA-106 GR. B	N5					
7	PIPE FITTINGS		SA-234 WPB	N6					
8	FLANGES		SA-105N	N7					
9	COUPLINGS		SA-105N	N8					
10	BOLTS		SA-193-B7M	N9					
11	NUTS		SA-194-2HM	N10					
12	GASKETS		316 SS FLEXITALLIC	N11					
13	COIL		-	N12					
14	RISER		-						
15	PACKING SUPPORT		-	C1	THERMOWELL	27	6000#	CPLG	
16	TRAY SUPPORTS		-	C2	DRAIN	27	6000#	CPLG	
17	BAFFLES		-	C3	NOTE: Plus any inspection openings if required under ASME Section VIII code.				
18	INLET BAFFLE		-	C4					
19	VORTEX BREAKER		-	C5					
20	SYPHON DRAIN		-	C6					
21	DEMISTER		-	C7					
22	DISTRIB. SPIDER		-	C8					
23	PACKING		-	C9					
24	TRAYS		-	C10					
25	PLATFORM		-	C11					
26	LADDER		-	C12					
27	DAVIT		-						LENGTH
28	INSULATION RINGS		-		CHOKE TUBE	60 SCH 160			940mm
29	LIFTING LUGS		-						
30	PIPE CLIPS		-						
31	PIPE SUPPORTS	YES	SA-516 GR. 70N						
32	RE-PADS/GUSSETS	YES, SEE SKETCH	SA-516 GR. 70N						
33	CHOKE TUBE	YES	SA-106 GR. B						
34	BELL MOUTH	YES	SA-234 WPB						
35	DESIGN DATA								
36	SIZE: ID		OD :	(mm)	356	NOTES: [1] SEE PAGE 2 FOR SKETCH. [2] UT ALL CAT "D" WELDS			
37	S/S (mm)	1016							
38	DES. PRESS (kPag)	11377	OPER. PRESS (kPag)						
39	DES. TEMP ° C	176	OPER. TEMP ° C						
40	HYDROTEST (kPag)	17066	CORR. ALLOW. (mm)	3.2					
41	MDMT ° C	-28	CYCLIC LOAD	NO					
42	X-RAY	FULL (RT1) [NOTE 2]	STRESS RELIEVE	YES					
43	WIND LOAD	NO	EARTHQUAKE ZONE	NO					
44	SOUR SERVICE	YES	INSUL. THK. (mm)	NO					
45	FIREPROOF	NO	REFRACTORY THK (mm)	NO					
46	INT. SURFACE PREP.	SHOP FLUSH	EXT. SURFACE PREP.	PNT-12					
47	INT. COATING	OIL	PRIMER COAT	PNT-12					
48	ASME SEC. VIII DIV.	Div. 1.95 Ed.,97 Add.	FINISH COAT	PNT-12					
49	STAMP REQ'D	YES	FINISH COLOR	C705 GREY					
50									
51	WEIGHT EMPTY (kg)		HYDRO WEIGHT (kg)						
52	LSD	ALBERTA (TBA)							
53									
54									
55									
56									
57									

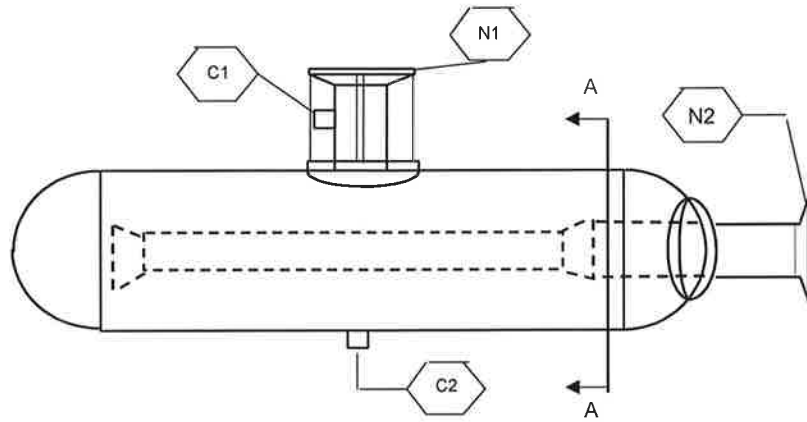
PROPAK SYSTEMS LTD POSTAL BAG #2, ARDRIE, CANADA, T4B 2C3			SHEET 2 OF 2				
CUSTOMER : STOCK UNIT			REV	BY	DATE	FILE #	REQ.#
PLANT :	STOCK 1380 HP COMPRESSOR		0	TK	01/24/00	REVISION DESCRIPTION ISSUED TO DRAFTING	
SERVICE :	STAGE-3 DISCHARGE BOTTLE		1	DP	03/21/00	GENERAL REVISION	
JOB NO. :	99420	TAG NO. :	V-126				
MFR	PROPAK	MODEL NO. :					

DISCHARGE BOTTLE

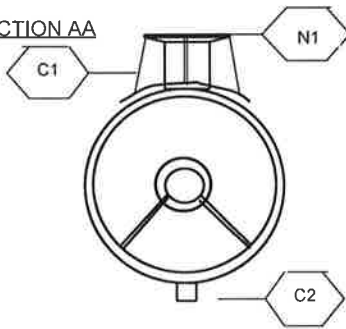
TOP VIEW



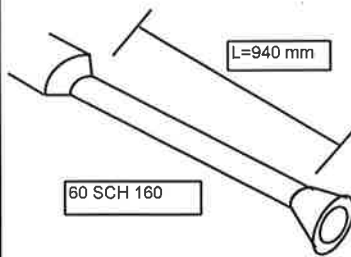
SIDE VIEW



SECTION AA



CHOKE TUBE

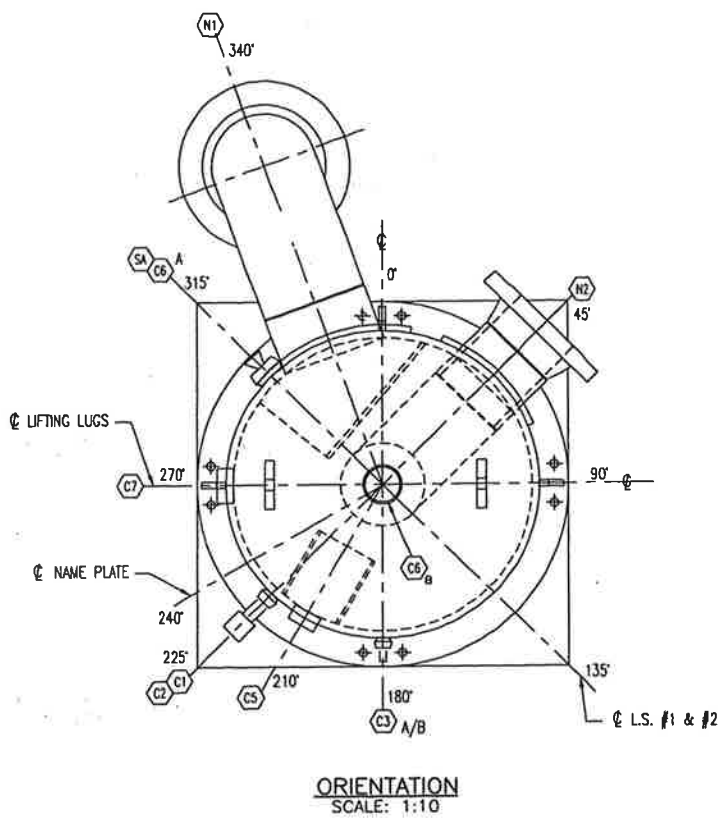
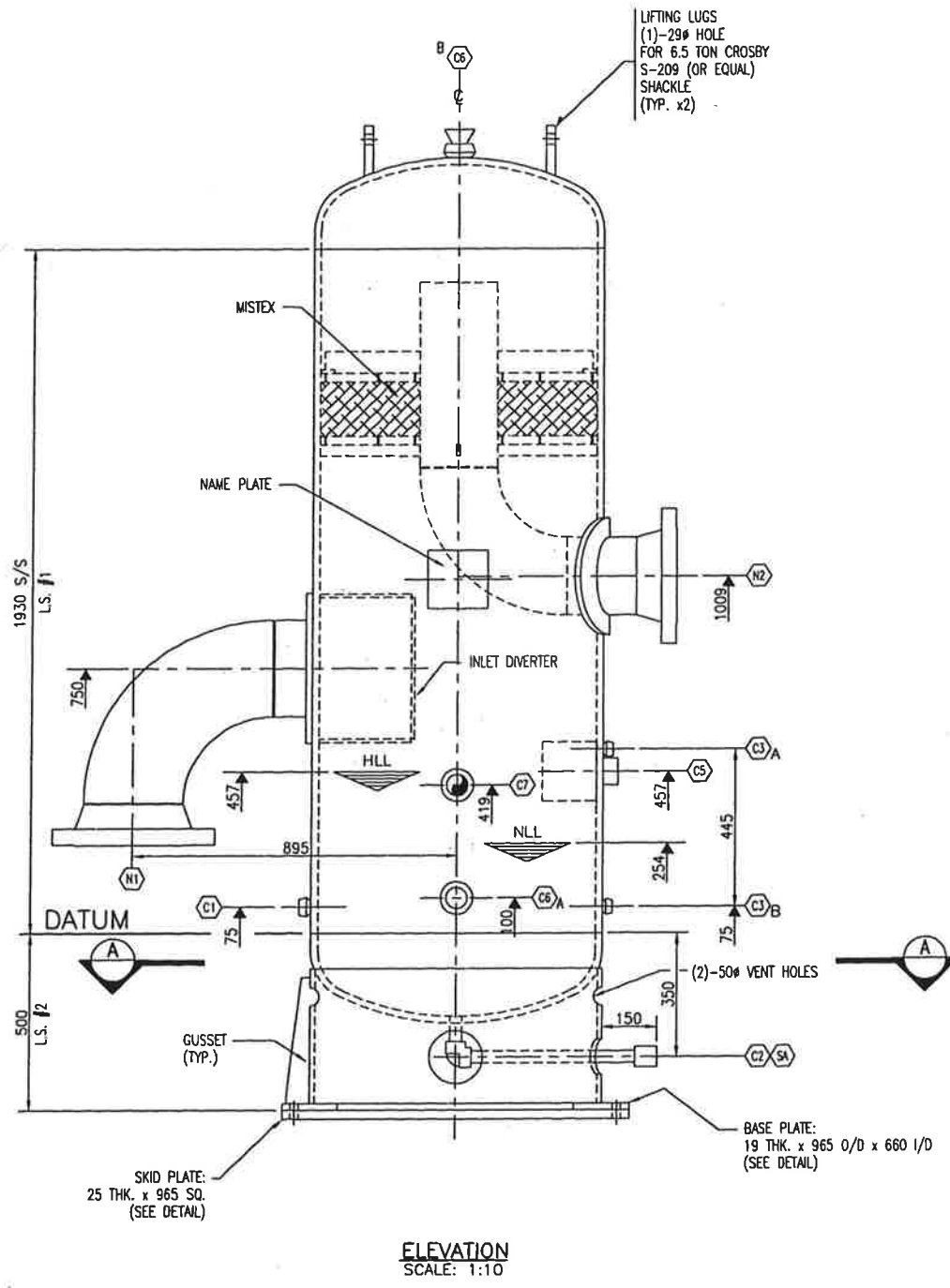


NOTES

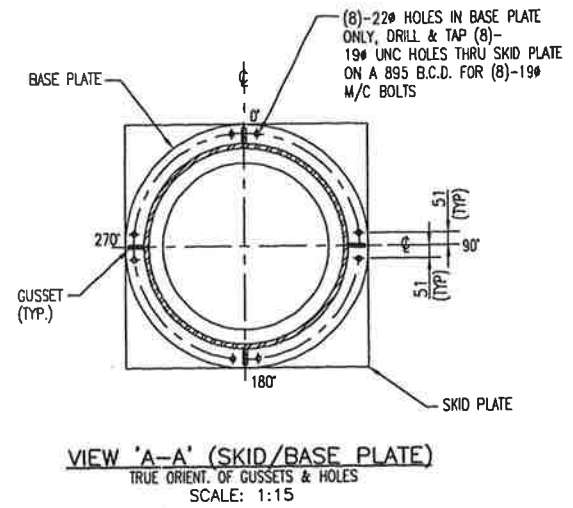
1. SIDE VIEW VIEWED FROM SKID EDGE
2. SEE TOP VIEW FOR C1 ORIENT

PROPAK SYSTEMS LTD POSTAL BAG # 2, AIRDRIE, ALBERTA, CANADA T4B 2C3				PRESSURE VESSEL				SHEET 1 OF 1	
				FILE NO: 11.7.V		REQ.#			
CUSTOMER : STOCK UNIT				REV	BY	DATE	REVISION DESCRIPTION		
PLANT : STOCK 1380 HP COMPRESSOR PACKAGE				0	TK	01/24/00	ISSUED TO DRAFTING		
SERVICE : PACKING VENT AND DRAIN SEAL POT									
JOB NO. : 99420 TAG NO: V-130									
MFR. : PROPAK MODEL NO:									
1	PART	REQ'D(THICKNESS)	MATERIAL (SPEC)	MK	SERVICE	SIZE	RATING	FLANGE	PROJECT
2	SHELL		SA-106-B	N1					
3	HEADS	PIPE CAP	SA-234-WPB	N2					
4	SKIRTS		N/A	N3					
5	SADDLES		C.S.	N4					
6	PIPE		SA-106-B	N5					
7	PIPE FITTINGS		SA-105-N	N6					
8	FLANGES		N/A	N7					
9	COUPLINGS		N/A	N8					
10	BOLTS		N/A	N9					
11	NUTS		N/A	N10					
12	GASKETS		N/A	N11					
13	COIL		N/A	N12					
14	RISER		N/A						
15	PACKING SUPPORT		N/A	C1	Cylinder packing vent & drain	33	3000#	NPT	
16	TRAY SUPPORTS		N/A	C2	Cylinder distance piece drain	33	3000#	NPT	
17	BAFFLES		N/A	C3	Seal pot vapour to flare header	33	3000#	NPT	
18	INLET BAFFLE		N/A	C4	Liquids to drain tank	33	3000#	NPT	
19	VORTEX BREAKER		N/A	C5A/B	Level gauge	21	3000#	NPT	
20	SYPHON DRAIN		N/A	C6	Seal Pot pressure relief	48	3000#	NPT	
21	DEMISTER		N/A	C7					
22	DISTRIB. SPIDER		N/A	C8					
23	PACKING		N/A	C9					
24	TRAYS		N/A	C10					
25	PLATFORM		N/A	C11					
26	LADDER		N/A	C12					
27	DAVIT		N/A						
28	INSULATION RINGS		N/A	M1					
29	LIFTING LUGS		N/A	M2					
30	PIPE CLIPS		N/A						
31	PIPE SUPPORTS		N/A						
32									
33									
34									
35	DESIGN DATA								
36	SIZE: ID (mm)		OD (mm)	273	NOTES: (1) Use 45° ELL threaded fittings for connections C1, C2, C6				
37	S/S (mm)	813							
38	DES PRESS (kPa)	ATMOSPHERIC	OPER. PRESS (kPa)	ATMOSPHERIC					
39	DES TEMP ° C	149	OPER. TEMP ° C	25					
40	HYDROTEST (kPag)	345	CORR. ALLOW. (mm)	N/A					
41	MDMT	-28	CYCLIC LOAD	N/A					
42	X-RAY	N/A	STRESS RELIEVE	NO					
43	WIND LOAD (km / h)	N/A	EARTHQUAKE ZONE	N/A					
44	SOUR SERVICE	YES	INSUL THK (mm)	NONE					
45	FIREPROOF	NO	REFRACTORY THK (mm)	NONE					
46	INT. SURFACE PREP.	NO	EXT. SURFACE PREP.	PNT-11					
47	INT. COATING	NO	PRIMER COAT	PNT-11					
48	ASME SEC. VIII DIV.	NO	FINISH COAT	PNT-11					
49	STAMP REQ'D	NO	FINISH COLOR	C705 GREY					
50									
51	WEIGHT EMPTY ((kg)		HYDRO WEIGHT (kg)						
52	LSD								
53									
54									
55									
56									
57									

THE DESIGN IT COVERS ARE CONFIDENTIAL AND THE PROPERTY OF PROPAC SYSTEMS LTD., AND SHALL NOT BE DISCLOSED TO OTHERS OR REPRODUCED IN ANY MANNER OR USED FOR ANY PURPOSE WHATSOEVER EXCEPT BY WRITTEN CONSENT OF PROPAC.



NOZZLE SCHEDULE											
MK	SIZE	RATING	FACING	SCH	SERVICE	INT. PROJ.	EXT. PROJ.	WELD			
N1	273	300	R/WN	80	INLET						
N2	219	300	R/WN	80	OUTLET						
C1	33	6000	TOL	-	LCV-100						
C2	33	6000	CPLG	XXH	DRAIN						
C3	27	6000	TOL	-	LC-100						
C4											
C5	48	6000	1/2 CPLG	NPT	LS-100						
C6	60	6000	TOL	-	INSPECTION w/PLUG						
C7	60	6000	1/2 CPLG	NPT	LC-100						
SA	150				SKIRT ACCESS						

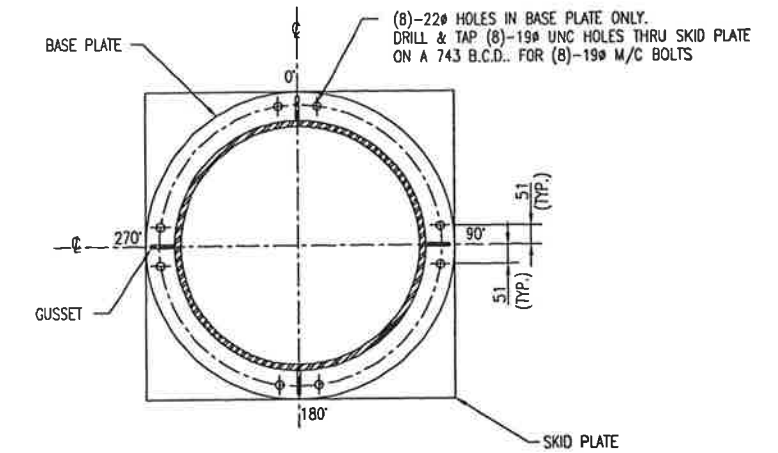
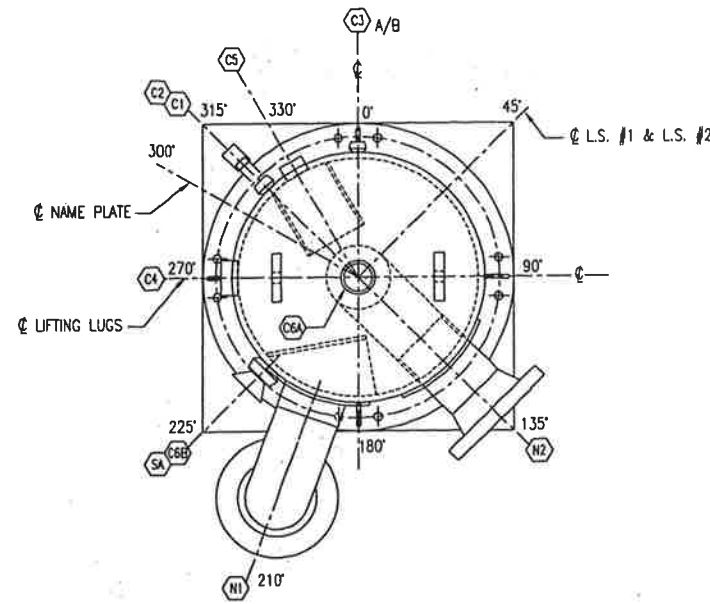
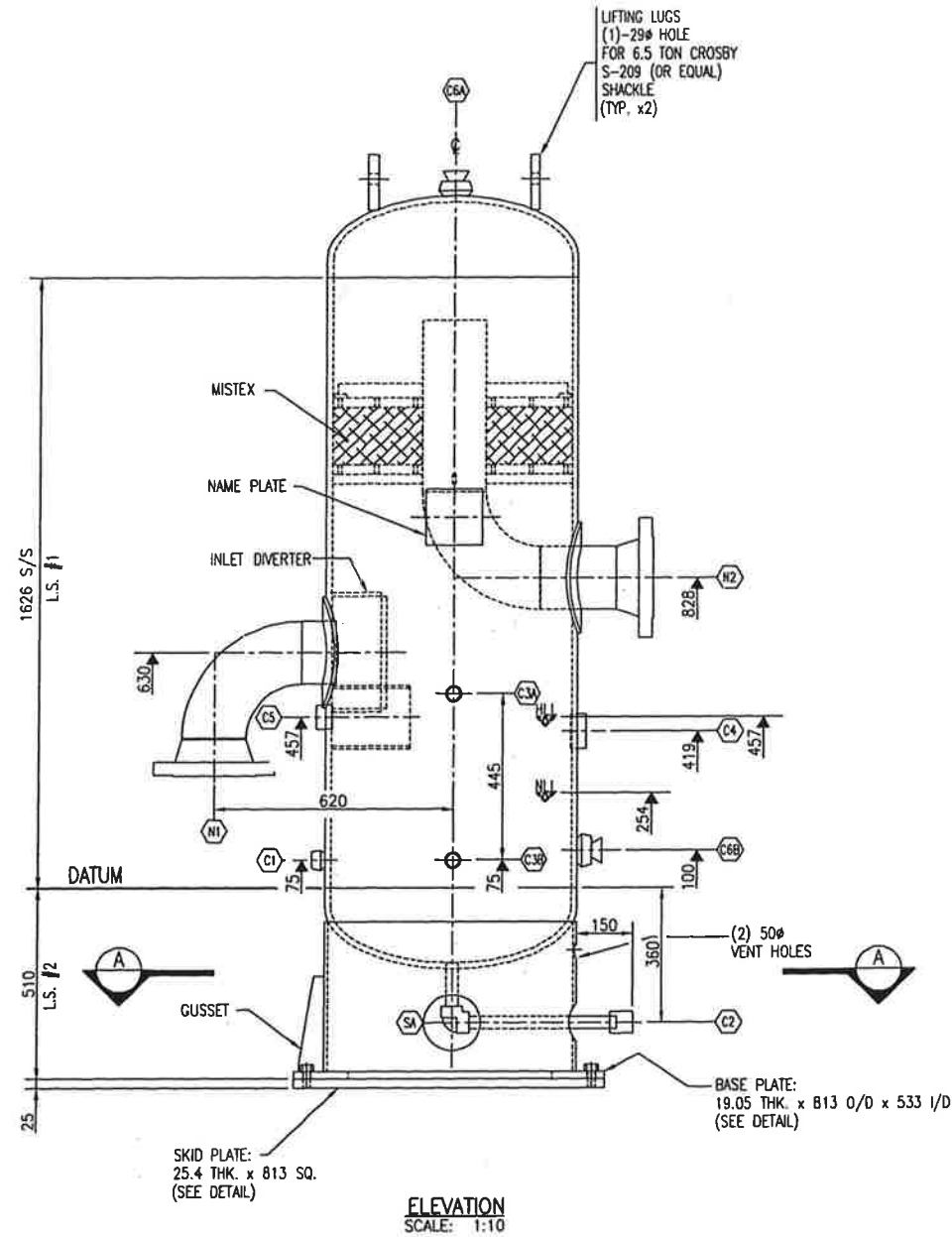


