

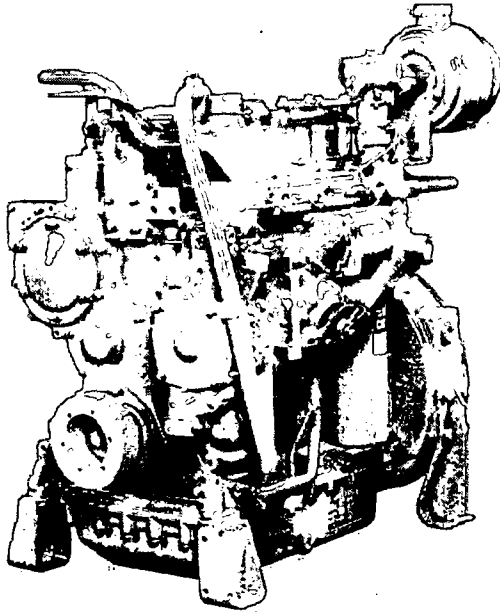
2

CATERPILLAR®

Gas Industrial Engines

G3304

41-95 hp
900-1800 rpm



SPECIFICATIONS

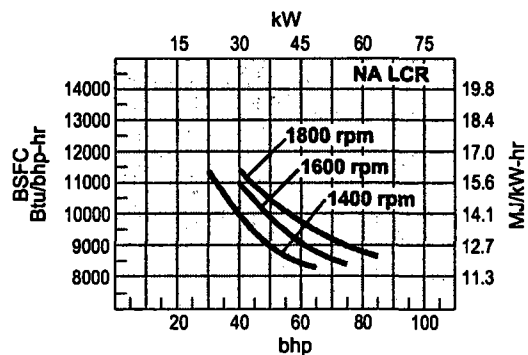
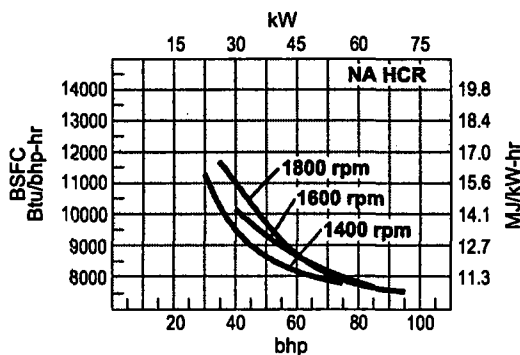
In-Line 4, 4-Stroke-Cycle
 Bore—in (mm)..... 4.75 (121)
 Stroke—in (mm)..... 6.0 (152)
 Displacement—cu in (L) 425 (7.0)
 Rotation (from flywheel end) Counterclockwise
 Compression Ratios 10.5:1 or 8:1
 Aspiration..... Naturally Aspirated
 Speed Range 900-1800 rpm
 Cooling System—gal (L) 4.2 (15.9)
 Lube Oil System—gal (L)..... 5.0 (18.9)
 Weight, Net Dry (approx)—lb (kg) 1630 (739)



FEATURES

- **DIESEL STRENGTH BUILT IN**
 Blocks, crankshafts, heads, liners, and connecting rods are common with Cat® Diesel Engines. Gas engine pressures are 40% to 50% lower: Result . . . extra long life.
- **APPLICATION FLEXIBILITY**
 Constant torque over a wide speed range offers more flexibility for matching engine power output to job needs.
- **SIMPLICITY**
 Time proven solid state magnetos provide ignition power without the need for belt driven alternators and batteries.
- **DURABILITY**
 Gas engine exhaust temperatures are higher than diesel. Watercooled exhaust manifolds provide longer life because they operate at lower temperatures, resulting in fewer cracks and less warpage.