CAPACITY: 1.08 m ³ WEIGHT EMPTY: 1842 kg WEIGHT FULL OF WATER: 2922 kg SURFACE PREPARATION: PRIMER: PNT-11 FINISH PAINT: INSULATION: NONE MECHANICAL LOADINGS GOVERN AS PER UG22: <input checked="" type="checkbox"/> YES <input type="checkbox"/> NO IMPACT TEST: <input checked="" type="checkbox"/> YES <input type="checkbox"/> NO	SERIAL NO: 99420-101 CRN: P-0223.2 TAG NO: V-100 YEAR BUILT: 2000 LSD #: - CODE: ASME SECT. VIII DIV I, '98, ADDENDA '99 MAX. DESIGN PRESS: 4516 kPag @ TEMP: 149°C HYDROTEST: 5871 kPag MIN ^m DESIGN METAL TEMP: -28°C @ MAWP 4516 kPag MATERIAL: HEAD: SA-516-70N SHELL: SA-516-70N
PRODUCTION IMPACT TEST REQ'D: <input checked="" type="checkbox"/> YES <input type="checkbox"/> NO SHIP LOOSE: <input checked="" type="checkbox"/> YES <input type="checkbox"/> NO SERVICE: HYDROCARBONS	RADIOGRAPHY: LONG- <input checked="" type="checkbox"/> FULL UNIT (G) <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> (INCLUDING ALL BUTT WELDS) CRG: <input checked="" type="checkbox"/> FULL UNIT (G) <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> (INCLUDING ALL BUTT WELDS) P.W.H.T.: <input checked="" type="checkbox"/> YES <input type="checkbox"/> NO MIN. TEMP: 593°C, TIME: (1) hr (MIN) CORR. ALLOW: 3.20 mm

"SOUR SERVICE"

PROPAC
 440 East Lake Road,
 Postal Bag #2
 Airdrie, Alberta
 Canada T4B 2C3

GENERAL NOTES		GENERAL NOTES		SKT		ISSUED FOR DOCUMENTATION		D. DOR		WK		SW		APPROVED		DRAWN		APACHE CANADA LIMITED		DWG. No.:	
DATE: 2000.09.26 8:08am	FILE NAME: J:\jobs99\DWG\99420\Comp\Misc\SCR-99420-101-SKT-01.dwg	No.	REVISION	BY	DATE	CRD	ENG	MECH./STRUCT.	BY	DATE	ELECTRICAL	BY	DATE	PROJECT	DATE	SCALE	AS NOTED	1478 HP HAMBURG COMPRESSOR PACKAGE STAGE-1 INLET SCRUBBER-SOUR GAS (V-100) 813 O/D x 1930 S/S		SHT. 1 OF 1	



NOZZLE SCHEDULE									
MK	SIZE	RATING	FACING	SCH	SERVICE	INT. PROJ.	EXT. PROJ.	WELD	
N1	168	300#	RFWN	XH	INLET	MIN	SPEC.	-	
N2	168	300#	RFWN	XH	OUTLET	SPEC.	200	-	
C1	33	6000#	TOL	-	CONTROL VALVE CONN.	-	-	-	
C2	33	6000#	CPLG	XXH	DRAIN	0	SPEC.	-	
C3	27	6000#	TOL	-	LC-110	-	-	-	
C4	60	6000#	CPLG	HALF	LC-110	MIN.	-	-	
C5	48	6000#	CPLG	HALF	LSH-110	MIN.	-	-	
C6	60	6000#	TOL	-	INSPECTION/VENT C/W PLUG	-	-	-	
C6	60	6000#	TOL	-	INSPECTION C/W PLUG	-	-	-	
SA	150	-	-	-	SKIRT ACCESS OPENING	-	-	-	

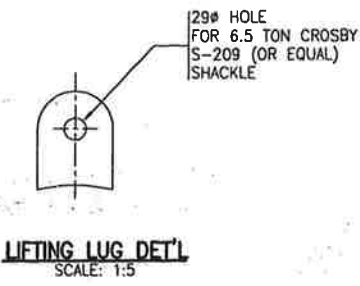
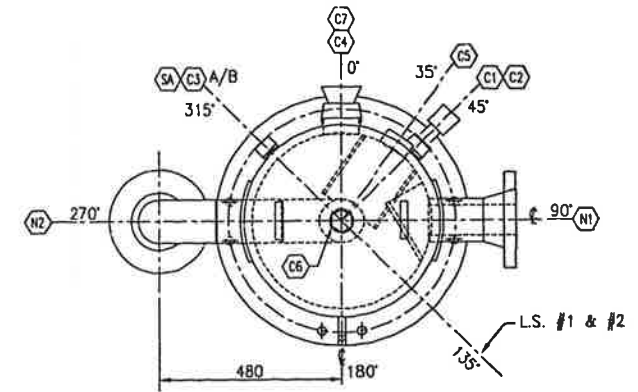
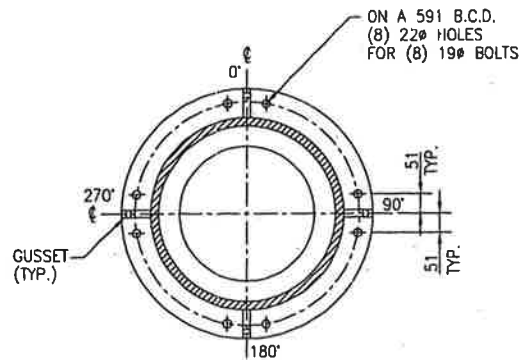
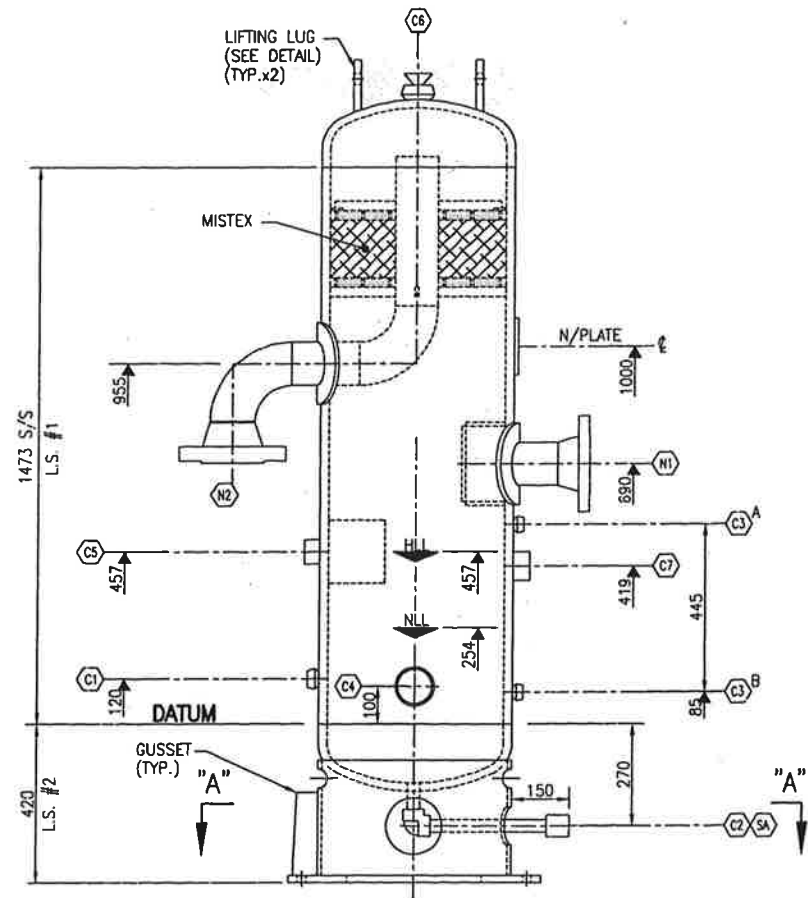
CAPACITY: 0.601 m ³	SERIAL NO: 99420-102 CRN: P-0225.2
SURFACE AREA OF TUBES: N/A m ²	TAG NO: V-110 YEAR BUILT: 2000
WEIGHT EMPTY: 1080 kg	LSD #: -
WEIGHT FULL OF WATER: 1681 kg	CODE:
SURFACE PREPARATION:	ASME SECT. VIII DIV I, '98, ADDENDA '99
PRIMER:	TEMA CLASS: N/A, ADDENDA N/A
FINISH PAINT: PNT-11	MAX. DESIGN PRESS: 4516 kPaG @ TEMP: 149 °C
INSULATION: NONE	MIN. DESIGN PRESS: N/A kPaG
MECHANICAL LOADINGS GOVERNS AS PER UG 22: <input checked="" type="checkbox"/> NO	HYDROTEST:
IMPACT TEST: <input checked="" type="checkbox"/> PER UG20(f)	VESSEL: 5871 kPaG
	COIL: N/A kPa
	MIN ^m DESIGN METAL TEMP: -28 °C @ MAWP 4516 kPaG
	MATERIAL: HEAD: SA-516-70N SHELL: SA-516-70N
	RADIOGRAPHY:
PRODUCTION IMPACT TEST REQ'D: <input checked="" type="checkbox"/> NO	LONG ^L FULL UWH(a)
SHIP LOOSE: <input checked="" type="checkbox"/> NO	CIRC: FULL UWH(a) (INCL ALL BUTT WELDS)
SERVICE: SOUR GAS	P.W.H.T.:
	<input checked="" type="checkbox"/> MIN. TEMP: 593 °C, TIME: 1hr MIN.
	CORR. ALLOW: 3.2 mm

SOUR SERVICE

PROPAC

APACHE CANADA LIMITED				440 East Lake Road, Postal Bag #2 Airdrie, Alberta Canada T4B 2C3	
1478 HP HAMBURG COMPRESSOR PACKAGE 2ND STAGE INLET SCRUBBER (V-110) 660 O/D X 1626 S/S				DWG. No.: D-SCR-99420-102-SKT SHT. 1 OF 1 REV. SKT	
APPROVED		DRAWN			
MECH./STRUCT.	BY	DATE	BY	DATE	
ELECTRICAL	BY	DATE	CHECKED	DATE	
PROJECT	BY	DATE			
DATE	BY	DATE	SCALE	AS NOTED	
GENERAL NOTES		GENERAL NOTES			
DATE: 2000.09.26 8:10am FILE NAME: J:\jobs99\DWG\99420\Comp\Misc\SCR-99420-102-SKT-01.dwg		SKT ISSUED FOR DOCUMENTATION		D. DOR 00/09/15 VK SW	
REVISION		BY		DATE CKD ENG	

NOZZLE SCHEDULE									
MK	SIZE	RATING	FACING	SCH	SERVICE	INT. PROJ	EXT. PROJ	WELD	
N1	114	600#	RFWN	XXH	INLET	MIN.	200		
N2	114	600#	RFWN	XXH	OUTLET	SPEC.	SPEC		
C1	33	6000#	TOL	-	CONTROL VALVE CONN.	-	-		
C2	33	6000#	CPLG	XXH	DRAIN	0	SPEC.		
C3	27	6000#	TOL	-	LEVEL GAUGE (LG-120)	-	-		
C4	60	6000#	TOL	-	INSPECTION c/w PLUG	-	-		
C5	48	6000#	1/2 CPLG	-	LEVEL SWITCH HIGH (LSDH-120)	MIN.	-		
C6	60	6000#	TOL	-	INSPECTION/VENT c/w PLUG	-	-		
C7	60	6000#	1/2 CPLG	-	LEVEL CONTROL (LC-120)	MIN.	-		
SA	150	-	-	-	SKIRT ACCESS OPENING	-	-		

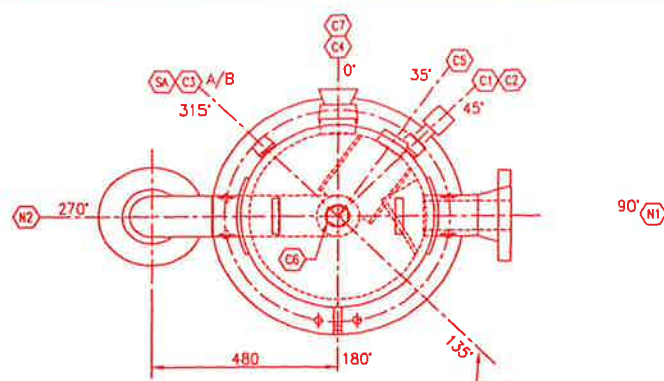


CAPACITY: 0.293 m ³	SERIAL NO: 99420-103	CRN: P-0226.2
SURFACE AREA OF TUBES: N/A m ²	TAG NO: V-120	YEAR BUILT: 2000
WEIGHT EMPTY: 816 kg	LSD #: -	CODE:
WEIGHT FULL OF WATER: 1109 kg	ASME SECT. VIII DIV I, '98, ADDENDA '99	TEMA CLASS: N/A, ADDENDA N/A
SURFACE PREPARATION:	MAX. DESIGN PRESS: 9067 kPag	TEMP: 149 °C
PRIMER: PNT-11	HYDROTEST:	VESSEL 11787 kPag
FINISH PAINT:	COIL N/A kPag	MIN ^m DESIGN METAL TEMP: -28 °C @ MAWP 9067 kPag
INSULATION: NONE	MATERIAL: HEAD: SA-516-70N SHELL: SA-516-70N	RADIOGRAPHY:
MECHANICAL LOADINGS GOVERNS AS PER UG 22: <input checked="" type="checkbox"/> NO	LONG ^L FULL UHM(a)	CIRC: FULL UHM(a) (INCL. ALL BUTT WELD)
IMPACT TEST: <input checked="" type="checkbox"/> NO - PER UG20(i)	P.W.H.T.:	<input checked="" type="checkbox"/> YES MIN. TEMP: 593 °C. TIME: 1h (MIN.)
PRODUCTION IMPACT TEST REQ'D: <input checked="" type="checkbox"/> NO	SERVICE: HYDROCARBONS	CORR. ALLOW: 3.2 mm
SHIP LOOSE: <input checked="" type="checkbox"/> NO		

'SOUR SERVICE'

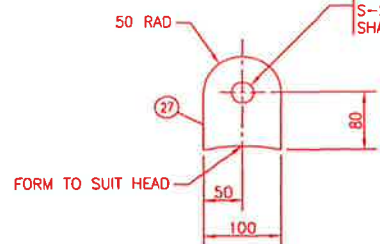
APPROVED		DRAWN		APACHE CANADA LIMITED		440 East Lake Road,	
MECH./STRUCT.	BY			1478 HP HAMBURG COMPRESSOR PACKAGE		Postal Bag #2	
DATE	DATE			STAGE-3 INLET SCRUBBER - SOUR GAS (V-120)		Airdrie, Alberta	
ELECTRICAL	CHECKED			508 O/D x 1473 S/S		Canada T4B 2C3	
DATE	BY			DWG. No.: D-SCR-99420-103-SKT	SHT. 1 OF 1	REV. SKT	
PROJECT	DATE						
DATE	SCALE	AS NOTED					

GENERAL NOTES		GENERAL NOTES		SKT		ISSUED FOR DOCUMENTATION		C. WEST		00/09/15		V.K.		S.W.	
DATE: 2000.09.26	8:11am	FILE NAME: J:\jobs99\DWG\99420\Comp\Misc\SCR-99420-103-SKT-01.dwg		No.		REVISION		BY	DATE	CKD	ENG				

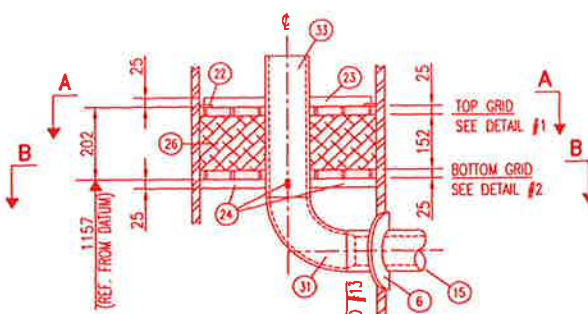


ORIENTATION
SCALE: 1:10

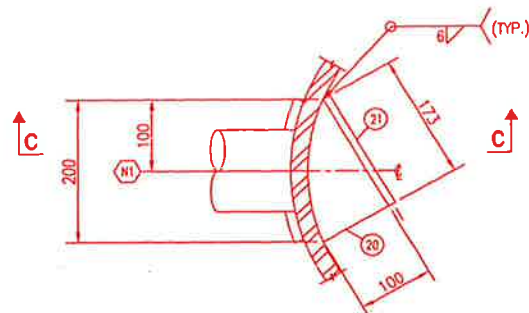
DRILL 29# HOLE FOR 6.5 TON CROSBY S-209 (OR EQUAL) SHACKLE



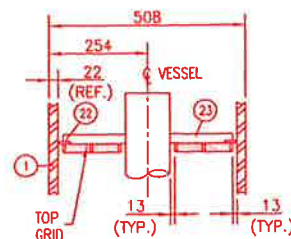
LIFTING LUG DET'L
SCALE: 1:5



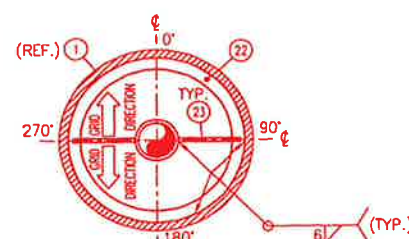
MISTEX SUPPORT DETAIL
SCALE: 1:10



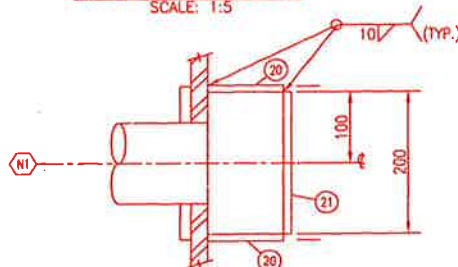
INLET DIVERTER DETAIL
SCALE: 1:5



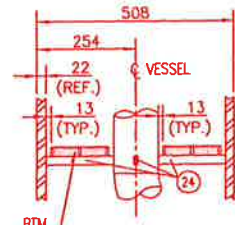
DETAIL #1
SCALE: 1:10



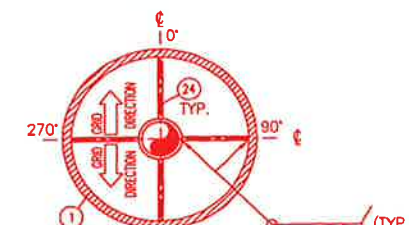
VIEW A-A
SCALE: 1:10



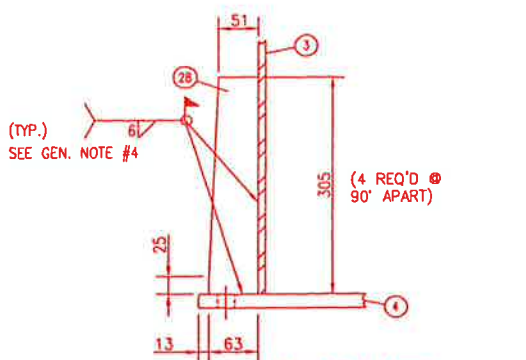
VIEW C-C
SCALE: 1:5



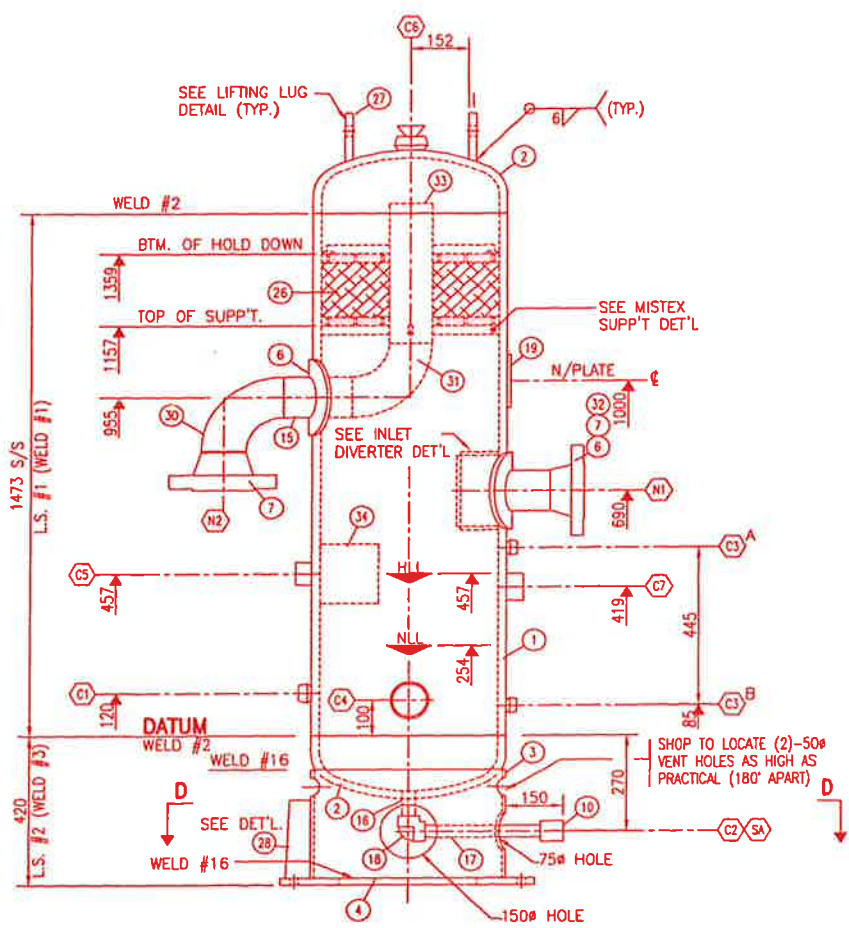
DETAIL #2
SCALE: 1:10



VIEW B-B
SCALE: 1:10



GUSSET PLATE (ITEM #28) DET'L
SCALE: 1:5



ELEVATION
SCALE: 1:10

NOZZLE SCHEDULE									
MK	SIZE	RATING	FACING	SCH	SERVICE	INT. PROJ.	EXT. PROJ.	WELD	
N1	114	600#	RFWN	XXH	INLET	MIN.	200	8/14	
N2	114	600#	RFWN	XXH	OUTLET	SPEC.	SPEC.	7/14	
C1	33	6000#	TOL		CONTROL VALVE CONN.			6	
C2	33	6000#	CPLG	XXH	DRAIN			11/SW	
C3	27	6000#	TOL		LEVEL GAUGE (LG-120)			6	
C4	60	6000#	TOL		INSPECTION c/w PLUG			6	
C5	48	6000#	1/2 CPLG		LEVEL SWITCH HIGH (LSDH-120)	MIN.		4	
C6	60	6000#	TOL		INSPECTION/VENT c/w PLUG			6	
C7	60	6000#	1/2 CPLG		LEVEL CONTROL (LC-120)	MIN.		4	
SA	150				SKIRT ACCESS OPENING				

BILL OF MATERIAL		
ITEM	QUA	DESCRIPTION
1	1	SHELL PLATE: 22.23 THK. x 1473 LG. (ROLL TO 508 O/D)
2	2	HEAD PLATE: 22.23 THK. NOM. (20.64 MIN.) x 508 O/D 2:1 c/w 51 S.F.
3	1	SKIRT PLATE: 10 THK. x 350 LG. (ROLL TO 508 O/D)
4	1	BASE PLATE: 19 THK. x 660 O/D x 356 I/D
5		
6	2	REPAD PLATE: 9.53 THK. x 216 O/D x 117 I/D (ROLL TO 508 I/D)
7	2	FLANGE: 114-600# SCH XXH BORE
8	1	HALF CPLG: 60-6000# NPT
9	1	HALF CPLG: 48-6000# NPT
10	1	CPLG: 33-6000# SW x NPT
11	2	TOL: 27-6000# (ON A 508 O/D RUN)
12	1	TOL: 33-6000# (ON A 508 O/D RUN)
13	1	TOL: 60-6000# (ON A 508 O/D RUN) c/w PLUG
14	1	TOL: 60-6000# (ON FLAT) c/w PLUG
15	1	PIPE: 114 O/D x 17.12 W.T. x 170 LG.
16	1	PIPE: 33 O/D x 9.09 W.T. x 101 LG. (CTS)
17	1	PIPE: 33 O/D x 9.09 W.T. x 333 LG.
18	1	ELBOW: 33-6000# SCH XXH BORE x 90° SW
19	1	NAMEPLATE c/w MOUNTING BRACKET
20	2	PLATE: 10 THK. x 100 WD. x 173 LG. (CTS)
21	1	PLATE: 10 THK. x 173 WD. x 200 LG. (CTS)
22	1	RING PLATE: 10 THK. x 461 O/D x 397 I/D
23	2	F/BAR: 10 THK. x 25 x 160 LG.
24	4	F/BAR: 10 THK. x 25 x 172 LG.
25		
26	1	MISTEX: 152 THK. x 464 O/D x 114 I/D c/w 25 x 3 x 438 O/D x 140 I/D
27	2	GRID (TOP & BOTTOM) IN (1) SECTION (144 kg/cu. M)
28	4	PLATE: 19 THK. x 100 WD. x 130 LG.
29		
30	1	ELBOW: 114 O/D 90° LR SCH. XXH B.W.
31	1	ELBOW: 114 O/D 90° LR SCH. XXH B.W.
32	1	PIPE: 114 O/D x 17.12 W.T. x 146 LG.
33	1	PIPE: 114 O/D x 8.56 W.T. x 399 LG.
34	1	PIPE: 168 O/D x 7.11 W.T. x 200 LG. (CTS)

NOTE: THE FOLLOWING SUBSTITUTIONS ARE PERMITTED (THE OPPOSITE NOT ALLOWED)
SA-350-LF2 for SA-105, SA-333-Gr6 for SA-106-B, SA-420-WPL6 for SA-234-WPB

CAPACITY: 0.293 m³
SURFACE AREA OF TUBES: N/A m²
WEIGHT EMPTY: 816 kg
WEIGHT FULL OF WATER: 1109 kg
SURFACE PREPARATION:
PRIMER: PNT-11
FINISH PAINT:
INSULATION: NONE
MECHANICAL LOADINGS GOVERNS AS PER UG 22: NO

SERIAL NO: 99420-103 CRN:
TAG NO: V-120 YEAR BUILT: 2000
LSD #: -
CODE:
ASME SECT. VIII DIV I, '98, ADDENDA '99
TEMA CLASS: N/A, ADDENDA N/A
MAX. DESIGN PRESS: 9067 kPag @ TEMP: 149 °C
HYDROTTEST:
VESSEL 11787 kPag
COIL N/A kPag
MIN. DESIGN METAL TEMP: -28 °C @ MAWP 9067 kPag
MATERIAL: HEAD: SA-516-70N SHELL: SA-516-70N
RADIOGRAPHY:
CIRC. FULL UWO(a)
LONG-L FULL UWO(a)

IMPACT TEST: NO PER UG20(i)

PRODUCTION IMPACT TEST REQ'D: NO

SHIP LOOSE: NO
SERVICE: HYDROCARBONS
LONG & CIRC. WELDS TYPE 1
QWP: 590.2
AQP-1050(S) AQP-1227(S)
TACK WELDS: WPS #101
PRESS. TO STRUCT. WELD WPS #: 102, 106 & 110

DOUBLE BUTT	SINGLE VEE	SQUARE	COUPLING	THREDOLET TO SUIT	NOZZLE & REPAD RECESSED	NOZZLE & REPAD FLUSH	NOZZLE FLUSH FULL PEN	TRANSITION WELD	PIPE TO FLANGE/FITTING	SKIRT TO HEAD/B.PL.
1. WPS# 102,106,110	2. WPS# 104,106,110	3. WPS# 102,106,110	4. WPS# 102,106,110	6. WPS# 102,106,110	7. WPS# 102,106,108,110	8. WPS# 102,106,108,110	11. WPS# 102,106,108,110	13. WPS# 104,106,110	14. WPS# 104,106,110	16. WPS# 102,106,110

GENERAL NOTES				GENERAL NOTES				ISSUED FOR CONSTRUCTION		APPROVED		DRAWN	
1) DO NOT PROFILE INTERNAL PROJECTION UNLESS SPECIFIED.	2) SANDBLAST INTERNALS TO ENSURE THAT THE INSIDE SURFACE OF THE VESSEL IS FREE OF LOOSE MILL SCALE AND WELD SPLATTER. PRIOR TO MISTEX INSTALLATION & CLOSING OF VESSEL.	3) VESSEL TO BE FLUSHED OUT AT HYDROTTEST, AIR DRIED AND OILED INTERNALLY.	4) VESSEL SHOP TO TACK WELD BASEPLATES & GUSSETS TO SKIRT, ASSEMBLY SHOP TO COMPLETE WELDING ON ASSEMBLY.	5) VESSEL OPENINGS TO BE SEALED PRIOR TO ANY SHIPPING TO OTHER SHOPS.	6) HALF CPLGS. ITEMS #8 & 9 MUST HAVE A FULL BORE.	7) TAPER BORE TO CLEAR FLOAT. CLEAN THREADS AFTER WELDING.	1		D. SMITH	00/05/10	M.J.	S.W.	
DATE: 2000.05.10 8:15am	FILE NAME: J:\jobs99\DWG\99420\Comp\VSL\SCR-99420-103.dwg	REVISION	BY	DATE	CKD	ENG							

PROPAK SYSTEMS LTD.
440 East Lake Road,
Postal Bag #2
Airdrie, Alberta
Canada T4B 2C3

STOCK 1380 HP COMPRESSOR
STAGE-3 INLET SCRUBBER - SOUR GAS
508 O/D x 1473 S/S

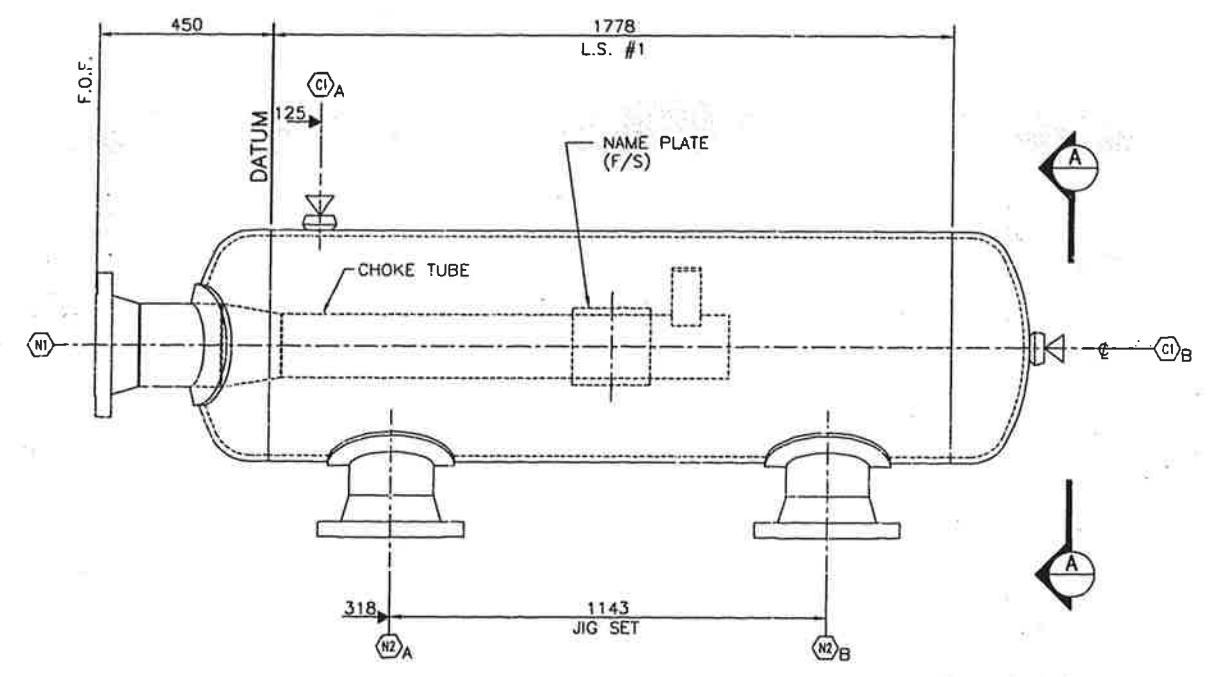
DWG. No.: D-SCR-99420-103

REV. 1

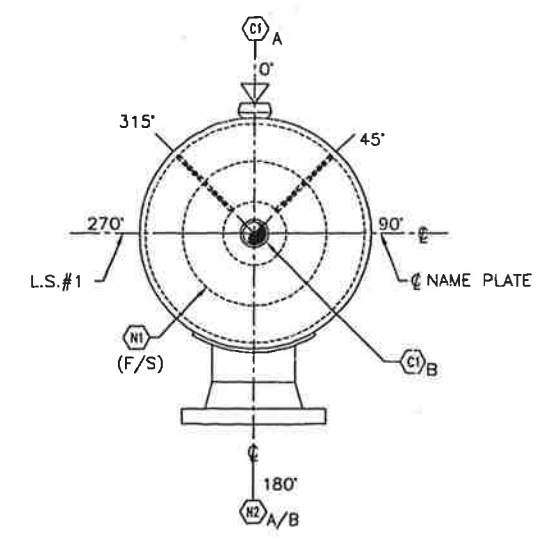
OF PROPAG

TO OTHERS OR REPRODUCED IN ANY MANNER OR USED FOR ANY PURPOSE WHATSOEVER EXCEPT BY WRITTEN CONSENT

THE DESIGN IT COVERS ARE CONFIDENTIAL AND THE PROPERTY OF PROPAG SYSTEMS LTD. AND SHALL NOT BE DISCLOSED



ELEVATION
SCALE: 1:10



ORIENTATION
VIEW 'A-A'
SCALE: 1:10

NOZZLE SCHEDULE									
MK	SIZE	RATING	FACING	SCH	SERVICE	INT. SPEC.	PROJ. SPEC.	EXT. SPEC.	WELD
N1	219	300	RFWN	XH	INLET PROCESS GAS				
N2	219	300	RFWN	XH	OUTLET PROCESS GAS	0	200		
A	C1	60	6000	TOL	INSPECTION/VENT c/w PLUG				
B	C1	60	6000	TOL	INSPECTION c/w PLUG				

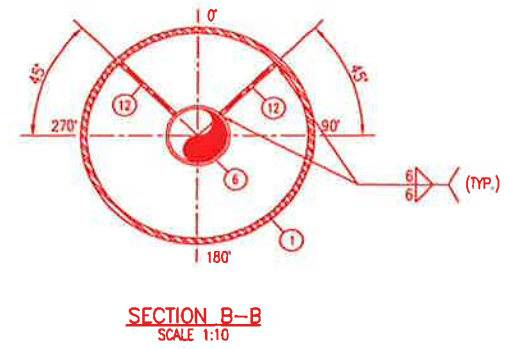
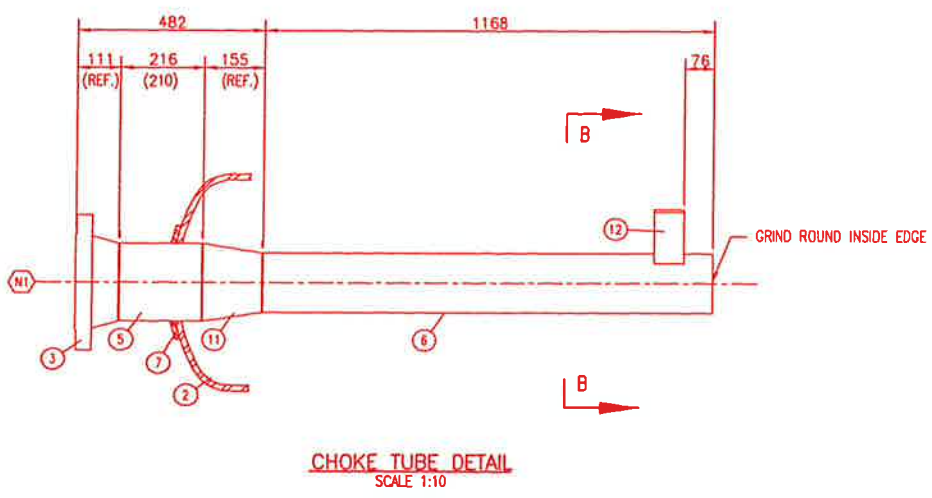
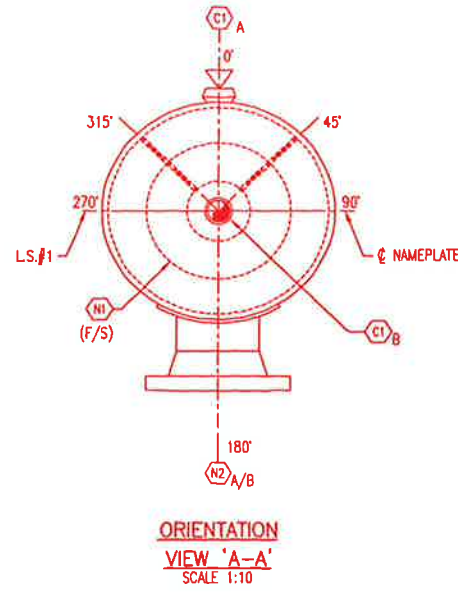
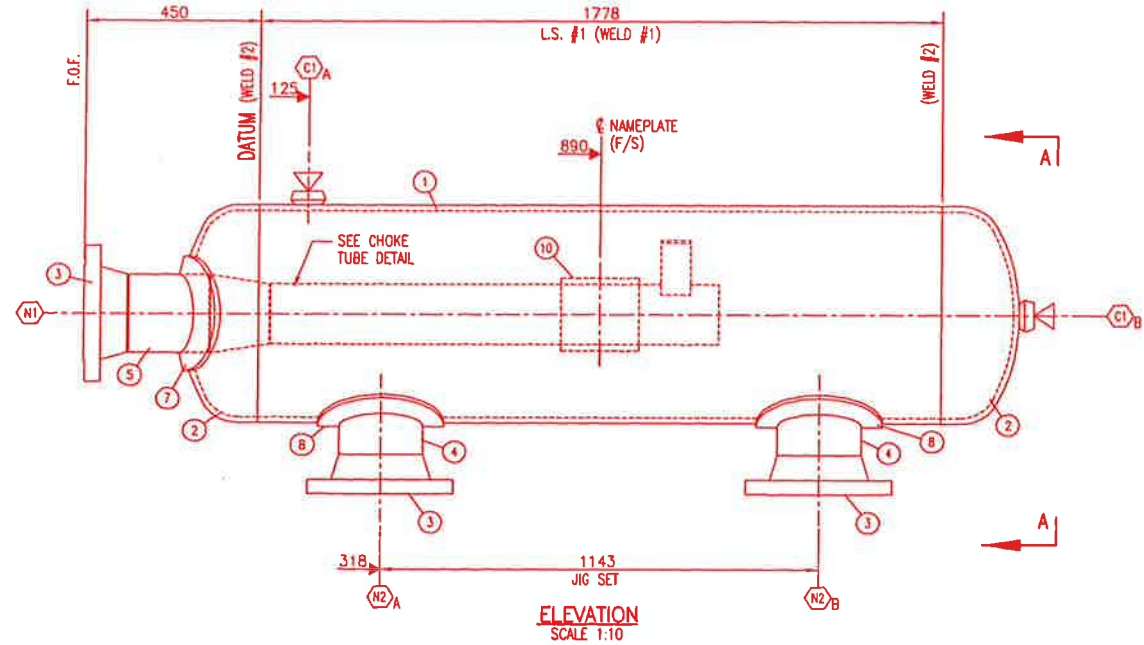
CAPACITY: 0.54 m³
 WEIGHT EMPTY: 797 kg
 WEIGHT FULL OF WATER: 1337 kg
 SURFACE PREPARATION: PNT-11
 PRIMER: PNT-11
 FINISH PAINT: PNT-11
 INSULATION: NONE
 MECHANICAL LOADINGS GOVERN AS PER UG22: YES NO
 IMPACT TEST: YES NO
 NO PER UG20(I);
 PRODUCTION IMPACT TEST REQ'D: YES NO
 SHIP LOOSE: YES NO
 SERVICE: SOUR GAS

SERIAL NO: 99420-104 CRN: P-0241.2
 TAG NO: V-121 YEAR BUILT: 2000
 LSD #: -
 CODE: ASME SECT. VIII DIV I, '98, ADDENDA '99
 MAX. DESIGN PRESS: 4516 kPag @ TEMP: 149 °C
 HYDROTEST: 5871 kPag
 MIN^M DESIGN METAL TEMP: -28 °C @ MAWP 4516 kPag
 MATERIAL: HEAD: SA-516-70N SHELL: SA-516-70N
 RADIOGRAPHY:
 LONG- [FULL UNIT] (INCLUDING ALL BUTT WELDS)
 SRC- [FULL UNIT] (INCLUDING ALL BUTT WELDS)
 P.W.H.T.: YES NO MIN. TEMP: 593 °C, TIME: (1) hr (MIN)
 CORR. ALLOW: 3.20 mm

"SOUR SERVICE"

DATE: 2000.09.26 8:14am		FILE NAME: J:\jobs99\DWG\99420\Comp\Misc\BTL-99420-104-SKT-01.dwg		SKT No.		ISSUED FOR DOCUMENTATION		H. LE 00/09/15		YK SW		BY DATE CKD ENG		APPROVED		DRAWN		APACHE CANADA LIMITED		440 East Lake Road, Postal Bag #2 Airdrie, Alberta Canada T4B 2C3	
GENERAL NOTES		GENERAL NOTES		No.		REVISION								MECH./STRUCT.		BY DATE		1478 HP HAMBURG COMPRESSOR PACKAGE		REV. SKT	
														ELECTRICAL		CHECKED		STAGE-1 SUCTION BOTTLE (V-121)		Dwg. No.: D-BTL-99420-104-SKT	
														PROJECT		DATE		610 O/D x 1778 S/S		SHT. 1 OF 1	
														DATE		SCALE AS NOTED					