FUEL CONSUMPTION





G3304 GAS INDUSTRIAL ENGINE - 41-95 hp

STANDARD EQUIPMENT

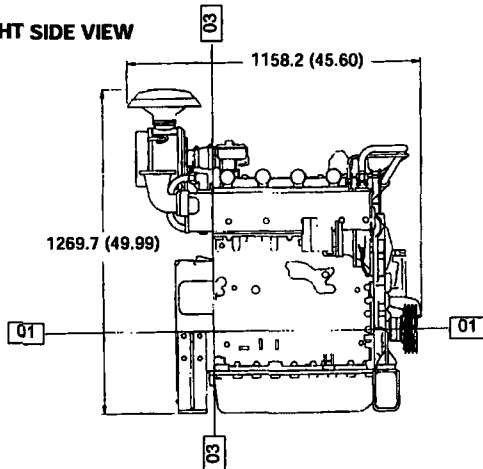
Air cleaner, single-stage, dry type
 rain cap, service indicator
 Cooler, lubricating oil
 Flywheel and SAE No. 1 housing
 Governor, hydra-mechanical
 Ignition system, Altronic V solid state
 Lifting eyes
 Manifold, exhaust, watercooled
 Pumps, jacket water, gear-driven
 Service meter
 Supports, engine
 Thermostats and housing

OPTIONAL EQUIPMENT

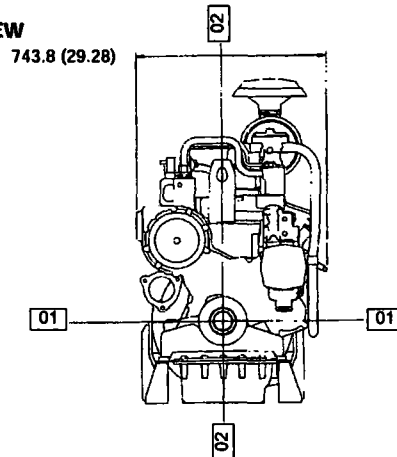
Cooling systems
 Fuel systems
 gas pressure regulator
 Ignition systems
 Altronic III solid state
 CSA shielded ignition
 (meets Class 1, Division 2, Group D)
 Power takeoffs
 Protection devices
 alarm switches (oil pressure and water
 temperature)
 Shutoffs
 oil pressure and water temperature
 Starting systems

DIMENSIONS

RIGHT SIDE VIEW



FRONT VIEW



See general dimension
 drawing 5N-6644 for
 additional engine detail.

POWER RATINGS

Gear Ratio	900 rpm (kW)	1000 rpm (kW)	1200 rpm (kW)	1400 rpm (kW)	1500 rpm (kW)	1600 rpm (kW)	1800 rpm (kW)
10.5:1	49 (37)	54 (40)	65 (48)	76 (57)	82 (61)	87 (65)	95 (71)
8:1	41 (31)	46 (34)	55 (41)	63 (47)	68 (51)	73 (54)	83 (62)

RATING CONDITIONS AND DEFINITIONS

Ratings are based on SAE J1349 standard conditions of 29.61 in Hg (100 kPa) and 77° F (25° C) ISO3046, DIN6271, BS5514. Standard conditions of 29.61 in Hg (100 kPa) 81° F (27° C) and API 7B-11C standard conditions of 29.62 in Hg (100 kPa) and 60° F (16° C) also apply.

Fuel consumption and ratings are based on dry natural gas having an LHV (low heat value) of 905 btu/cu ft (33.74 kJ/L). Variations in altitude,

temperature, and gas composition from standard conditions may require a reduction in engine horsepower.

Naturally aspirated engines are rated at 500 ft (150 m) and 77° F (25° C). For applications which exceed these limits consult your Caterpillar dealer.

Additional ratings may be available for specific customer requirements. Consult your Caterpillar representative for details.

Materials and specifications are subject to change without notice.

LEHQ6796
 Supersedes LEHQ5127

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G3304

Engine Speed (rpm)	1800	Fuel	NAT GAS
Compression Ratio	10.5:1	LHV of Fuel (Btu/SCF)	920
Aftercooler Inlet Temperature (°F)	N/A	Fuel System	LPG IMPCO
Jacket Water Outlet Temperature (°F)	210		
Ignition System	MAG	Minimum Fuel Pressure (psig)	1.5
Exhaust Manifold	WATER COOLED	Methane Number at Conditions Shown	80
Combustion System Type	STANDARD	Rated Altitude (ft)	500

at 77°F Design Temperature

Engine Rating Data

Engine Power (w/o fan)

% Load	100%	75%	50%
bhp	95	71	48

Engine Data

Specific Fuel Consumption (BSFC) (1)

Air Flow (Wet, @77°F, 28.8 in Hg)

Air Mass Flow (Wet)

Compressor Out Pressure

Compressor Out Temperature

Inlet Manifold Pressure

Inlet Manifold Temperature (10)

Timing (11)