THIS DRAWING IS CONFIDENTIAL AND THE PROPERTY OF PROPAC SYSTEMS LTD. AND SHALL NOT BE DISCLOSED



NOZZLE SCHEDULE									
MK	SIZE	RATING	FACING	SCH	SERVICE	INT. PROJ	EXT. PROJ	WELD	
N1	219	300#	RFWN	XH	INLET PROCESS GAS			7/14	
N2	219	300#	RFWN	XH	OUTLET PROCESS GAS	0	200	8/14	
A	C1	60	6000#	TOL	INSPECTION/VENT c/w PLUG	-	-	6	
B	C1	60	6000#	TOL	INSPECTION c/w PLUG	-	-	6	

BILL OF MATERIAL			
ITEM	QUA	DESCRIPTION	
1	1	SHELL PLATE: 15.88 THK x 1778 LG. (ROLLED TO 610 O/D)	SA-516-70N
2	2	HEAD PLATE: 15.88 NOM. (13.72 MIN.) THK. x 610 O/D, 2:1 S.E. c/w 51 S.F.	SA-516-70N
3	3	FLANGE: 219-300# RFWN SCH XH BORE	SA-105N
4	2	PIPE: 219 O/D x 12.7 WT. x 152 LG. (CTS)	SA-106-B
5	1	PIPE: 219 O/D x 7.11 WT. x 210 LG.	SA-106-B
6	1	PIPE: 168 O/D x 7.11 WT. x 1168 LG.	SA-106-B
7	1	REPAD PLATE: 12.7 THK. x 321 O/D x 222 I/D (DISHED TO SUIT 610 O/D, 2:1 S.E. HEAD)	SA-516-70N
8	2	REPAD PLATE: 9.53 THK. x 330 O/D x 222 I/D (ROLLED TO 610 I/D)	SA-516-70N
9	2	TOL: 60-6000# NPT c/w PLUG (1)-ON A 610 O/D RUN, (1)-FLAT	SA-105N
10	1	NAMEPLATE c/w MOUNTING BRACKET	SS/SA-36
11	1	CONCENTRIC REDUCER: 219 XH x 168 SCH 40 BH (SMLS)	SA-214-WPB
12	2	F/BAR: 10 THK x 76 x 202 LG.	G40.21M-300W

CAPACITY: 0.54 m³
 WEIGHT EMPTY: 797 kg
 WEIGHT FULL OF WATER: 1337 kg
 SURFACE PREPARATION: PNT-11
 PRIMER:
 FINISH PAINT:
 INSULATION: NONE
 MECHANICAL LOADINGS GOVERN AS PER UG22: **YES/NO**
 IMPACT TEST: **YES/NO**

SERIAL NO: 99420-104 CRN:
 TAG NO: V-121 YEAR BUILT: 2000
 LSD #: -
 CODE:
 ASME SECT. VIII DIV 1, '98, ADDENDA '99
 MAX. DESIGN PRESS: 4516 kPag @ TEMP: 149°C
 HYDROTEST: 5871 kPag
 MIN^m DESIGN METAL TEMP: -28°C @ MAWP 4516 kPag
 MATERIAL: HEAD: SA-516-70N SHELL: SA-516-70N

RADIOGRAPHY:
 LONG: FULL UNIT(s)
 CIRC: FULL UNIT(s)
 PRODUCTION IMPACT TEST REQ'D: **YES/NO**
 SHIP LOOSE: **YES/NO**
 SERVICE: SOUR GAS
 LONG & CIRC. WELDS TYPE 1
 QWP: 590.2
 QCP: AQP-1050 (S) AQP-1227 (S)
 TACK WELDS WPS# 101
 PRESS. TO STRUCT. WELD WPS# 102, 106, 110

"SOOR SERVICE"

DOUBLE BUTT	SINGLE VEE	THREDOLET	NOZZLE & REPAD RECESSED	NOZZLE & REPAD FLUSH	PIPE TO FLANGE/FITTING
WPS# 102, 106, 110	2. WPS# 104, 106, 110	6. WPS# 102, 106, 110	7. WPS# 102, 106, 108	8. WPS# 102, 106, 108, 110	14. WPS# 104, 106, 110

1. DO NOT PROFILE INTERNAL PROJECTION UNLESS SPECIFIED.
 2. SANDBLAST INTERNALS TO ENSURE THAT THE INSIDE SURFACE OF THE VESSEL IS FREE OF LOOSE MILL SCALE AND WELD SPLATTER.
 3. VESSEL TO BE FLUSHED OUT AT HYDROTEST, AIR DRIED AND OILED INTERNALLY.
 4. VESSEL OPENINGS TO BE SEALED PRIOR TO ANY SHIPPING TO OTHER SHOPS.

GENERAL NOTES		GENERAL NOTES		REVISION	
1	ISSUED FOR CONSTRUCTION	D. SMITH	00/05/10	M.I.	S.W.
No.		BY	DATE	CKD	ENG

APPROVED		DRAWN	
MECH./STRUCT.	BY D. SMITH	DATE	00/04/06
ELECTRICAL	CHECKED	DATE	00/05/10
PROJECT	BY M. IWANIUK	DATE	00/05/10
DATE	S. WARD	SCALE	AS NOTED

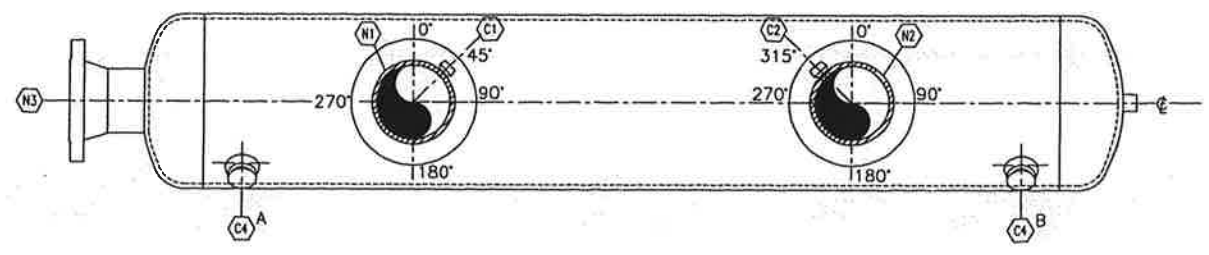
PROPAC SYSTEMS LTD.
 STOCK 1380HP COMPRESSOR
 STAGE-1 SUCTION BOTTLE
 610mm O/D x 1778 mm S/S

DWG. No.: D-BTL-99420-104
 REV. 1

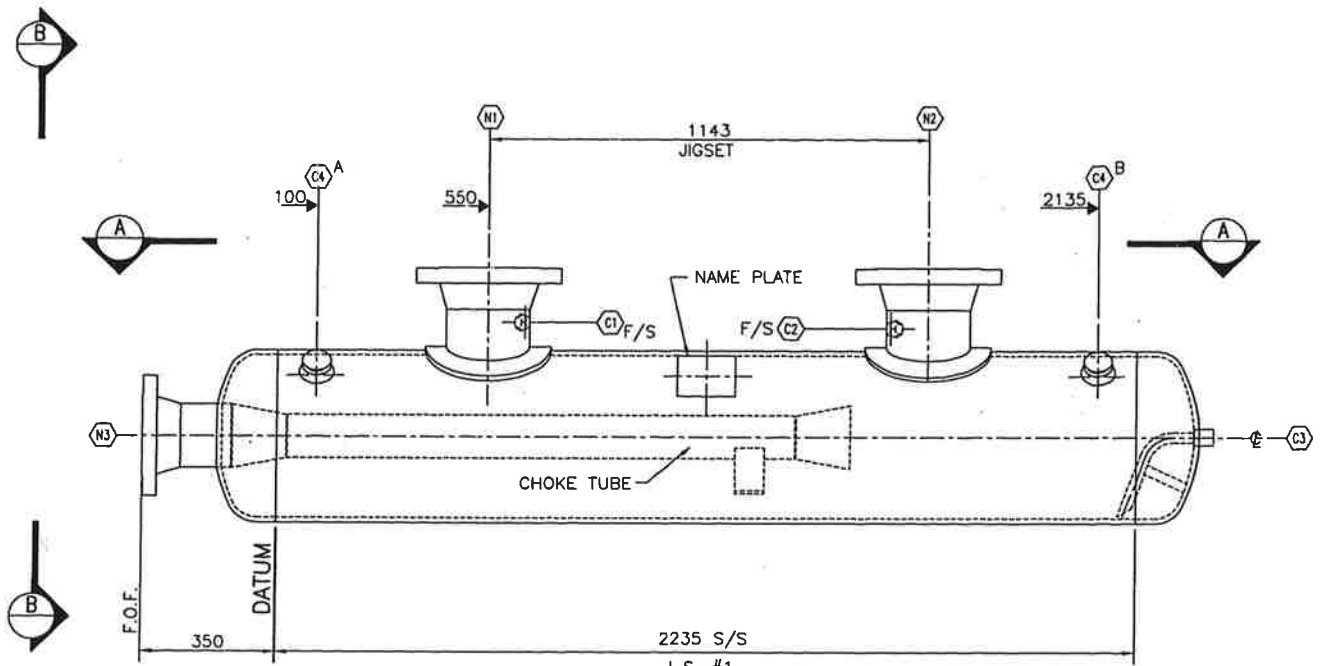
440 East Lake Road,
 Postal Bag #2
 Airdrie, Alberta
 Canada T4B 2C3

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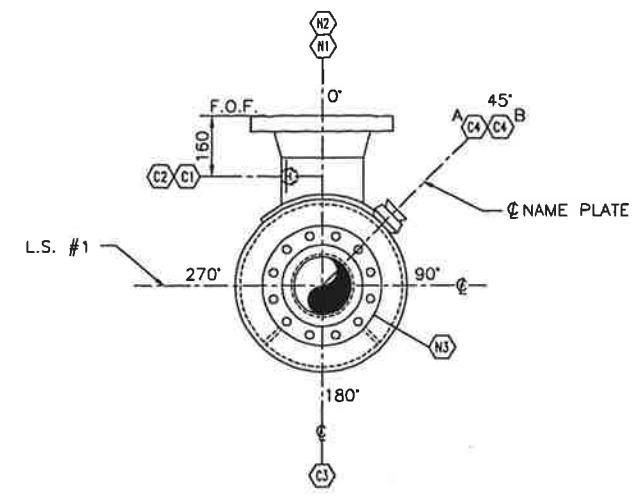
NOZZLE SCHEDULE									
MK	SIZE	RATING	FACING	SCH	SERVICE	INT. PROJ	EXT. PROJ	WELD	
N1	219	300#	RFWN	XH	INLET CYL #1	MIN	220	-	
N2	219	300#	RFWN	XH	INLET CYL #2	MIN	220	-	
N3	168	300#	RFWN	XXH	PROCESS GAS OUTLET	SPEC.	SPEC.	-	
C1	27	6000#	TOL	-	THERMOWELL	-	-	-	
C2	27	6000#	TOL	-	THERMOWELL	-	-	-	
C3	27	6000#	CPLG	XXH	SYPHON DRAIN	-	-	-	
C4	48	6000#	TOL	-	INSPECTION (PLUGGED)	-	-	-	



PLAN VIEW 'A-A'
SCALE: 1:10



ELEVATION VIEW
SCALE: 1:10



ORIENTATION 'B-B'
SCALE: 1:10

CAPACITY: 0.364 m ³	SERIAL NO: 99420-105 CRN: P-0242.2
WEIGHT EMPTY: 586 kg	TAG NO: V-122 YEAR BUILT: 2000
WEIGHT FULL OF WATER: 950 kg	LSD #: -
SURFACE PREPARATION: PNT-12	CODE: ASME SECT. VIII DIV I, '98, ADDENDA '99
PRIMER: NONE	TEMA CLASS: N/A, ADDENDA N/A
FINISH PAINT: NONE	MAX: DESIGN PRESS: 4447 kPag @ TEMP: 176 °C
INSULATION: NONE	MIN: DESIGN PRESS: N/A kPag
MECHANICAL LOADINGS GOVERNS AS PER UG 22: <input checked="" type="checkbox"/> NO	HYDROTEST: VESSEL 5781 kPag
IMPACT TEST: <input checked="" type="checkbox"/> PER UG20(f)	COIL: N/A kPag
PRODUCTION IMPACT TEST REQ'D: <input checked="" type="checkbox"/> NO	MIN ^m DESIGN METAL TEMP: -28 °C @ MAWP 4447 kPag
SHIP LOOSE: <input checked="" type="checkbox"/> NO	MATERIAL: HEAD: SA-516-70N SHELL: SA-516-70N
SERVICE: SOUR GAS	RADIOGRAPHY: LONG L. FULL UWII(o)
	CIRC: FULL UWII(o) (INCL. ALL BUTT WELDS)
	P.W.H.T.: YES <input checked="" type="checkbox"/> MIN. TEMP: 593 °C, TIME: 1.0 h (MIN.)
	CORR. ALLOW: 3.2 mm

"SOUR SERVICE"



APACHE CANADA LIMITED
1478 HP HAMBURG COMPRESSOR PACKAGE
1st STAGE DISCHARGE BOTTLE (V-122)
457 O/D x 2235 S/S

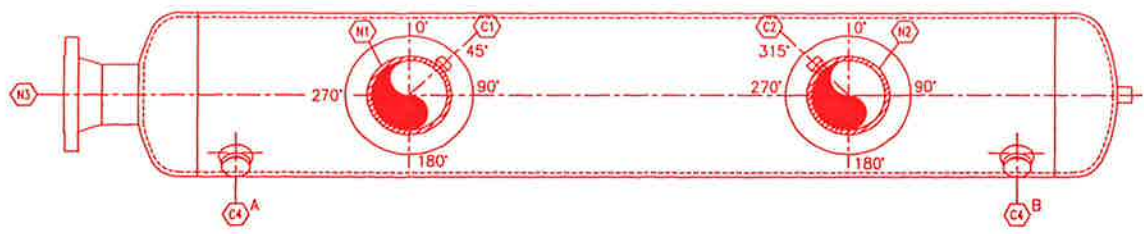
440 East Lake Road,
Postal Bag #2
Aldrie, Alberta
Canada T4B 2C3

GENERAL NOTES		GENERAL NOTES		APPROVED		DRAWN	
DATE: 2000.09.26 B:19am	FILE NAME: J:\jobs99\DWG\99420\Comp\Misc\BTL-99420-105-SKT-01.dwg	SKT No.	ISSUED FOR DOCUMENTATION	H. LE	00/09/15	VK	SW
			REVISION	BY	DATE	CKD	ENG

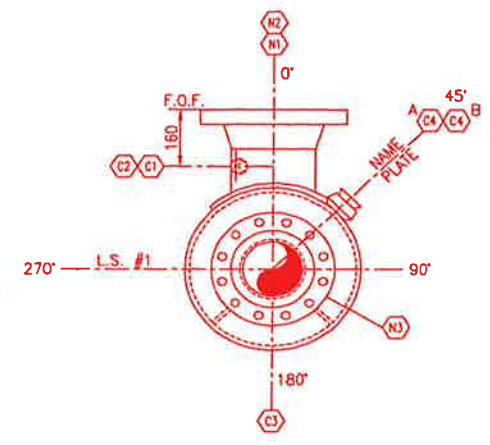
MECH/STRUCT.	BY	DATE
ELECTRICAL	BY	DATE
PROJECT	BY	DATE
DATE	SCALE	AS NOTED

DWG. No.:	D-BTL-99420-105-SKT	SHT. 1 OF 1	REV. SKT
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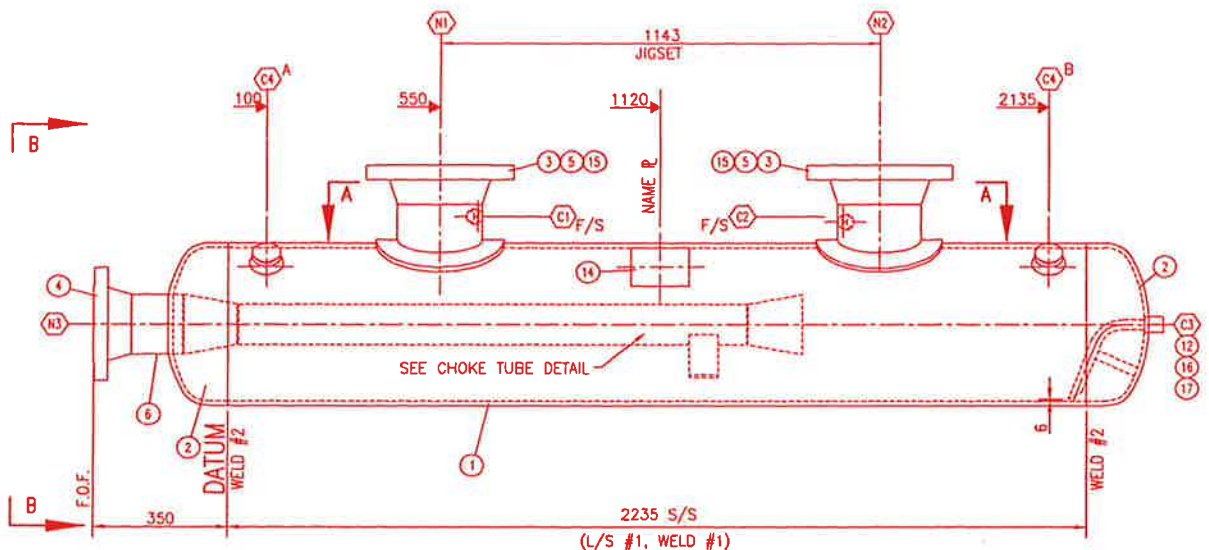
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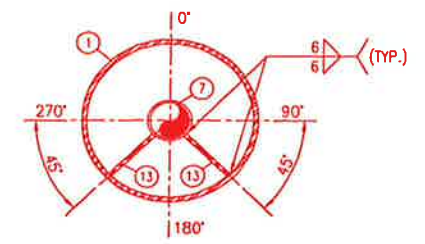
PLAN VIEW A-A
SCALE 1:10



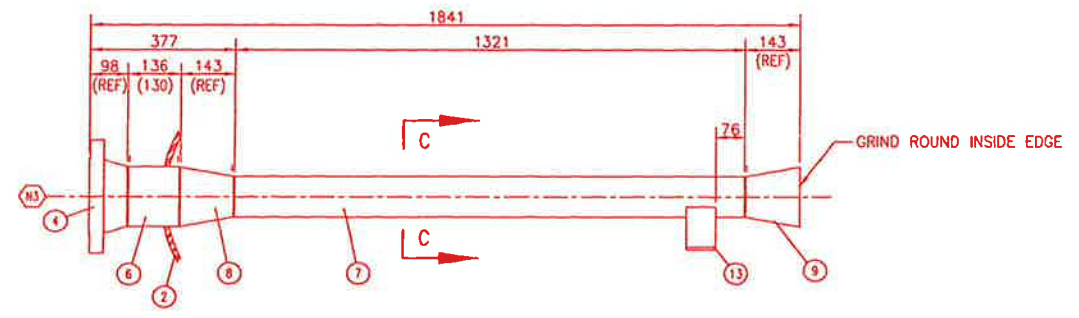
ORIENTATION B-B
SCALE 1:10



ELEVATION VIEW
SCALE 1:10



VIEW C-C
SCALE 1:10



CHOKE TUBE DETAIL
SCALE 1:10

NOZZLE SCHEDULE									
MK	SIZE	RATING	FACING	SCH	SERVICE	INT. PROJ.	EXT. PROJ.	PROJ.	WELD
N1	219	300#	RFWN	XH	INLET CYL. #1	MIN	220	8	14
N2	219	300#	RFWN	XH	INLET CYL. #2	MIN	220	8	14
N3	168	300#	RFWN	XXH	PROCESS GAS OUTLET	SPEC.	SPEC.	10	14
C1	27	6000#	TOL	-	THERMOWELL	-	-	-	6
C2	27	6000#	TOL	-	THERMOWELL	-	-	-	6
C3	27	6000#	CPLG	XXH	SYPHON DRAIN	-	-	-	4
C4	48	6000#	TOL	-	INSPECTION (PLUGGED)	-	-	-	6

BILL OF MATERIAL		
ITEM	QUA	DESCRIPTION
1	1	SHELL PLATE: 12.7 THK. x 2235 LG. (ROLL TO 457 O/D)
2	2	HEAD PLATE: 457 O/D x 12.70 NOM. (10.62 MIN.) 2:1 S.E. c/w 51 S.F.
3	2	FLANGE: 219-300# RFWN XXH BORE
4	1	FLANGE: 168-300# RFWN XXH BORE
5	2	PIPE: 219 O/D x 12.70 WT x 177 LG. (SMLS)
6	1	PIPE: 168 O/D x 21.92 WT x 130 LG. (SMLS)
7	1	PIPE: 114 O/D x 6.02 WT x 1321 LG. (SMLS)
8	1	CONC. RED: 168 O/D XXH x 114 O/D SCH 40 BW (SMLS)
9	1	CONC. RED: 168 O/D x 114 O/D, SCH 40 SMLS
10	2	TOL: 48-6000# c/w PLUG (ON 457 O/D RUN)
11	2	TOL: 27-6000# (ON 219 O/D RUN)
12	1	CPLG: 27 - 6000# SW x NPT
13	2	FLAT BAR: 10 THK. x 76 x 156 LG.
14	1	NAMEPLATE c/w MOUNTING BRACKET
15	2	REPAD: 9.53 THK x 330 O/D x 222 I/D (ROLLED TO 457 I/D)
16	1	PIPE: 27 O/D x 7.82 WT x 400 LG (SMLS) (C.T.S. & B.T.S.)
17	1	F/BAR: 10 THK x 25 x 111 LG

NOTE: THE FOLLOWING SUBSTITUTIONS ARE PERMITTED (THE OPPOSITE NOT ALLOWED)
SA-350-LF2 for SA-105, SA-333-Gr6 for SA-420-WPL6 for SA-234-WPB

CAPACITY: 0.364 m³
WEIGHT EMPTY: 586 kg
WEIGHT FULL OF WATER: 950 kg
SURFACE PREPARATION: PNT-12
PRIMER: PNT-12
FINISH PAINT: PNT-12
INSULATION: NONE
MECHANICAL LOADINGS GOVERNS AS PER UG 22: 30

SERIAL NO: 99420-105 CRN:
TAG NO: V-122 YEAR BUILT: 2000
LSD #: -
CODE: ASME SECT. VIII DIV I, '98, ADDENDA '99
TEMA CLASS: N/A, ADDENDA N/A
MAX: DESIGN PRESS: 4447 kPag @ TEMP: 176 °C
MIN: DESIGN PRESS: N/A kPag
HYDROTEST: VESSEL 5781 kPag
COIL: N/A kPag
MIN^m DESIGN METAL TEMP: -28 °C @ MAWP 4447 kPag
MATERIAL: HEAD: SA-516-70N SHELL: SA-516-70N
RADIOGRAPHY: LONG^l FULL UWI(a)
CIRC: FULL UWI(a) (INCL. ALL BUTT WELDS)
P.W.H.T.: YES MIN. TEMP: 593 °C, TIME: 1.0 h (MIN.)
CORR. ALLOW: 3.2 mm

IMPACT TEST: PER UG20(f)

PRODUCTION IMPACT TEST REQ'D:
SHIP LOOSE:
SERVICE: SOUR GAS
LONG & CIRC. WELDS TYPE 1
OWP: 590.2
QCP: AQP-1050(S) AQP-1227(S)
TACK WELDS: WPS# 101
PRESS. TO STRUCT: WPS# 102 106 110

DOUBLE BUTT	SINGLE VEE	COUPLING	THREDOLET	NOZZLE & REPAD FLUSH	NOZZLE RECESSED	PIPE TO FLANGE/FITTING
BACK GOUGE TO SOUND METAL BEFORE 2nd WELD 1. WPS# 102,106,110	GMAW ROOT PASS 2. WPS# 104, 106, 110	2x45° CHAM. 1.5 4. WPS# 102,106,110	2x45° CHAM. 6. WPS# 102,106,110	WELD FLUSH INSIDE 2x45° CHAM. 8. WPS# 102,106,108,110	SPEC 10. WPS# 102,106,108,110	GMAW ROOT PASS 14. WPS# 104,106,110

1) DO NOT PROFILE INTERNAL PROJECTION UNLESS SPECIFIED.
2) SANDBLAST INTERNALS TO ENSURE THAT THE INSIDE SURFACE OF THE VESSEL IS FREE OF LOOSE MILL SCALE AND WELD SPLATTER.
3) VESSEL TO BE FLUSHED OUT AT HYDROTEST, AIR DRIED AND OILED INTERNALLY.
4) VESSEL OPENINGS TO BE SEALED PRIOR TO ANY SHIPPING TO OTHER SHOPS.