Exhaust Stack Temperature

Exhaust Gas Flow (Wet, @ stack temperature, 29.7 in Hg)

Exhaust Gas Mass Flow (Wet)

Btu/bhp-hr	7640	7917	10073
lb/hr	666	533	414
scfm	145	116	90
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
in. Hg (abs)	27.5	23.5	19.4
°F	100	100	131
°BTDC	30	30	30
°F	1045	1004	988
CFM	461	351	276
lb/hr	702	561	438

Engine Emissions DataNitrous Oxides (NOx as NO₂) (9)(Corr. 15% O₂)

g/bhp-hr	15.8	16.8	19.7
ppm	1174	1161	1086

Carbon Monoxide (CO) (9)

(Corr. 15% O₂)

g/bhp-hr	1.6	1.7	1.8
ppm	201	191	160

Total Hydrocarbons (THC) (9)

(Corr. 15% O₂)

g/bhp-hr	2.4	2.4	3.2
ppm	520	473	519

Non-Methane Hydrocarbons (NMHC) (9)

(Corr. 15% O₂)

g/bhp-hr	0.36	0.36	0.48
ppm	78	71	78

Exhaust Oxygen (9)

Lambda

%	3.1	2.9	1.7
	1.17	1.18	1.10

Engine Heat Balance Data

Input Energy LHV (1)

Work Output

Heat Rejection to Jacket (2) (6)

Heat Rejection to Atmosphere (Radiated) (4)

Heat Rejection to Lube Oil (5)

Total Heat Rejection to Exhaust (to 77°F) (2)

Heat Rejection to Exhaust (LHV to 350°F) (2)

Heat Rejection to Aftercooler (3) (7) (8)

Btu/min	12097	9401	7974
Btu/min	4029	3022	2014
Btu/min	4344	3502	3634
Btu/min	484	376	319
Btu/min	0	0	0
Btu/min	3106	2369	1826
Btu/min	2259	1693	1295
N/A	N/A	N/A	N/A

Engine Noise Data - at 100% load

Noise - Mechanical @ 1 m 93 dB(A)
 Noise - Exhaust @ 1.5 m 106 dB(A)

Fuel Usage Guide

Derate Factor / Engine Timing vs Methane Number

<30	30	35	40	45	50	55	60	65	70	75	80 to 100
0	1.0/15	1.0/16	1.0/17	1.0/20	1.0/21	1.0/22	1.0/23	1.0/25	1.0/26	1.0/27	1.0/30

Altitude Deration Factors

AIR INLET TEMP. (°F)	ALTITUDE (FEET ABOVE SEA LEVEL)												
	0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	11000	12000
130	0.93	0.89	0.86	0.83	0.80	0.77	0.74	0.71	0.69	0.66	0.64	0.61	0.59
120	0.94	0.91	0.88	0.84	0.81	0.78	0.76	0.73	0.70	0.67	0.65	0.62	0.60
110	0.96	0.93	0.89	0.86	0.83	0.80	0.77	0.74	0.71	0.69	0.66	0.63	0.61
100	0.98	0.94	0.91	0.88	0.84	0.81	0.78	0.75	0.73	0.70	0.67	0.65	0.62
90	0.99	0.96	0.92	0.89	0.86	0.83	0.80	0.77	0.74	0.71	0.68	0.66	0.63
80	1.00	0.98	0.94	0.91	0.87	0.84	0.81	0.78	0.75	0.72	0.70	0.67	0.64
70	1.00	0.99	0.96	0.92	0.89	0.86	0.83	0.80	0.77	0.74	0.71	0.68	0.66
60	1.00	1.00	0.98	0.94	0.91	0.87	0.84	0.81	0.78	0.75	0.72	0.70	0.67
50	1.00	1.00	1.00	0.96	0.93	0.89	0.86	0.83	0.80	0.77	0.74	0.71	0.68

Aftercooler Heat Rejection Factors

AIR INLET TEMP. (°F)	ALTITUDE (FEET ABOVE SEA LEVEL)												
	0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	11000	12000
130	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
120	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
110	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
100	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
90	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
80	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
70	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
60	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

TM9744-02 Data is intended to be used with Gas Engine Performance Book Parameters – DM5901-00 on page 8

Special Instruction

101011441

Installation And Initial Start Up Procedures For G3300 And G3400 Engines

SMCS Code: 1000-012

Engines:

G3304 (S/N: 37Y)
 G3306 (S/N: 07Y)
 G3406 (S/N: 4FD, 1RK)
 G3408 (S/N: 6NB, 6FW)
 G3408B (S/N: 6RJ)
 G3408C (S/N: 3WR, 8YR)
 G3412 (S/N: 7DB, 3NK, 8LW)
 G3412C (S/N: 6ZM, 9RR)

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Introduction

This Special Instruction includes the installation procedures and the start up procedures for G3300 and G3400 engines. The correct start up adjustment of the engine is essential for the following reasons:

- long engine life
- good fuel economy
- acceptable emissions

Service technicians should have a thorough understanding of the relationship between the fuel system and the ignition system. The technician must also be familiar with the Service Manual, "Systems Operation Testing And Adjusting" Section and the Service Manual, "Operation And Maintenance" Section.

References

- G3300 Gas Engine Performance, LEBQ4197
- G3400 Industrial Engine Performance, LEBQ6483
- G3400 Generator Set Engine Performance Data Books, LEBQ6484
- G3300 Service Manual
- G3400 Service Manual
- Methane Number Program, LEKQ6378
- EIS Diagnostic Code Card, RENR1234

Table 1

Tools Needed	
Part Number	Description
7X-1400	Electronic Tool Group ⁽¹⁾
NEXG4511	Electronic Tool Group ⁽¹⁾
140-2304	Electronic Control Programmer ⁽²⁾
8T-0452	Manometer Gauge
156-1060	Emissions Analyzer Group
8T-5160	Setting Tool Group

⁽¹⁾ For 3400 EIS engines only. Refer to Using The NEXG4511 Spark Ignited Engine Service Program Module, SEHS8806 for more information on using the Digital Diagnostic Tool. Also refer to Service Program Module For Spark Ignited Engines, NEXG4511. You must have the chip in order for the 7X-1400 Electronic Tool Group to work.

⁽²⁾ For Engines equipped with ProAct Speed Control.

Required Information

Ignition Timing

A complete fuel analysis must be conducted prior to putting the engine into service. Obtain a fuel analysis in order to determine the BTU content and calculate the Methane Number. The BTU content indicates the amount of energy that is available in the fuel. The Methane Number indicates the ability of the fuel to be ignited. The Methane Number is determined when you input the constituents of the fuel into the Methane Number Program, LEKQ6378. Use the Methane Number and the Engine Performance Book, "Fuel Usage Guide" in order to determine the ignition timing.

Obtain several samples of fuel if the quality is expected to change. If the chemistry of the fuel will vary during engine operation, use the lowest expected value in order to determine ignition timing.

Maximum Load

Refer to the Engine Performance Book in order to determine the engine power derates for altitude, temperature, and Methane Number. Use the derate range in order to determine the maximum engine load.

Inlet Manifold Pressure At Full Load

For generator set applications, use the generator power output to determine the engine load. For other applications, use the inlet manifold pressure to estimate the engine load. The Engine Performance Book provides inlet manifold pressures for a specific timing and emissions setting. If the engine power is derated, interpolate the desired inlet manifold pressure between the 100 percent and the 75 percent load ratings.

Note: The inlet manifold pressure may be used if the engine timing and the exhaust oxygen are set properly.

Exhaust Oxygen Level

The 156-1060 Emissions Analyzer or equivalent is required in order to properly set up a gas engine. The engine should be set up at the desired full load with the data that was taken at 100 percent load. Do not exceed the maximum load.

Carburetor Adjustments

The carburetor and the gas pressure regulator require adjustment when the engine is installed. The initial factory settings are based on the following conditions:

- an ambient temperature of 25 °C (77 °F)
- a barometric pressure of 96 kPa (28.4 in Hg)
- the use of a natural gas pipeline with a Low Heating Value of 33.74 kJ/L (905 BTU/cu ft)

The factory ratings comply with SAE J1349 Standards. An engine that does not use natural gas may be shipped with optional orifices and valves. An engine of this type will be run with a catalyst and an air/fuel ratio control. Engine applications that do not use dry pipeline gas may be shipped with carburetor jets and valves for field installation. Contact your Caterpillar dealer for more information.