GENERAL NOTES

1 ISSUED FOR CONSTRUCTION

DATE: 2000.05.10 8:20am FILE NAME: J:\jobs99\DWG\99420\Comp\VSL\BTL-99420-105.dwg

No.	REVISION	BY	DATE	CKD	ENG
1	ISSUED FOR CONSTRUCTION	D. SMITH	00/05/10	M.I.	S.W.

APPROVED		DRAWN	
MECH./STRUCT.	DATE	BY	DATE
ELECTRICAL	DATE	CHECKED	DATE
PROJECT	DATE	BY	DATE
DATE	00/05/10	M. IWANIUK	00/05/10

PROPAC SYSTEMS LTD.
440 East Lake Road,
Postal Bag #2
Airdrie, Alberta
Canada T4B 2C3

STOCK 1380 HP COMPRESSOR
1st STAGE DISCHARGE BOTTLE
457 O/D x 2235 S/S

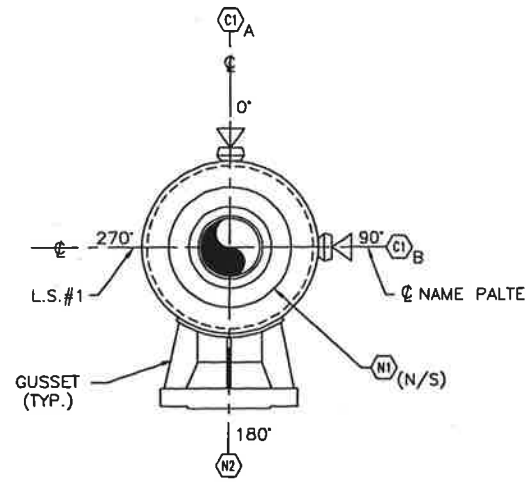
DWG. No.: D-BTL-99420-105

OF PROPAK

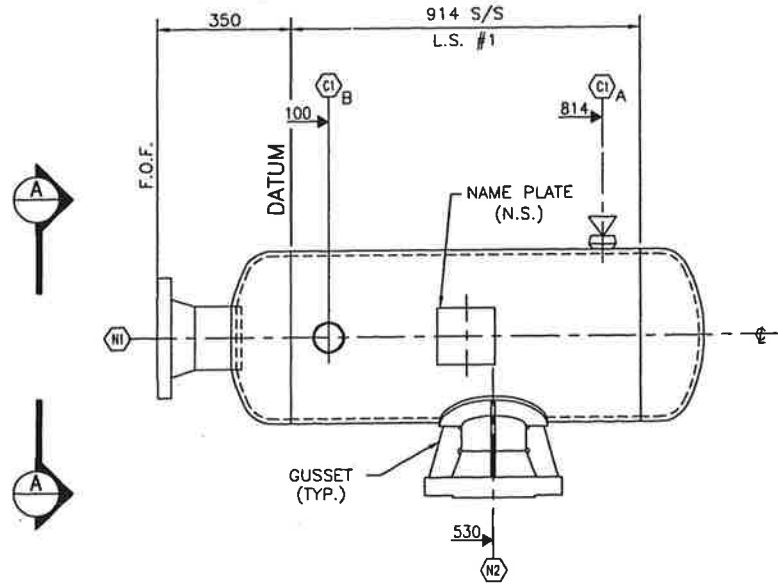
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NOZZLE SCHEDULE									
MK	SIZE	RATING	FACING	SCH	SERVICE	INT. PROJ	EXT. PROJ	WELD	
N1	168	300	RFWN	XH	INLET PROCESS GAS	13	SPEC.	-	
N2	168	600	RFWN	XH	OUTLET PROCESS GAS	0	200	-	
C1	48	6000	TOL	-	INSPECTION/VENT c/w PLUG	-	-	-	
C1	48	6000	TOL	-	INSPECTION c/w PLUG	-	-	-	



ORIENTATION
VIEW 'A-A'
SCALE: 1:10



ELEVATION
SCALE: 1:10

CAPACITY: 0.17 m³
 WEIGHT EMPTY: 301 kg
 WEIGHT FULL OF WATER: 471 kg
 SURFACE PREPARATION: PNT-11
 PRIMER: PNT-11
 FINISH PAINT: PNT-11
 INSULATION: NONE
 MECHANICAL LOADINGS GOVERN AS PER UG22: YES NO
 IMPACT TEST: YES NO
 NO-PER UG20(f);
 PRODUCTION IMPACT TEST REQ'D: YES NO
 SHIP LOOSE: YES NO
 SERVICE: SOUR GAS

SERIAL NO: 99420-106 CRN: P-0245.2
 TAG NO: V-123 YEAR BUILT: 2000
 LSD #: -
 CODE: ASME SECT. VIII DIV I, '98, ADDENDA '99
 MAX. DESIGN PRESS: 4516 kPag @ TEMP: 149°C
 HYDROTEST: 5871 kPag
 MIN^m DESIGN METAL TEMP: -28°C @ MAWP 4516 kPag
 MATERIAL: HEAD: SA-516-70N SHELL: SA-516-70N
 RADIOGRAPHY:
 LONG- [FULL UNIT(S)] (INCLUDING ALL BUTT WELDS)
 CIRC [FULL UNIT(S)] (INCLUDING ALL BUTT WELDS)
 P.W.H.T.:
 YES NO MIN. TEMP: 593°C, TIME: (1) hr (MIN)
 CORR. ALLOW: 3.20 mm

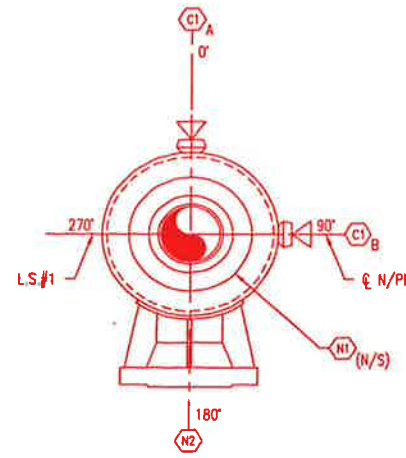
"SOUR SERVICE"

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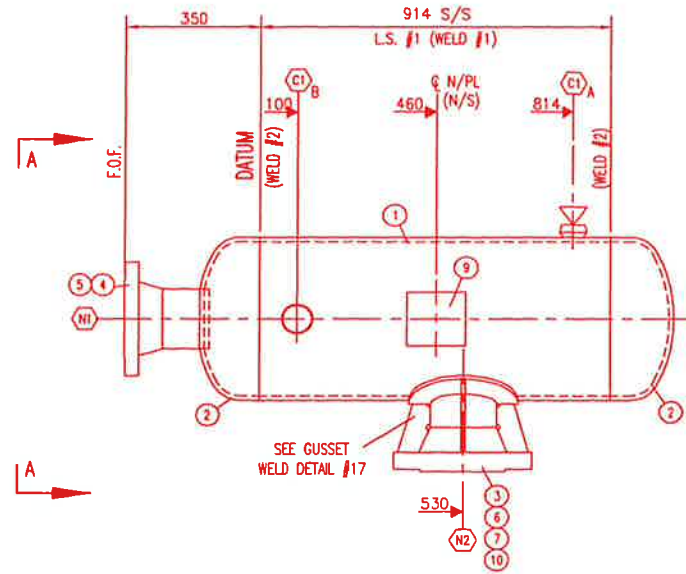
GENERAL NOTES		GENERAL NOTES		SKT	ISSUED FOR DOCUMENTATION	H. LE	00/09/19	VK	SW	APPROVED		DRAWN		APACHE CANADA LIMITED	
DATE: 2000.09.26 8:21am	FILE NAME: J:\jobs99\DWG\99420\Comp\Misc\BTL-99420-106-SKT-01.dwg	No.	REVISION	BY	DATE	CKD	ENG			MECH./STRUCT.	BY	DATE	DATE	1478 HP HAMBURG COMPRESSOR PACKAGE	
										ELECTRICAL	BY	DATE	CHECKED	STAGE-2 SUCTION BOTTLE (V-123)	
										PROJECT	BY	DATE		457 O/D x 914 S/S	
										DATE	SCALE	AS NOTED		DWG. No.: D-BTL-99420-106-SKT	
														SHT. 1 OF 1	
														REV. SKT	

PROPAK
 440 East Lake Road,
 Postal Bag #2
 Airdrie, Alberta
 Canada T4B 2C3

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ORIENTATION
VIEW 'A-A'
SCALE 1:10



ELEVATION
SCALE 1:10

NOZZLE SCHEDULE							
MK	SIZE	RATING	FACING	SCH	SERVICE	INT. PROJ	EXT. PROJ
N1	168	300#	RFWN	XXH	INLET PROCESS GAS	13	10/14
N2	168	600#	RFWN	XH	OUTLET PROCESS GAS	0	200
C1	48	6000#	TOL	-	INSPECTION/VENT c/w PLUG	-	-
C1	48	6000#	TOL	-	INSPECTION c/w PLUG	-	-

BILL OF MATERIAL		
ITEM	QUA	DESCRIPTION
1	1	SHELL PLATE: 12.70 THK. x 914 LG. (ROLLED TO 457 O/D)
2	2	HEAD PLATE: 457 O/D x 12.70 NOM. (10.82 MIN. THK. 2:1 S.E. c/w 51 S.F.
3	1	FLANGE: 168-600# RFWN XXH BORE
4	1	FLANGE: 168-300# RFWN XXH BORE
5	1	PIPE: 168 O/D x 21.95 WT. x 125 LG
6	1	PIPE: 168 O/D x 10.97 WT. x 131 LG (CTS)
7	1	REPAD PLATE: 9.53 THK. x 279 O/D x 171 I/D (ROLLED TO 457 I/D)
8	2	TOL: 48-6000# NPT c/w PLUG (ON 457 O/D RUN)
9	1	NAMEPLATE c/w MOUNTING BRACKET
10	4	PLATE: 10 THK. x 84 WD x 200 LG. (CTS)

CAPACITY: 0.17 m³
 WEIGHT EMPTY: 301 kg
 WEIGHT FULL OF WATER: 471 kg
 SURFACE PREPARATION: PNT-11
 PRIMER:
 FINISH PAINT:
 INSULATION: NONE
 MECHANICAL LOADINGS GOVERN AS PER UG22: YES NO
 IMPACT TEST: YES NO

SERIAL NO: 99420-106 CRN:
 TAG NO: V-123 YEAR BUILT: 2000
 LSD #: -
 CODE:
 ASME SECT. VIII DIV I, '98, ADDENDA '99
 MAX. DESIGN PRESS: 4516 kPag @ TEMP: 149°C
 HYDROTEST: 5871 kPag
 MIN M DESIGN METAL TEMP: -28°C @ MAWP 4516 kPag
 MATERIAL: HEAD: SA-516-70N SHELL: SA-516-70N

PRODUCTION IMPACT TEST REQ'D: YES NO
 SHIP LOOSE: YES NO
 SERVICE: SOUR GAS
 LONG & CIRC. WELDS TYPE 1
 QWP: 590.2
 QCP: AQP-1050 (S) AQP-1227 (S)
 TACK WELDS WPS# 101
 PRESS. TO STRUCT. WELD WPS# 102, 106, 110

RADIOGRAPHY:
 LONG: FULL URT1(a)
 CIRC: FULL URT1(a)
 P.W.H.T.:
 YES NO MIN. TEMP: 593°C, TIME: (1) hr (MIN)
 CORR. ALLOW: 3.20 mm

"SOOR SERVICE"

DOUBLE BUTT	SINGLE VEE	THREDOLET	NOZZLE & REPAD FLUSH	NOZZLE RECESSED	PIPE TO FLANGE/FITTING	GUSSETS
1. WPS# 102, 106, 110	2. WPS# 104, 106, 110	6. WPS# 102, 106, 110	8. WPS# 102, 106, 108, 110	10. WPS# 102, 106, 108, 110	14. WPS# 104, 106, 110	17. WPS# 102, 106, 110

- DO NOT PROFILE INTERNAL PROJECTION UNLESS SPECIFIED.
- SANDBLAST INTERNALS TO ENSURE THAT THE INSIDE SURFACE OF THE VESSEL IS FREE OF LOOSE MILL SCALE AND WELD SPLATTER.
- VESSEL TO BE FLUSHED OUT AT HYDROTEST, AIR DRIED AND OILED INTERNALLY.
- VESSEL OPENINGS TO BE SEALED PRIOR TO ANY SHIPPING TO OTHER SHOPS.

GENERAL NOTES		GENERAL NOTES		REVISION	
DATE: 2000.05.10 8:23am	FILE NAME: j:\jobs99\DWG\99420\Comp\VSL\BTL-99420-106.dwg	No.	1	ISSUED FOR CONSTRUCTION	D. SMITH 00/05/10
					M.I. S.W.
					BY DATE CKD ENG

APPROVED		DRAWN	
MECH./STRUCT.	BY D. SMITH	DATE	00/04/11
ELECTRICAL	BY CHECKED	DATE	00/05/10
PROJECT	BY S. WARD	DATE	00/05/10
DATE	00/05/10	SCALE	AS NOTED

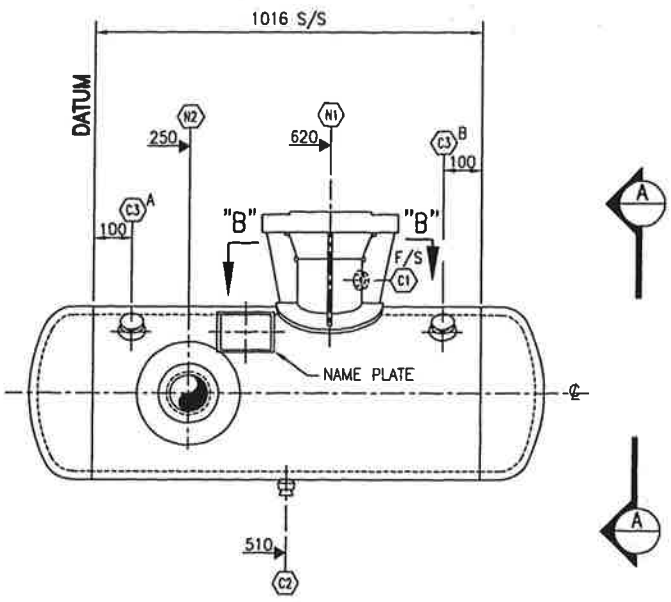
PROPAC SYSTEMS LTD.
 440 East Lake Road,
 Postal Bag #2
 Airdrie, Alberta
 Canada T4B 2C3

STOCK 1380HP COMPRESSOR
 STAGE-2 SUCTION BOTTLE
 457mm O/D x 914 mm S/S

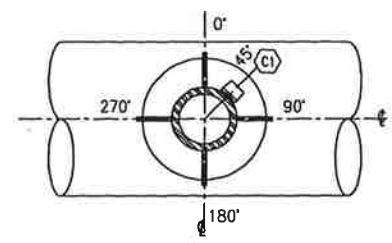
DWG. No.: D-BTL-99420-106
 REV. 1

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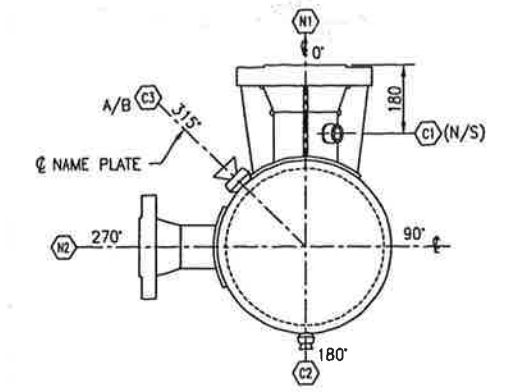
NOZZLE SCHEDULE									
MK	SIZE	RATING	FACING	SCH	SERVICE	INT. PROJ.	EXT. PROJ.	WELD	
N1	168	600#	RFWN	XXH	PROCESS INLET	MIN.	250	—	
N2	114	600#	RFWN	XXH	PROCESS OUTLET	0	200	—	
C1	27	6000#	TOL	—	THERMOWELL	—	—	—	
C2	27	6000#	TOL	—	DRAIN c/w PLUG	—	—	—	
C3	48	6000#	TOL	—	INSPECTION c/w PLUG	—	—	—	



ELEVATION
SCALE: 1:10



VIEW B-B
SCALE: 1:10



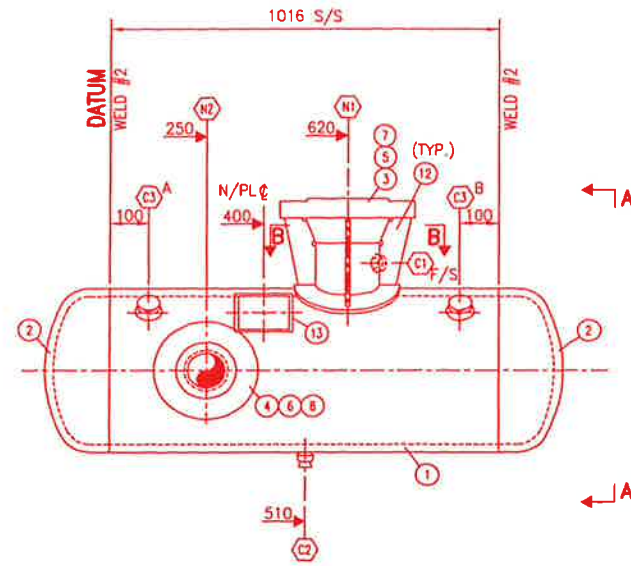
ORIENTATION
VIEW A-A
SCALE: 1:10

CAPACITY: 0.13 m ³ SURFACE AREA OF TUBES: N/A m ² WEIGHT EMPTY: 460 kg WEIGHT FULL OF WATER: 590 kg SURFACE PREPARATION: PRIMER: PNT-12 FINISH PAINT: PNT-12 INSULATION: NONE MECHANICAL LOADINGS GOVERNS AS PER UG 22: <input checked="" type="checkbox"/> NO	SERIAL NO: 99420-107 CRN: P-0247.2 TAG NO: V-124 YEAR BUILT: 2000 LSD #: - CODE: ASME SECT. VIII DIV I, '98, ADDENDA '99 TEMA CLASS N/A, ADDENDA N/A DESIGN PRESS: 8908kPag @ TEMP: 176 °C HYDROTEST: VESSEL 11580 kPag COIL N/A kPa MIN ^m DESIGN METAL TEMP: -28 °C @ MAWP 8908 kPag MATERIAL: HEAD: SA-516-70N SHELL: SA-106B RADIOGRAPHY: LONG- FULL UWI(a) (CIRC: FULL UWI(a) (INCL ALL BUTT WELDS)) P.W.H.T.: YES MIN. TEMP: 593 °C, TIME: 1 hr min. CORR. ALLOW: 3.2 mm 'SOUR SERVICE'
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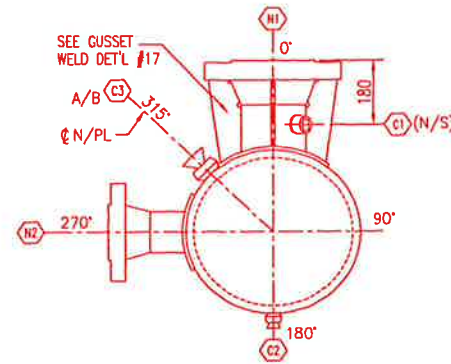
GENERAL NOTES		GENERAL NOTES		SKT	ISSUED FOR DOCUMENTATION			APPROVED		DRAWN		APACHE CANADA LIMITED		440 East Lake Road, Postal Bag #2 Airdrie, Alberta Canada T4B 2C3	
DATE: 2000.09.26 8:23am	FILE NAME: J:\Jobs99\DWG\99420\Comp\Misc\BTL-99420-107-SKT-01.dwg	SKT	ISSUED FOR DOCUMENTATION	C. WEST	00/09/15	VK	SW	MECH./STRUCT.	BY	DATE	DATE	1478 HP HAMBURG COMPRESSOR PACKAGE	Dwg. No.: D-BTL-99420-107-SKT SHT. 1 OF 1 REV. SKT		
		No.	REVISION	BY	DATE	CKD	ENG	ELECTRICAL	BY	DATE	2ND STAGE DISCHARGE BOTTLE (V-124)				
								PROJECT	BY	DATE	406 O/D x 1016 S/S				
								DATE	SCALE	AS NOTED					

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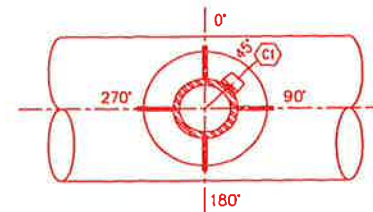
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ELEVATION
SCALE: 1:10



ORIENTATION
VIEW A-A
SCALE: 1:10



VIEW B-B
SCALE: 1:10

NOZZLE SCHEDULE									
MK	SIZE	RATING	FACING	SCH	SERVICE	INT. PROJ	EXT. PROJ	WELD	
N1	168	600#	RFWN	XXH	PROCESS INLET	MIN.	250	B/14	
N2	114	600#	RFWN	XXH	PROCESS OUTLET	0	200	B/14	
C1	27	6000#	TOL	-	THERMOWELL	-	-	6	
C2	27	6000#	TOL	-	DRAIN c/w PLUG	-	-	6	
C3	48	6000#	TOL	-	INSPECTION c/w PLUG	-	-	6	

BILL OF MATERIAL			
ITEM	QUA	DESCRIPTION	
1	1	SHELL PIPE: 406 O/D x 21.44 WT x 1016 LG.	SA-106-B
2	2	HEAD PLATE: 406 O/D x 22.23 THK. NOM. (20.07 MIN.) 2:1 S.E. c/w 51 S.F.	SA-516-70N
3	1	FLANGE: 168-600# RFWN XXH BORE	SA-105N
4	1	FLANGE: 114-600# RFWN XXH BORE	SA-105N
5	1	REPAD: 9.53 x 280 O/D x 171 I/D (ROLL TO 406 I/D)	SA-516-70N
6	1	REPAD: 9.53 x 216 O/D x 117 I/D (ROLL TO 406 I/D)	SA-516-70N
7	1	PIPE: 168 O/D x 21.95 W.T. x 190 LG.	SMLS SA-106-B
8	1	PIPE: 114 O/D x 17.12 W.T. x 147 LG.	SMLS SA-106-B
9	1	TOL: 27-6000# (ON A 168 O/D RUN)	SA-105N
10	1	TOL: 27-6000# (ON A 406 O/D RUN) c/w PLUG	SA-105N
11	2	TOL: 48-6000# (ON A 406 O/D RUN) c/w PLUG	SA-105N
12	4	PLATE: 10 THK. x 84 WD. x 250 LG. (CTS)	SA-36
13	1	NAMEPLATE c/w MOUNTING BRACKET	SS/SA-36
14			

NOTE: THE FOLLOWING SUBSTITUTIONS ARE PERMITTED (THE OPPOSITE NOT ALLOWED)
SA-350-LF2 for SA-105, SA-333-Gr6 for SA-106-B, SA-420-WPL6 for SA-234-WPB

CAPACITY: 0.13 m³
SURFACE AREA OF TUBES: N/A m²
WEIGHT EMPTY: 460 kg
WEIGHT FULL OF WATER: 590 kg
SURFACE PREPARATION: PNT-12
PRIMER:
FINISH PAINT:
INSULATION: NONE
MECHANICAL LOADINGS GOVERNS AS PER UG 22: (NO)

IMPACT TEST: NO - PER UG20(f)
SERIAL NO: 99420-107 CRN:
TAG NO: V-124 YEAR BUILT: 2000
LSD #: -
CODE:
ASME SECT. VIII DIV I, '98, ADDENDA '99
TEMA CLASS, N/A, ADDENDA N/A
DESIGN PRESS: 8908 kPag @ TEMP: 176 °C
HYDROTEST:
VESSEL 11580 kPag
COIL N/A kPa
MIN^m DESIGN METAL TEMP: -28 °C @ MAWP 8908 kPag
MATERIAL: HEAD: SA-516-70N SHELL: SA-106B
RADIOGRAPHY:
[LONG & FULL UG1110] [CIRC: FULL UG1110] [INCL. ALL BUTT WELDS]
P.W.H.T.:
YES, MIN. TEMP: 593 °C, TIME: 1 hr min.
CORR. ALLOW: 3.2 mm
'SOOR SERVICE'

SINGLE VEE	THREDOLET	NOZZLE & REPAD FLUSH	PIPE TO FLANGE/FITTING	GUSSETS
2. WPS# 104.106.110	6. WPS# 102.108.110	8. WPS# 102.106.108.110	14. WPS# 104.106.110	17. WPS# 102.106.110

GENERAL NOTES	GENERAL NOTES	1	ISSUED FOR CONSTRUCTION	D. SMITH	00/05/10	M.L.	S.W.
1) DO NOT PROFILE INTERNAL PROJECTION UNLESS SPECIFIED.		No.	REVISION	BY	DATE	CKD	ENG
2) SANDBLAST INTERNALS TO ENSURE THAT THE INSIDE SURFACE OF THE VESSEL IS FREE OF LOOSE MILL SCALE AND WELD SPLATTER.							
3) VESSEL TO BE FLUSHED OUT AT HYDROTEST, AIR DRIED AND OILED INTERNALLY							
4) VESSEL OPENINGS TO BE SEALED PRIOR TO ANY SHIPPING TO OTHER SHOPS							

APPROVED	DRAWN	PROPAC SYSTEMS LTD.	
MECH./STRUCT. DATE	BY D. SMITH DATE 00/04/11	1380 HP STOCK COMPRESSOR	
ELECTRICAL DATE	CHECKED	2ND STAGE DISCHARGE BOTTLE	
PROJECT S. WARD	BY M. IWANIUK	406mm O/D x 1016mm S/S	
DATE 00/05/10	DATE 00/05/10	DWG. No.: D-BTL-99420-107	REV. 1

PROPAC
440 East Lake Road,
Postal Bag #2
Airdrie, Alberta
Canada T4B 2C3

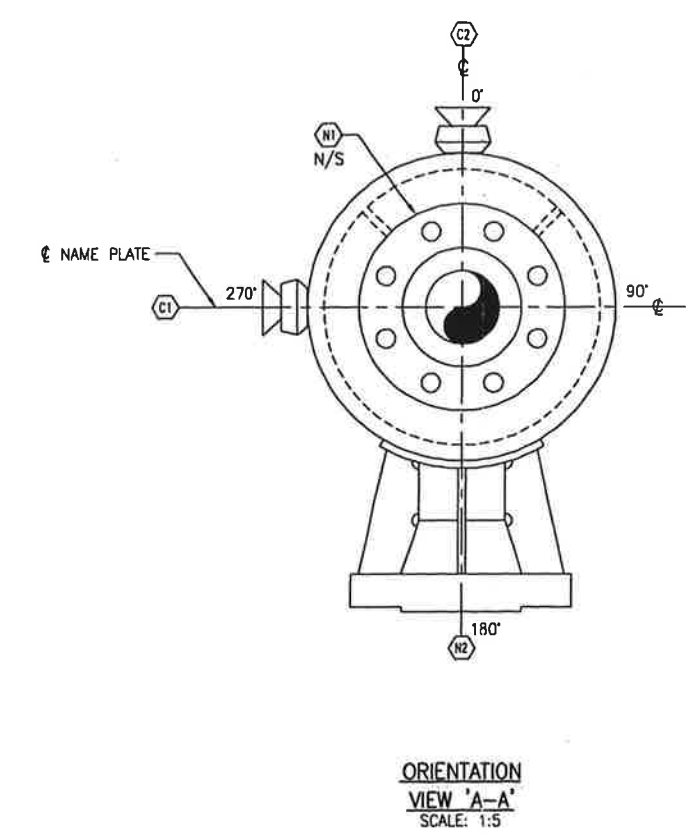
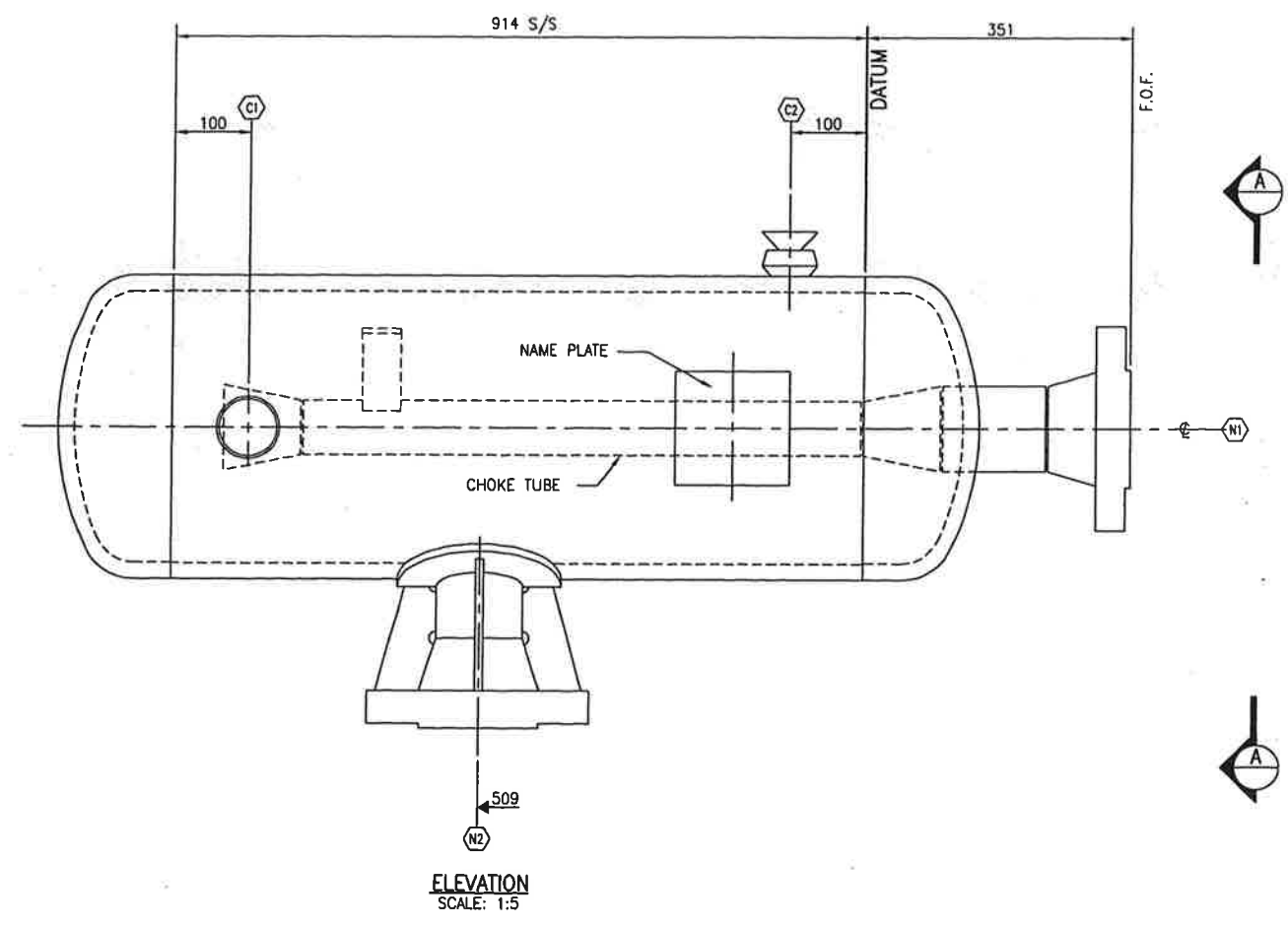
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THIS DRAWING AND

NOZZLE SCHEDULE									
MK	SIZE	RATING	FACING	SCH	SERVICE	INT. PROJ	EXT. PROJ	WELD	
N1	114	600#	RFWN	XXH	PROCESS INLET				
N2	114	900#	RFWN	XXH	PROCESS OUTLET	0	200		
C1	48	6000#	TOL	-	INSPECTION c/w PLUG				
C2	48	6000#	TOL	-	INSPECTION/VENT c/w PLUG				



CAPACITY: 0.12 m³

SURFACE AREA OF TUBES: N/A m²

WEIGHT EMPTY: 402 kg

WEIGHT FULL OF WATER: 522 kg

SURFACE PREPARATION: PNT-11

PRIMER: PNT-11

FINISH PAINT: PNT-11

INSULATION: NONE

MECHANICAL LOADINGS GOVERNS AS PER UG 22: NO

IMPACT TEST: NO - PER UG20(f)

PRODUCTION IMPACT TEST REQ'D: NO

SHIP LOOSE: NO

SERVICE: SOUR GAS

SERIAL NO: 99420-108 CRN: P-0248.2

TAG NO: V-125 YEAR BUILT: 2000

LSD #: -

CODE: ASME SECT. VIII DIV I, '98, ADDENDA '99

TEMA CLASS: N/A, ADDENDA N/A

DESIGN PRESS: 9067kPag @ TEMP: 149 °C

HYDROTEST: VESSEL 11787 kPag

COIL N/A kPag

MIN^m DESIGN METAL TEMP: -28 °C @ MAWP: 9067 kPag

MATERIAL: HEAD: SA-516-70N SHELL: SA-106-B

RADIOGRAPHY: LONG FULL UWH(g)

CIRC: FULL UWH(g) (INCL. ALL BUTT WELDS)

P.W.H.T.: YES MIN. TEMP: 593 °C, TIME: 1 h (MIN.)

CORR. ALLOW: 3.2 mm

"SOUR SERVICE"

APPROVED		DRAWN		APACHE CANADA LIMITED	
MECH./STRUCT.	BY	BY	DATE	1478 HP HAMBURG COMPRESSOR PACKAGE	
				3RD STAGE SUCTION BOTTLE (V-125)	
				406 O/D x 914 S/S	
				DWG. No.: D-BTL-99420-108-SKT	SHT. 1 OF 1
					REV. SKT

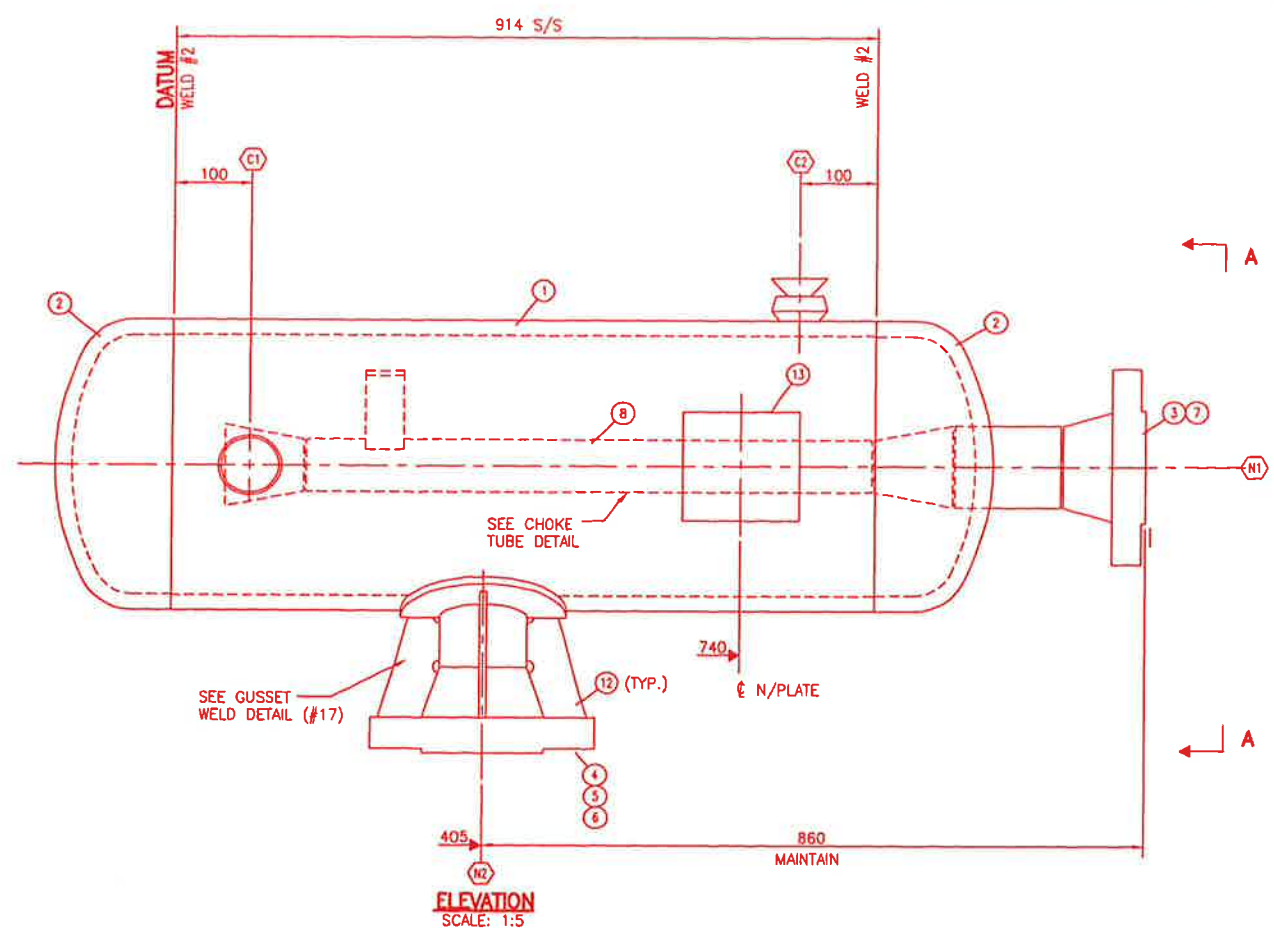
PROPAG
440 East Lake Road,
Postal Bag #2
Airdrie, Alberta
Canada T4B 2C3

GENERAL NOTES
DATE: 2000.09.26 8:24am FILE NAME: J:\jobs99\DWG\99420\Comp\Misc\BTL-99420-108-SKT-01.dwg

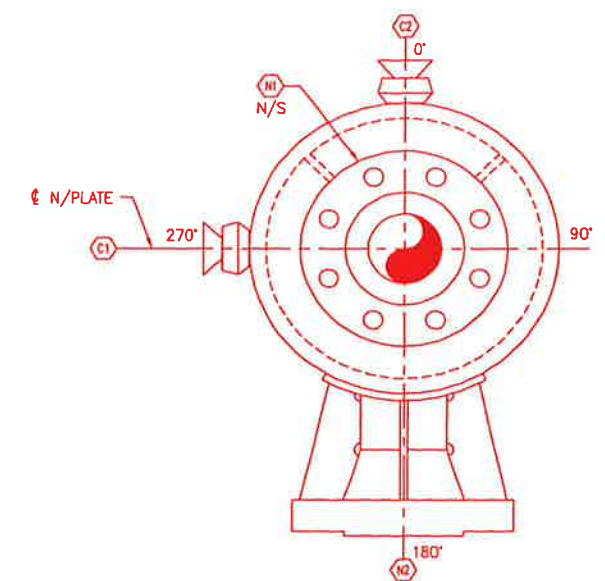
GENERAL NOTES
SKT ISSUED FOR DOCUMENTATION
No. REVISION

J. JUA 00/09/15 VK SW
BY DATE CKD ENG

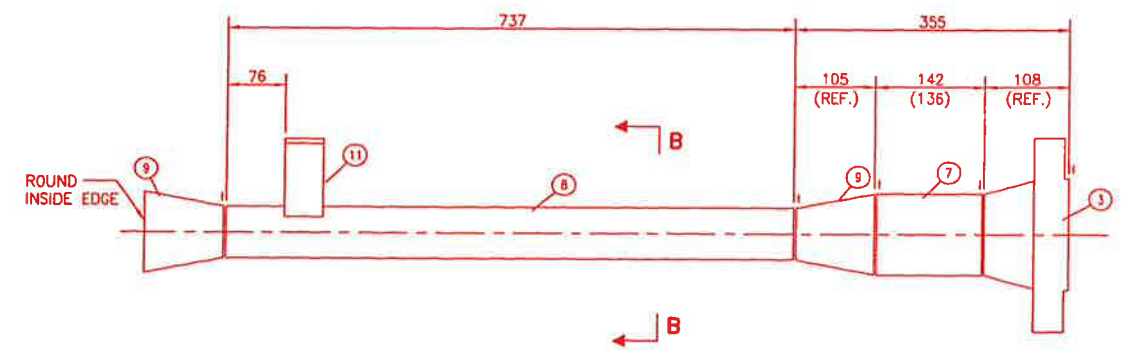
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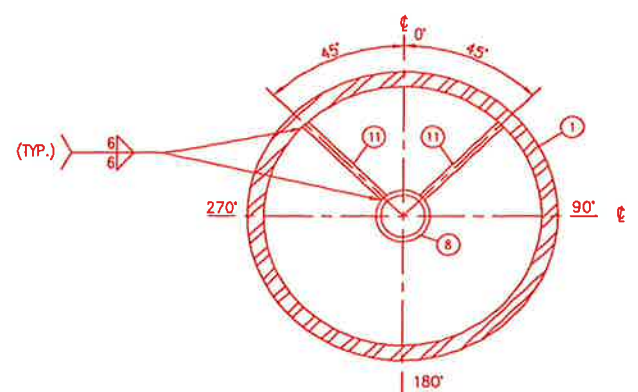
ELEVATION SCALE: 1:5