Gas Pressure Regulator

The gas pressure regulator requires adjustment when the engine is installed. Use only Caterpillar approved regulators in order to avoid problems with performance. A balance line for the regulator is required in all gas engines. This line compensates for changes in boost pressure or air filter restriction. Refer to the Systems Operation Manual for details.

Note: The supply line to the gas pressure regulator must be of adequate diameter in order to provide constant pressure to the regulator from idle to full load. Do not use supply lines that are smaller than the inlet to the pressure regulator.

Governors

It may be necessary to make one or more of the following governor adjustments during start-up:

- low idle speed
- high idle speed
- droop

- gain

Refer to the Service Manual for further information.

Hydramechanical

The Hydramechanical Governor is a simple governor for the G3300 and some of the G3400 applications that do not require close speed regulation. The standard Hydramechanical Governor has approximately 7 percent droop at 1800 rpm. Special springs can be ordered in order to lessen the droop.

Pressure Compensated Simple Governor (PSG)

The PSG Governor is a mechanical-hydraulic governor that is capable of isochronous speed control. The speed is controlled by a simple hand lever. A pneumatic control is available for remote speed control. A motor (24 VDC) is also available for remote speed control. Refer to Service Manual, SENR6514, "PSG Governor".

Flo-Tech

The Flo-Tech system is an electronic governor with an electrical actuator for the throttle. The electronic governor control provides a 0 - 200 mA signal to the Flo-Tech actuator in order to position the throttle. The position of the Flo-Tech actuator can not be observed. Instead, a signal voltage that indicates the throttle position is provided. A DC feedback voltage of 0.5 VDC corresponds to a closed throttle position. A signal voltage of 4.5 VDC corresponds to a fully open throttle position. Refer to Service Manual, RENR1356, "Flo-Tech Speed Control" for details.

The EG3P Hydraulic Actuator And The 2301A Electronic Governor

The 2301A electronic governor is used primarily for generator set applications. The EG-3P hydraulic actuator responds to electrical signals from the 2301A governor in order to position the throttle. Refer to Service Manual, SENR1196, "2301A Electric Governors".

ProAct Digital Speed Control

The ProAct digital speed control is an electronic governor that is based on a microprocessor. Adjustment of the ProAct control module requires the 140-2304 Electronic Control Programmer. The ProAct Actuator is electrically driven and connected directly to the throttle shaft. Refer to Service Manual, SENR1196, "ProAct Digital Speed Control".

Connect Gauges And Instruments

7X-1400 Electronic Tool Group

The Digital Diagnostic Tool (DDT) is used only for engines with the Caterpillar Electronic Ignition System (EIS). The DDT is used to program customer specified parameters such as information on the status of the engine and the DDT also reads the diagnostic codes.

Note: The DDT must have the Service Program Module For Spark Ignited Engines, NEXG4511 installed.