ORIENTATION VIEW A-A SCALE: 1:5



CHOKE TUBE DETAIL SCALE: 1:5



SECTION B-B SCALE: 1:5

MK	SIZE	RATING	FACING	SCH	SERVICE	INT. PROJ.	EXT. PROJ.	WELD
N1	114	600#	RFWN	XXH	PROCESS INLET			10/14
N2	114	900#	RFWN	XXH	PROCESS OUTLET	0	200	8/14
C1	48	6000#	TOL	-	INSPECTION c/w PLUG	-	-	6
C2	48	6000#	TOL	-	INSPECTION/VENT c/w PLUG	-	-	6

ITEM	QUA	DESCRIPTION	
1	1	SHELL PIPE: 406 O/D x 21.44 WT x 914 LG.	SA-106-B
2	2	HEAD PLATE: 406 O/D x 22.23 THK. NOM. [20.06 MIN.] 2:1 S.E. c/w S.F.	SA-516-70N
3	1	FLANGE: 114-600# RFWN XXH BORE	SA-105N
4	1	FLANGE: 114-900# RFWN XXH BORE	SA-105N
5	1	REPAD PLATE: 9.53 THK. x 216 O/D x 117 I/D (ROLL TO 406 I/D)	SA-516-70N
6	1	PIPE: 114 O/D x 17.11 W.T. x 135 LG. (CTS)	SMLS SA-106-B
7	1	PIPE: 114 O/D x 17.11 W.T. x 136 LG. (CTS)	SMLS SA-106-B
8	1	PIPE: 73 O/D x 9.53 W.T. x 737 LG.	SMLS SA-106-B
9	2	CONC. RED: 114 O/D x 73 O/D SCH XXH LE x SCH 160 SE BW	SMLS SA-234-WPB
10	2	TOL: 48-6000# (ON A 406 O/D RUN) c/w PLUG	SA-105N
11	2	F/BAR: 10 THK. x 50 x 143 LG.	G40.21M-300W
12	4	PLATE: 10 THK. x 79 WD. x 200 LG. (CTS)	SA-36
13	1	NAMEPLATE c/w MOUNTING BRACKET	SS/SA-36
14			

NOTE: THE FOLLOWING SUBSTITUTIONS ARE PERMITTED (THE OPPOSITE NOT ALLOWED)
SA-350-LF2 for SA-105, SA-333-Gr6 for SA-106-B, SA-420-WPL6 for SA-234-WPB

CAPACITY: 0.12 m³
SURFACE AREA OF TUBES: N/A m²
WEIGHT EMPTY: 402 kg
WEIGHT FULL OF WATER: 522 kg

SERIAL NO: 99420-108 CRN:
TAG NO: V-125 YEAR BUILT: 2000
LSD #: -
CODE:
ASME SECT. VIII DIV I, '98, ADDENDA '99
TEMA CLASS N/A, ADDENDA N/A
DESIGN PRESS: 9067kPag @ TEMP: 149 °C
HYDROTEST:
VESSEL 11787 kPag
COIL N/A kPag
MIN^m DESIGN METAL TEMP: -28 °C @ MAWP 9067 kPag
MATERIAL: HEAD: SA-516-70N SHELL: SA-106-B

IMPACT TEST: NO - PER UG20(f)
RADIOGRAPHY:
[LONG - FULL UWH(G)] [CIRC - FULL UWH(G)] [INCL. ALL BUY WELDS]

PRODUCTION IMPACT TEST REQ'D: [NO] [YES] P.W.H.T.:
SHIP LOOSE: [NO] [YES] SERVICE: SOUR GAS
LONG & CIRC. WELDS TYPE 1
QWP: 590.2
AQP-1050(S) AQP-1227(S)
TACK WELDS: WPS #101
PRESS. TO STRUCT. WELD: WPS #102,106,110
CORR. ALLOW: 3.2 mm
'SOUR SERVICE'

SINGLE VEE	THREDOLET	NOZZLE & REPAD FLUSH	NOZZLE RECESSED	PIPE TO FLANGE/FITTING	GUSSETS
2. WPS# 104,106,110	6. WPS# 102,108,110	8. WPS# 102,106,108,110	10. WPS# 102,106,108,110	14. WPS# 104,106,110	17. WPS# 102,106,110

1. DO NOT PROFILE INTERNAL PROJECTION UNLESS SPECIFIED.
2. SANDBLAST INTERNALS TO ENSURE THAT THE INSIDE SURFACE OF THE VESSEL IS FREE OF LOOSE MILL SCALE AND WELD SPLATTER.
3. VESSEL TO BE FLUSHED OUT AT HYDROTEST, AIR DRIED AND OILED INTERNALLY.
4. VESSEL OPENINGS TO BE SEALED PRIOR TO ANY SHIPPING TO OTHER SHOPS.

1. ISSUED FOR CONSTRUCTION
D. SMITH 00/05/10 M.I. S.W.
BY DATE CKD ENG

APPROVED		DRAWN	
MECH./STRUCT.	DATE	BY	D. SMITH
ELECTRICAL	DATE	DATE	00/04/12
PROJECT	S. WARD	BY	M. IWANIUK
DATE	00/05/10	DATE	00/05/10

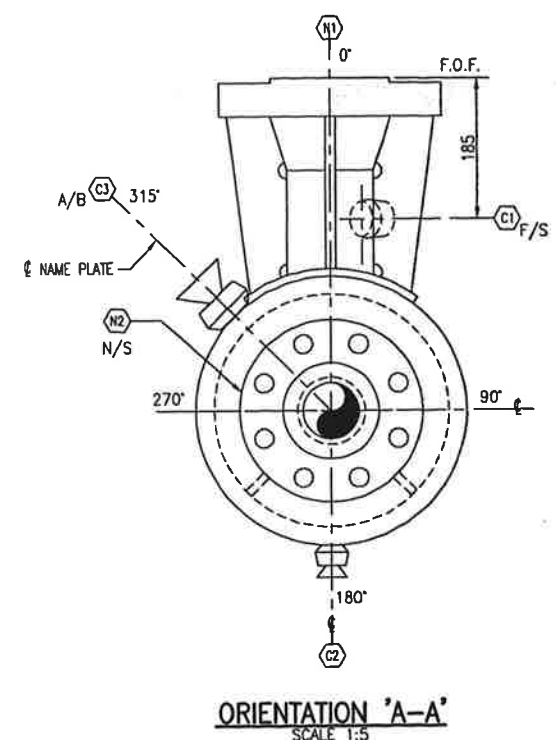
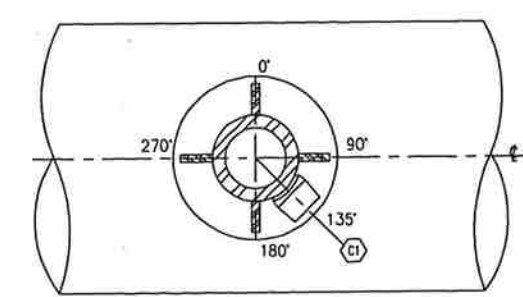
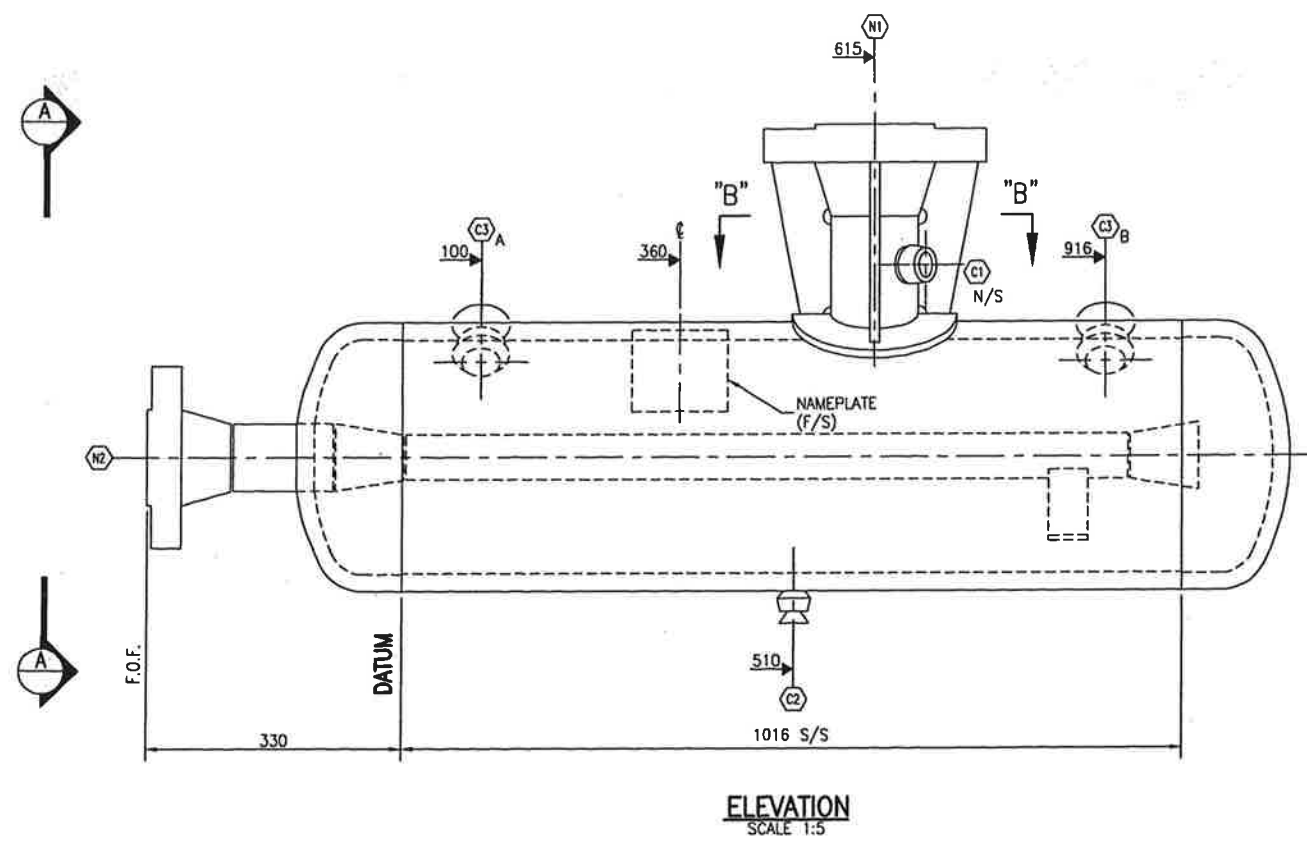
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DATE: 2000.05.10 8:28am	FILE NAME: J:\jobs99\DWG\99420\Comp\VSL\BTL-99420-108.dwg	1	ISSUED FOR CONSTRUCTION
		No.	REVISION

APPROVED		DRAWN		PROPAG SYSTEMS LTD.	
MECH./STRUCT.	DATE	BY	D. SMITH	1380 HP STOCK COMPRESSOR	
ELECTRICAL	DATE	DATE	00/04/12	3RD STAGE SUCTION BOTTLE	
PROJECT	S. WARD	BY	M. IWANIUK	406mm O/D x 914mm S/S	
DATE	00/05/10	DATE	00/05/10	DWG. No.:	D-BTL-99420-108
				SCALE	AS NOTED
				REV.	1

PROPAG
440 East Lake Road,
Postal Bag #2
Airdrie, Alberta
Canada T4B 2C3

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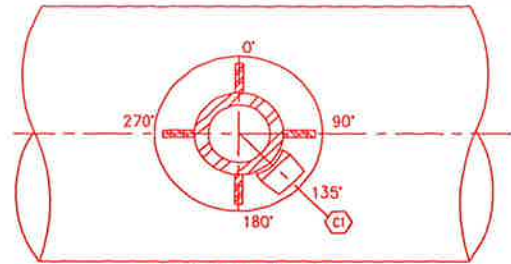
NOZZLE SCHEDULE									
MK	SIZE	RATING	FACING	SCH	SERVICE	INT. PROJ.	EXT. PROJ.	WELD	
N1	114	900#	RFWN	XXH	INLET	MIN.	260	-	
N2	89	900#	RFWN	XXH	PROCESS GAS OUTLET	SPEC.	SPEC.	-	
C1	27	6000#	TOL	-	THERMOWELL (TE-126)	-	-	-	
C2	27	6000#	TOL	-	DRAIN c/w PLUG	-	-	-	
C3	48	6000#	TOL	-	INSPECTION c/w PLUG	-	-	-	



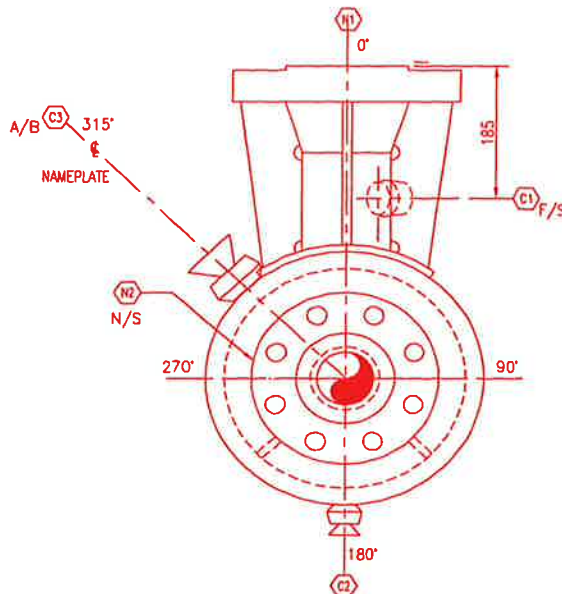
CAPACITY: 0.091 m ³	SERIAL NO: 99420-109	CRN: P-0249.2
SURFACE AREA OF TUBES: N/A m ²	TAG NO: V-126	YEAR BUILT: 2000
WEIGHT EMPTY: 393 kg	LSD #: -	
WEIGHT FULL OF WATER: 484 kg	CODE:	
SURFACE PREPARATION:	ASME SECT. VIII DIV I, '98, ADDENDA '99	
PRIMER: PNT-12	TEMA CLASS: N/A, ADDENDA N/A	
FINISH PAINT:	DESIGN PRESS: 11377 kPag @ TEMP: 176 °C	
INSULATION: NONE		
MECHANICAL LOADINGS GOVERNS AS PER UG 22: YES/NO		
IMPACT TEST: NO - PER UG20(1)	HYDROTEST:	
	VESSEL 14790 kPag	
	COIL N/A kPag	
	MIN ^m DESIGN METAL TEMP: -28 °C @ MAMP 11377 kPag	
	MATERIAL: HEAD: SA-516-70N SHELL: SA-106-B	
	RADIOGRAPHY:	
	LONG - FULL UWI(a)	
	CIRC - FULL UWI(a) (INCL. ALL BUTT WELDS)	
PRODUCTION IMPACT TEST REQ'D: NO	P.W.H.T.:	
SHIP LOOSE: NO	YES: MIN. TEMP: 593 °C, TIME: 1h(MIN.)	
SERVICE: SOUR GAS	CORR. ALLOW: 3.2 mm	
	'SOOR SERVICE'	

GENERAL NOTES		GENERAL NOTES		SKT	ISSUED FOR DOCUMENTATION	C. WEST	00/09/15	VK	SW	APPROVED	DRAWN	APACHE CANADA LIMITED	
DATE: 2000.09.26 8:26am	FILE NAME: J:\jobs99\DWG\99420\Comp\Misc\BTL-99420-109-SKT-01.dwg	No.	REVISION	BY	DATE	CKD	ENG			MECH./STRUCT.	BY	440 East Lake Road,	
										DATE	DATE	Postal Bag #2	
										ELECTRICAL	CHECKED	Airdrie, Alberta	
										DATE	BY	Canada T4B 2C3	
										PROJECT	DATE		
										DATE	SCALE	AS NOTED	
												Dwg. No.: D-BTL-99420-109-SKT SHT. 1 OF 1 REV. SKT	

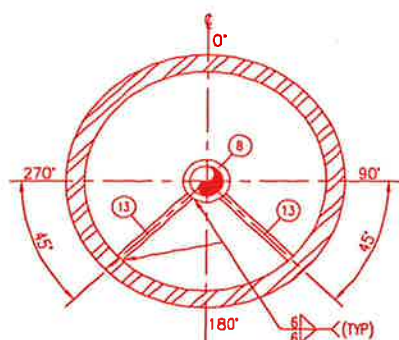
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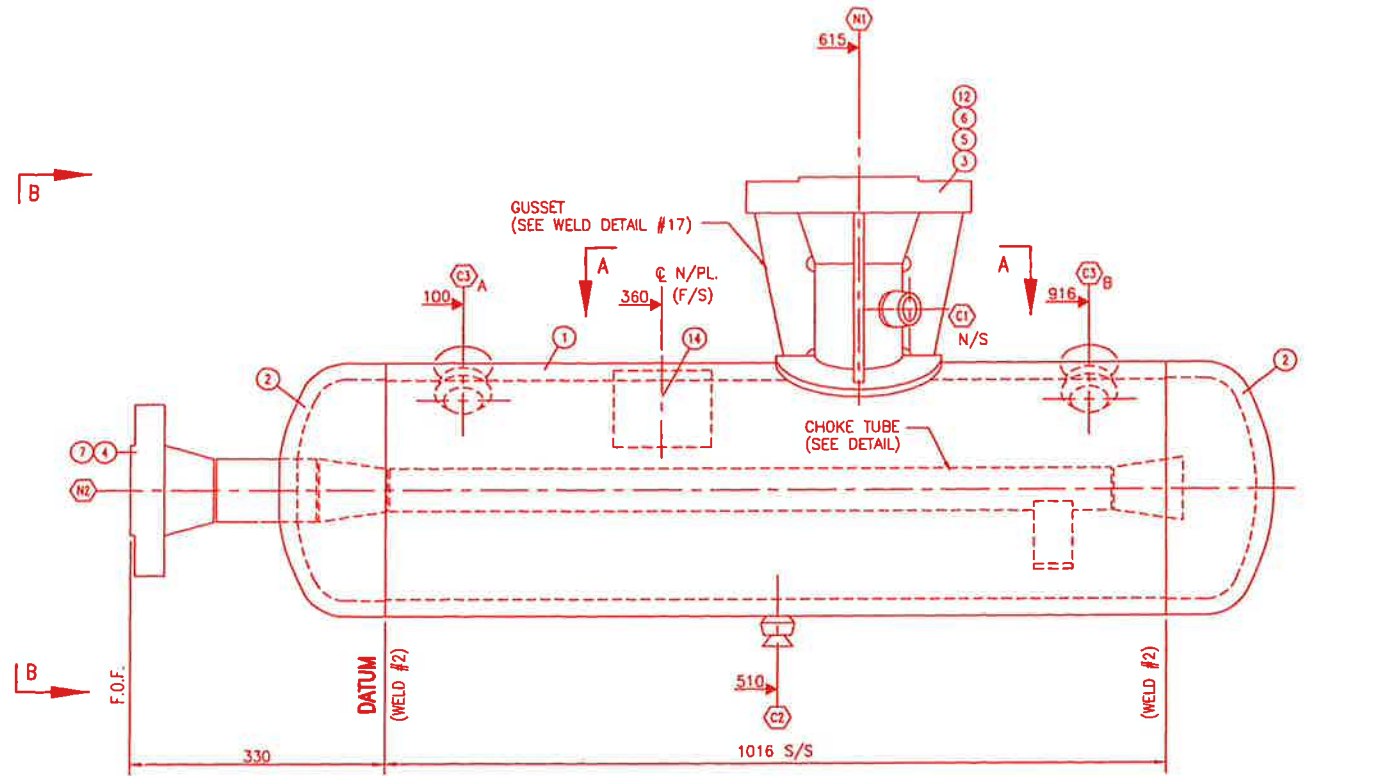
SECTION 'A-A'
SCALE 1:5