Measuring The Fuel/Air Delta Pressure

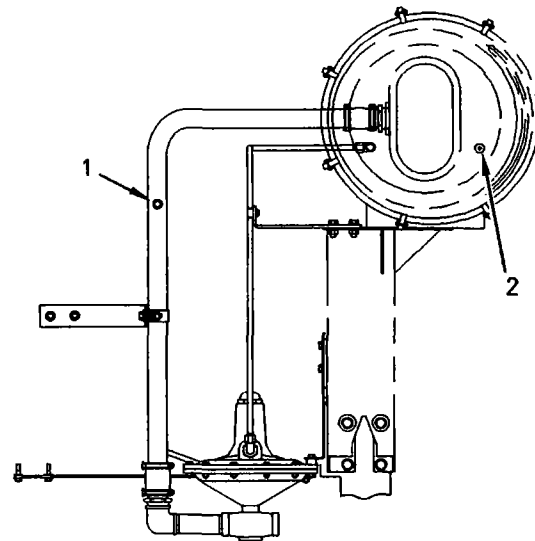


Illustration 1

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Low Pressure Gas Regulator

- (1) Gas Plug
- (2) Air Plug

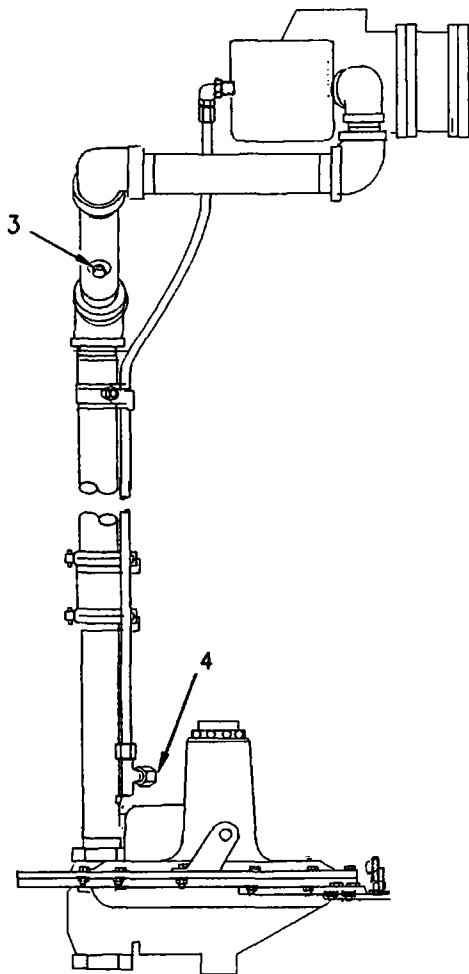


Illustration 2
 High Pressure Gas Regulator
 (3) Gas Plug
 (4) Air Plug

g00529597

The Water Manometer or the differential pressure gauge is required for the Impco fuel system and the Fisher gas regulator.

- Turn the main gas valve OFF.
- Remove the plug (1,3) from the gas supply line to the mixer.
- Remove the plug (4) from the balance line on a high pressure system. Remove the plug (2) from the air cleaner on a system that has low pressure.
- Connect an 1U-5470 Engine Pressure Group or a water manometer between the two pressure taps with the proper adapter fittings.

Note: Install a shutoff valve between the carburetor and the manometer for the high pressure systems. Close this valve when you start the engine or you stop the engine.

Emissions Analyzer

Install the 156-1060 Emissions Analyzer in order to monitor the exhaust oxygen levels before the turbocharger. Remove the plug that is located in the exhaust inlet of the turbocharger, or in the exhaust elbow on naturally aspirated engines. Connect the 156-1060 Emissions Analyzer in accordance with the manufacturer's instructions.

Note: The measurements of the NOx and the CO may also be required.

Inlet Manifold Pressure

The inlet manifold pressure is measured below the throttle plate with a pressure gauge. The inlet manifold pressure is used to indicate the engine load.

Gas Supply Line Pressure

Remove the plug from the gas supply line and install a pressure gauge.

Flo-Tech Actuator Position

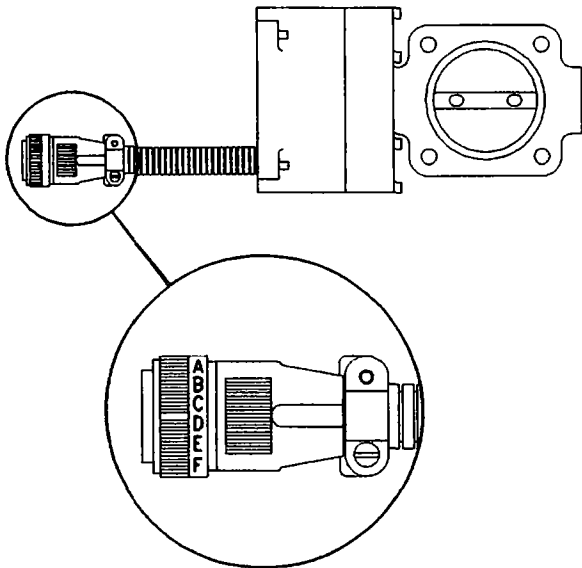


Illustration 3

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Flo-Tech Actuator

- (A) (Red) Positive Actuator Supply (12 gage)
- (B) (Blue) Negative Position Command (16 gage)
- (C) (Orange) Positive Position Command (16 gage)
- (D) (Black) Negative Actuator Supply (12 gage)
- (E) (White) Position Feedback (16 gage)
- (F) Not Used

The throttle position may be monitored by a DC voltmeter on engines that are equipped with a Flo-Tech actuator. Connect the negative probe of the DC voltmeter to the black terminal "B" of the controller. Connect the positive probe of the DC voltmeter to the white terminal "E". The signal for the position will only be present when the actuator is provided with voltage. The voltage is applied between the terminals "A" and "B" of the actuator.

Adjustment Of The High Pressure And The Low Pressure IMPCO Carburetor Mixer Systems

1. Ensure that the throttle linkage is correctly adjusted if the engine has this linkage. Refer to the Service Manual, "Systems Operation Testing And Adjusting " Section.

Note: The angle of the throttle can not be observed on engines that are equipped with a Flo-Tech actuator.

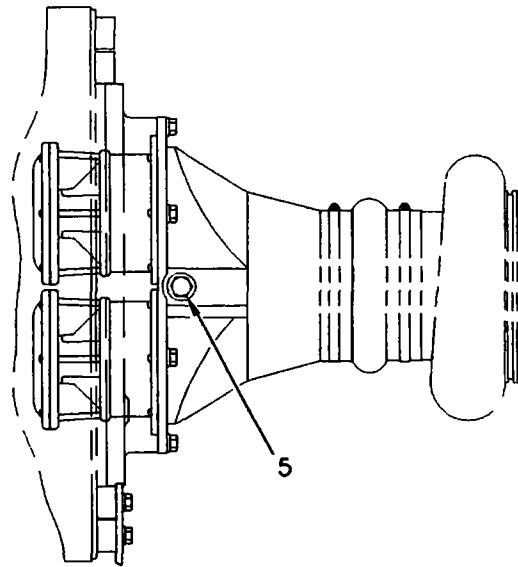


Illustration 4

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(5) Carburetor Adjusting Screw (Low Pressure Gas)

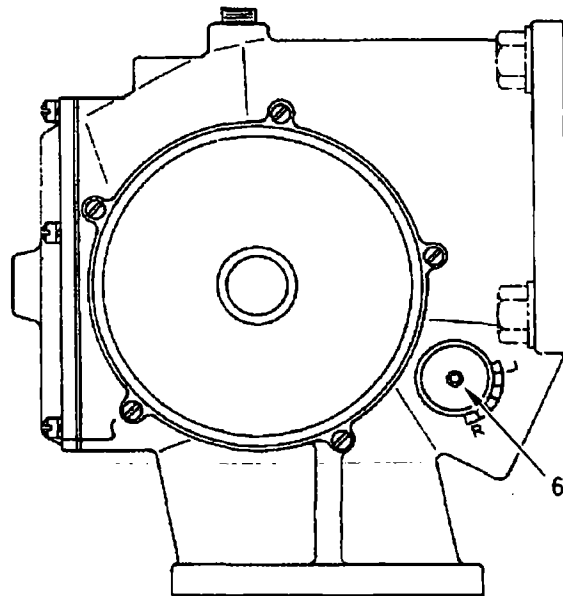


Illustration 5

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(6) Carburetor Adjusting Screw (High Pressure Gas)

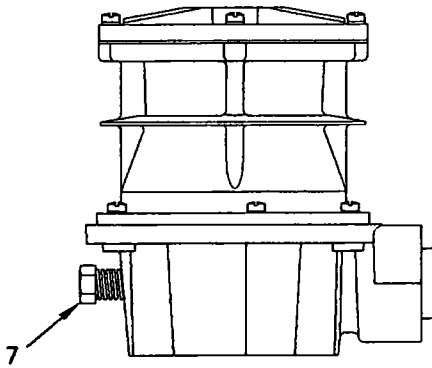


Illustration 6

g00545666

Impco 400 Low And High Pressure Carburetor
(7) Carburetor Adjusting Screw

2. Locate the carburetor adjusting screw (5,6). Refer to illustration 4 for carburetors of this type. Turn the screw clockwise until the screw is fully seated. Next, turn the screw 3.5 times in the counterclockwise direction. Refer to illustration 5 for carburetors of this type. Set the screw (6) halfway between the rich "R" setting and the lean "L" setting.

3. Set the gas line pressure into the gas pressure regulator. The proper range of the pressure settings follow:

- 10 kPa (1.5 psi) to 35 kPa (5 psi) for engines with low pressure
- 138 kPa (20 psi) to 207 kPa (30 psi) for turbocharged engines
- 10 kPa (1.5 psi) to 138 kPa (20 psi) for naturally aspirated engines

Note: Authorization from the local utility may be required in order to obtain these supply pressures.