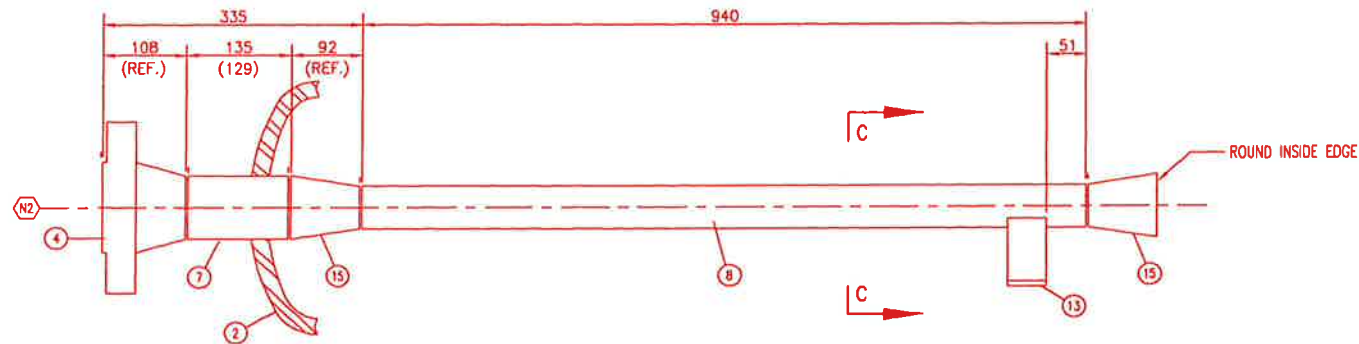
ORIENTATION 'B-B'
SCALE 1:5



SECTION 'C-C'
SCALE 1:5



ELEVATION
SCALE 1:5



CHOKE TUBE DETAIL
SCALE 1:5

NOZZLE SCHEDULE

MK	SIZE	RATING	FACING	SCH	SERVICE	INT. PROJ.	EXT. PROJ.	WELD
N1	114	900#	RFWN	XXH	INLET	MIN.	260	8/14
N2	89	900#	RFWN	XXH	PROCESS GAS OUTLET	SPEC	SPEC.	10/14
C1	27	6000#	TOL	-	THERMOWELL (TE-126)	-	-	6
C2	27	6000#	TOL	-	DRAIN c/w PLUG	-	-	6
C3	48	6000#	TOL	-	INSPECTION c/w PLUG	-	-	6

BILL OF MATERIAL

ITEM	QUA	DESCRIPTION	
1	1	SHELL PIPE: 356 O/D x 23.83 THK. x 1016 LG.	SA-106-B
2	2	HEAD PLATE: 356 O/D x 22.23 THK. NOM. (19.81 MIN.) 2:1 SE c/w 51 SF.	SA-516-70N
3	1	FLANGE: 114-900 RFWN XXH BORE	SA-105N
4	1	FLANGE: 89-900 RFWN XXH BORE	SA-105N
5	1	REPAD: 9.53 x 216 O/D x 117 I/D (ROLL TO 356 I/D)	SA-516-70N
6	1	PIPE: 114 O/D x 17.12 WT. x 199 LG.	(SMLS) SA-106-B
7	1	PIPE: 89 O/D x 15.24 WT. x 129 LG.	(SMLS) SA-106-B
8	1	PIPE: 60 O/D x 8.74 WT x 940 LG.	(SMLS) SA-106-B
9	1	TOL: 27-6000# (ON A 114 O/D RUN)	SA-105N
10	1	TOL: 27-6000# (ON A 356 O/D RUN) c/w PLUG	SA-105N
11	2	TOL: 48-6000# (ON A 356 O/D RUN) c/w PLUG	SA-105N
12	4	PLATE: 10 THK. x 79 WD. x 260 LG. (CTS)	SA-516-70N
13	2	PLATE: 10 THK. x 51 WD. x 122 LG. (CTS)	SA-516-70N
14	1	NAMEPLATE c/w MOUNTING BRACKET	SS/SA-36
15	2	CONC. REDUCER: 89 XXH x 80 SCH 160 BW	(SMLS) SA-234-WPB
16			

NOTE: THE FOLLOWING SUBSTITUTIONS ARE PERMITTED (THE OPPOSITE NOT ALLOWED)
 SA-350-LF2 for SA-105, SA-333-Gr6 for SA-106-B, SA-420-WPL6 for SA-234-WPB

CAPACITY: 0.091 m³
 SURFACE AREA OF TUBES: N/A m²
 WEIGHT EMPTY: 393 kg
 WEIGHT FULL OF WATER: 484 kg
 SURFACE PREPARATION: PNT-12
 PRIMER:
 FINISH PAINT:
 INSULATION: NONE
 MECHANICAL LOADINGS GOVERNS AS PER UG 22: YES (NO) X

SERIAL NO: 99420-109 CRN:
 TAG NO: V-126 YEAR BUILT: 2000
 LSD #: -
 CODE:
 ASME SECT. VIII DIV I, '98, ADDENDA '99
 TEMA CLASS: N/A, ADDENDA N/A
 DESIGN PRESS: 11377 kPag @ TEMP: 176 °C

HYDROTEST:
 VESSEL 14790 kPag
 COIL N/A kPag
 MIN⁶ DESIGN METAL TEMP: -28 °C @ MAWP 11377 kPag
 MATERIAL: HEAD: SA-516-70N SHELL: SA-106-B
 RADIOGRAPHY:
 LONG L FULL UNW (a)
 (CIRC. FULL UNW (a) (INCL. ALL BUT WELDS))
 P.W.H.T.:
 YES MIN. TEMP: 593 °C, TIME: 1h (MIN.)
 CORR. ALLOW: 3.2 mm
 'SOUR SERVICE'

PRODUCTION IMPACT TEST REQ'D: (NO) X
 SHIP LOOSE: (NO) X
 SERVICE: SOUR GAS
 LONG & CIRC. WELDS TYPE 1
 QWP: 590.2
 QCP: AQP: 1050(S) AQP: 1227(S)
 TACK WELDS: WPS #101
 PRESS. TO STRUCT WELD: WPS #102, 106, 110

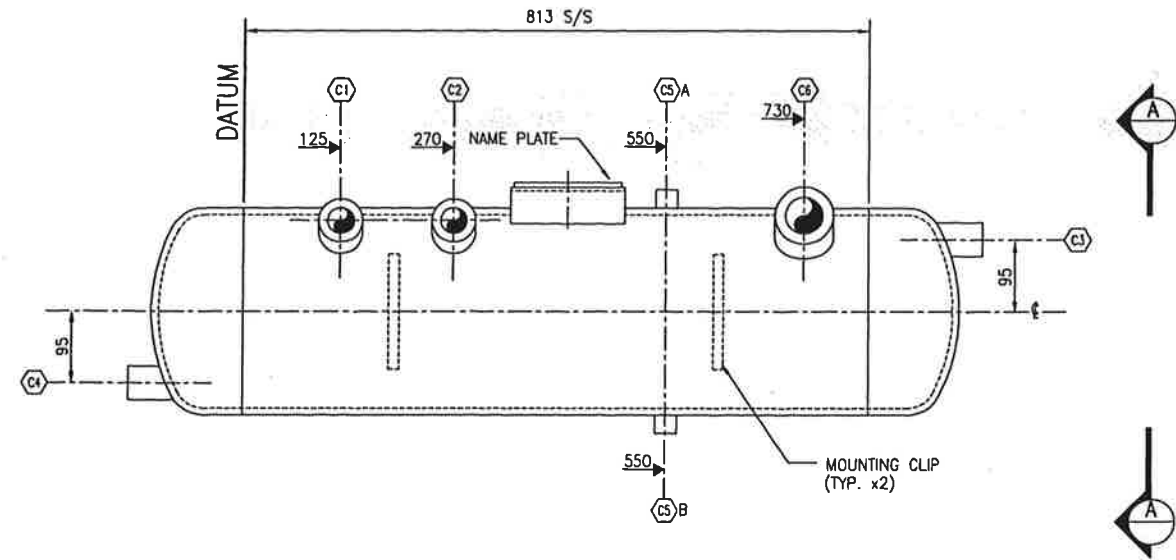
SINGLE VEE	THREDOLET	NOZZLE & REPAD FLUSH	NOZZLE RECESSED	PIPE TO FLANGE/FITTING	GUSSETS
2. WPS# 104, 106, 110	6. WPS# 102, 108, 110	8. WPS# 102, 106, 108, 110	10. WPS# 102, 106, 108, 110	14. WPS# 104, 106, 110	17. WPS# 102, 106, 110

GENERAL NOTES	GENERAL NOTES	REVISION
1) DO NOT PROFILE INTERNAL PROJECTION UNLESS SPECIFIED. 2) SANDBLAST INTERNALS TO ENSURE THAT THE INSIDE SURFACE OF THE VESSEL IS FREE OF LOOSE MILL SCALE AND WELD SPLATTER. 3) VESSEL TO BE FLUSHED OUT AT HYDROTEST, AIR DRIED AND OILED INTERNALLY 4) VESSEL OPENINGS TO BE SEALED PRIOR TO ANY SHIPPING TO OTHER SHOPS	1 ISSUED FOR CONSTRUCTION	D. SMITH 00/05/10 M.L. S.W. BY DATE CKD ENG

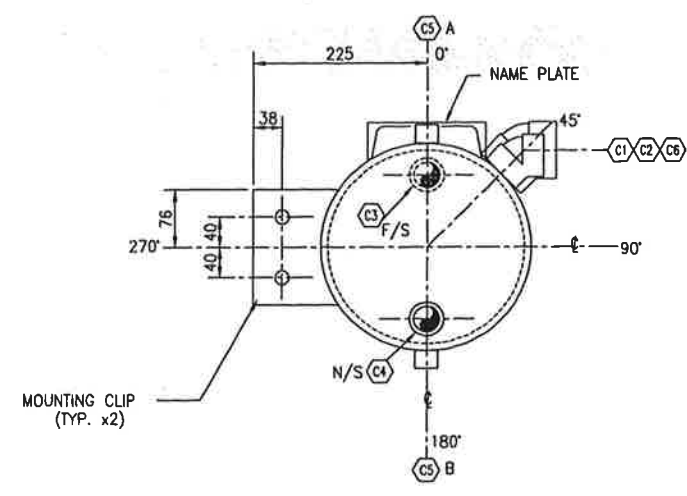
APPROVED	DRAWN	PROPAC SYSTEMS LTD.	
MECH./STRUCT.	BY D. SMITH	STOCK 1380 HP COMPRESSOR 3RD STAGE DISCHARGE BOTTLE 356mm O/D x 1016mm S/S	
DATE	DATE 00/04/12		
ELECTRICAL	CHECKED	DWG. No.: D-BTL-99420-109	
DATE	BY M. IWANIUK	REV. 1	
PROJECT S. WARD	DATE 00/05/10		
DATE 00/05/10	SCALE AS NOTED		

PROPAC
 440 East Lake Road,
 Postal Bag #2
 Airdrie, Alberta
 Canada T4B 2C3

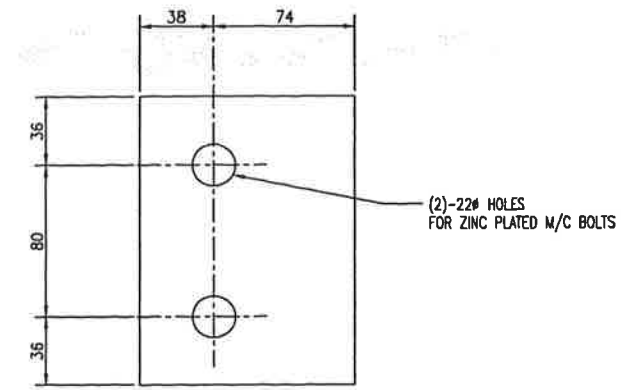
NOZZLE SCHEDULE										
MK	SIZE	RATING	FACING	SCH	SERVICE	INT.	PROJ	EXT.	PROJ	WELD
C1	33	3000#	45° ELBOW	-	CYLINDER PACKING VENT & DRAIN	-	-	-	-	-
C2	33	3000#	45° ELBOW	-	CYLINDER DISTANCE PIECE DRAIN	-	-	-	-	-
C3	33	3000#	1/2 CPLG	-	SEAL POT VAPOUR TO FLARE HEADER	-	-	-	-	-
C4	33	3000#	1/2 CPLG	-	LIQUIDS TO DRAIN TANK	-	-	-	-	-
C5	21	3000#	1/2 CPLG	-	LEVEL GAUGE	-	-	-	-	-
C6	48	3000#	45° ELBOW	-	SEAL POT PRESSURE RELIEF	-	-	-	-	-



ELEVATION
SCALE: 1:5



ORIENTATION
VIEW 'A-A'
SCALE: 1:5

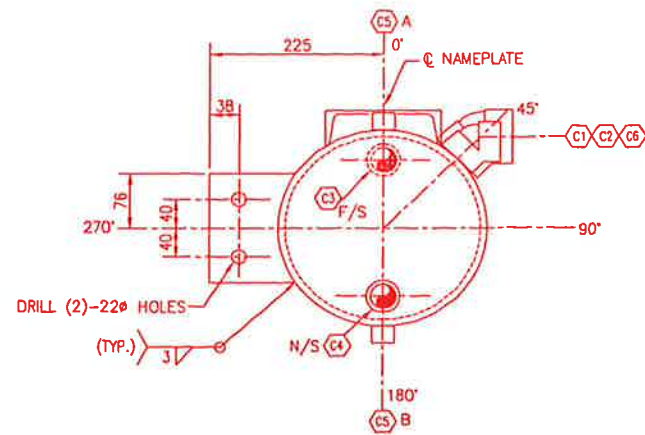


MOUNTING CLIP DETAIL
SCALE: 1:2 (2-REQ'D)

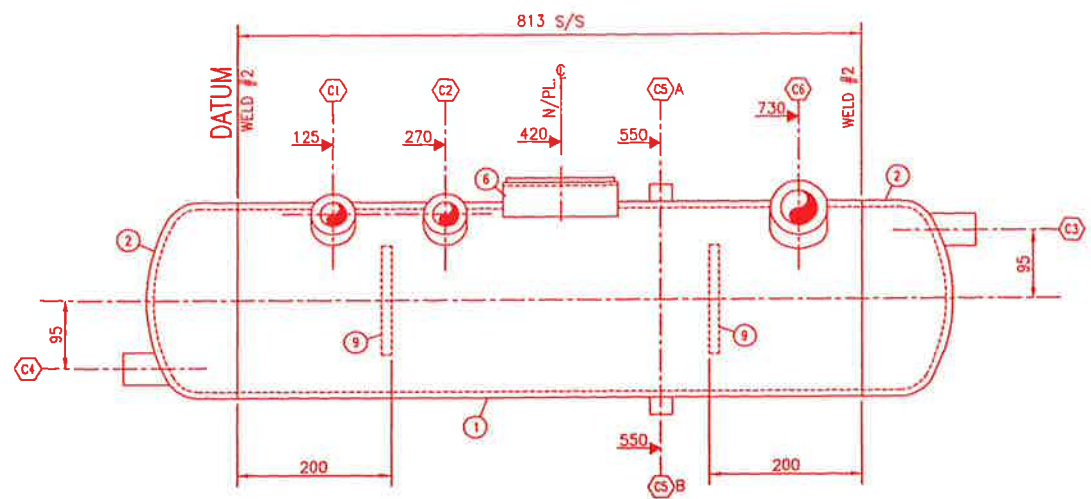
CAPACITY: 0.05 m ³ WEIGHT EMPTY: 90 kg WEIGHT FULL OF WATER: 140 kg SURFACE PREPARATION: PRIMER: PNT-11 FINISH PAINT: PNT-11 INSULATION: NONE IMPACT TEST: NO YES PER UG61 IS FOLLOWS NO PER UG61, UG68, UG69 PRODUCTION IMPACT TEST REQ'D: YES <input type="checkbox"/> NO <input checked="" type="checkbox"/> SHIP LOOSE: YES/NO SERVICE: HYDROCARBONS	SERIAL NO: 99420-111 CRN: N/A TAG NO: V-130 YEAR BUILT: 2000 LSD #: . CODE: NON-CODE MAX: DESIGN PRESS: 101 kPag @ TEMP. 149°C HYDROTEST: VESSEL 345 kPag MIN ^m DESIGN METAL TEMP: -28 °C MATERIAL: HEAD: SA-234-WPB SHELL: SMLS SA-106-B RADIOGRAPHY: LONG L: N/A ORC: N/A P.W.H.T.: NO CORR. ALLOW: NONE *SOUR SERVICE*
---	--

APPROVED		DRAWN		APACHE CANADA LIMITED		440 East Lake Road,	
MECH./STRUCT.	BY	BY	DATE	1478 HP HAMBURG COMPRESSOR PACKAGE	Postal Bag #2	Airdrie, Alberta	
DATE	DATE	CHECKED		PACKING VENT & DRAIN SEAL POT (V-130)	Canada T4B 2C3		
ELECTRICAL	BY	DATE		273 O/D x 813 S/S			
DATE	DATE			DWG. No.:	D-POT-99420-111-SKT		REV. SKT
PROJECT	DATE			SCALE	AS NOTED		
DATE	SCALE	AS NOTED		SHT. 1 OF 1			
GENERAL NOTES		GENERAL NOTES		SKT ISSUED FOR DOCUMENTATION		J. JUA 00/09/15 VK SW	
DATE: 2000.09.26 8:27am FILE NAME: J:\jobs99\DWG\99420\Camp\Misc\POT-99420-111-SKT-01.dwg		No.		REVISION		BY DATE CKD ENG	

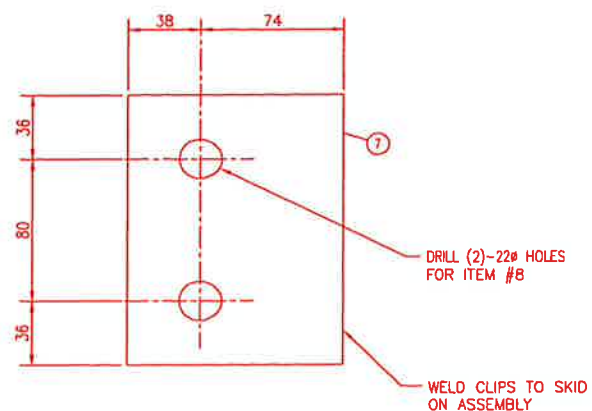
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ORIENTATION
SCALE 1:5



ELEVATION
SCALE 1:5



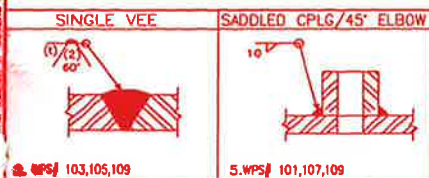
MOUNTING CLIP DETAIL
SCALE 1:2 (2-REQ'D)

NOZZLE SCHEDULE							
MK	SIZE	RATING	FACING	SCH	SERVICE	INT. PROJ.	EXT. PROJ. WELD
C1	33	3000#	45° ELBOW	-	CYLINDER PACKING VENT & DRAIN	-	5
C2	33	3000#	45° ELBOW	-	CYLINDER DISTANCE PIECE DRAIN	-	5
C3	33	3000#	1/2 CPLG	-	SEAL POT VAPOUR TO FLARE HEADER	-	5
C4	33	3000#	1/2 CPLG	-	L IQUIDS TO DRAIN TANK	-	5
C5	21	3000#	1/2 CPLG	-	LEVEL GAUGE	-	5
C6	48	3000#	45° ELBOW	-	SEAL POT PRESSURE RELIEF	-	5

BILL OF MATERIAL			
ITEM	QUA	DESCRIPTION	SMLS
1	1	SHELL PIPE: 273 O/D x 9.27 W.T. x 813 L.G.	SA-106-B
2	2	PIPE CAP: 273 O/D SCH STD. BW	SA-234-WPB
3	2	HALF CPLG: 33-3000# NPT. (CTS)	SA-105N
4	2	HALF CPLG: 21-3000# NPT	SA-105N
5	2	ELBOW: 33-3000# 45° NPT	SA-105N
6	1	NAMEPLATE c/w MOUNTING BRACKET	SS/SA-36
7	2	PLATE: 13 THK x 112 WD. x 152 LG.	SA-36
8	4	ZINC PLATED M/C BOLTS: 19# x 51 L.G. c/w NUT & LOCKWASHER EACH	SA-325
9	2	F/BAR: 13 THK x 152 SQUARE (CTS)	G40.21M-300W
10	1	ELBOW: 48-3000# 45° NPT	SA-105N

CAPACITY: 0.05 m³
 WEIGHT EMPTY: 90 kg
 WEIGHT FULL OF WATER: 140 kg
 SURFACE PREPARATION:
 PRIMER: PNT-11
 FINISH PAINT:
 INSULATION: NONE
 IMPACT TEST: NO
~~YES - PER US&C-NO FOLLOWUP~~
~~NO - PER US&C(-) US&C- US&C-~~
~~NO US&C(-) US&C(-) US&C(-) OR F&O~~
 PRODUCTION IMPACT TEST REQ'D: YES NO
 SHIP LOOSE: YES NO
 SERVICE: HYDROCARBONS
 LONG & CIRC. WELDS TYPE 1
 QWP: 590.2
 QCP: AQP-1050(S) AQP-1227(S)
 TACK WELDS WPS# 101
 PRESS. TO STRUCT. WPS# 101,105 & 109

SERIAL NO: 99420-111 CRN: N/A
 TAG NO: V-130 YEAR BUILT: 2000
 LSD #: .
 CODE: NON-CODE
 MAX: DESIGN PRESS: 101 kPag @ TEMP. 149°C
 HYDROTEST:
 VESSEL 345 kPag
 MIN^m DESIGN METAL TEMP: -28 °C
 MATERIAL: HEAD: SA-234-WPB SHELL: SMLS SA-106-B
 RADIOGRAPHY:
 LONG: N/A
 CIRC: N/A
 P.W.H.T.: NO
 CORR. ALLOW: NONE
"SOUR SERVICE"



GENERAL NOTES		GENERAL NOTES		APPROVED			DRAWN			PROPAK SYSTEMS LTD			
DATE: 2000.05.10 11:45am	FILE NAME: J:\jobs99\DWG\99420\Comp\VSL\POT-99420-111.dwg	1	ISSUED FOR CONSTRUCTION	D. SMITH	00/05/10	M.J.	S.W.	BY	DATE	00/05/03	00/05/10	STOCK 1380 HP COMPRESSOR PACKAGE	440 East Lake Road,
		No.	REVISION	BY	DATE	CKD	ENG	SCALE	AS NOTED	DWG. No.:	D-POT-99420-111	Packing Vent & Drain Seal Pot	Postal Bag #2
										REV.	1	273mm O/D x 813mm S/S	Airdrie, Alberta
												Canada T4B 2C3	