4. While the engine is OFF, adjust the gas pressure regulator in order to obtain a differential pressure of 10 cm (4 inch) to 12.7 cm (5 inch) of water. Adjust the differential pressure by removing the cap from the regulator. Turn the threaded disk with the 8T-5160 Gas Regulator Setting Tool. Turning the disk clockwise will increase differential pressure. Turning the disk counterclockwise will decrease the differential pressure.

Note: Check the differential pressure once the engine is started. If necessary, readjust the regulator. Obtain a differential pressure of 10 cm (4 inch) to 12.7 cm (5 inch) of water.

5. If the engine is equipped with a magneto, set the timing with a timing light. Refer to the Service Manual, "Testing And Adjusting " for the correct procedure. Use the DDT to program the desired timing in engines that use the EIS. Refer to "Required Information" and to the Service Manual, "Electronic Troubleshooting". Ensure that the timing is set based on the Fuel Usage Guide.

Note: Before you start the engine, be sure that the engine and the driven equipment are ready for operation. Ensure this operation by performing the daily maintenance items.

6. Start the engine.

7. Allow the engine to reach full operating temperature.

8. Gradually increase the load until the engine is carrying the desired full load. Do not exceed the maximum load that is determined in "Required Information".

Slowly adjust the power adjustment screw on the carburetor if the full load can not be reached. This adjustment will increase the gas supply to the carburetor. Monitor the reading on an emissions analyzer such as the 156-1060 Emissions Analyzer, while turning the carburetor adjusting screw. The emissions are monitored in order to prevent adding too much fuel to the fuel air mixture.

Note: It may be necessary to turn the adjustment screw (10) on engines with an adjustable exhaust bypass valve. Perform this adjustment if the engine will not make the full load. This adjustment will increase the boost pressure and this adjustment will allow the engine to operate at full load.

9. While the engine is at full load, adjust the carburetor adjusting screw. Perform this adjustment in order to obtain the exhaust oxygen level that was determined in "Required Information".

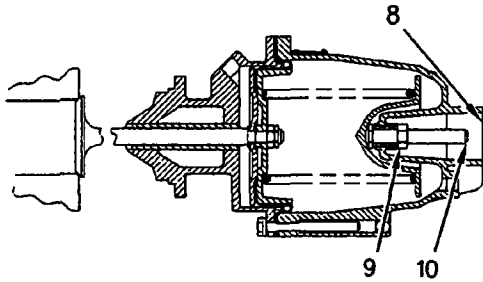


Illustration 7

g00529461

- (8) Cap
- (9) Locknut
- (10) Adjustment Screw

10. For engines with an adjustable exhaust bypass valve, remove the cap (8) and loosen the locknut (9). Turn the adjustment screw (10) in order to obtain a throttle angle of 60° to 70° at full load. It may be necessary to readjust the carburetor adjusting screw and the exhaust bypass valve several times. This adjustment is made in order to obtain the correct angle of the throttle at full load. This adjustment is also made in order to obtain the correct exhaust oxygen level.

Note: The angle of the throttle can not be observed on engines that are equipped with a Flo-Tech actuator. Adjust the exhaust bypass valve until a signal voltage of 4.0 VDC is generated between the terminals "E" and "B" at full load. Refer to the "Flo-Tech Actuator Position" for details.

11. Operate the engine throughout the expected load range. Verify that the engine rpm is stable. Verify that the angle of the throttle and the exhaust oxygen level at full load is correct. If the engine rpm is unstable, verify that the gas line pressures at no load and at full load are within acceptable limits. The pressure must not vary more than 1.7 kPa (0.25 psi) for low pressure fuel systems. The pressure must not vary more than 6.9 kPa (1 psi) for high pressure fuel systems. If the gas line pressure is within acceptable limits, it may be necessary to adjust the governor settings. Refer to the Governor Service Manual for details.

12. Check the final adjustments to the engine in order to ensure compliance with the emissions requirement. Use a NOx meter or a CO meter, or use both of these meters together in order to perform this check. In order to obtain desired emission levels, it may be necessary to make slight adjustments to the following settings:

- the carburetor adjusting screw
- the differential pressure
- the setting of the exhaust bypass valve

These adjustments are particularly important for low emissions engines and for engines that are equipped with a catalyst.

Adjustment Procedure For Deltec Mixer And Zero Pressure Regulators

Note: Gas can leak through the zero pressure regulator into the fuel system when the gas shutoff valve is open. Do not leave the gas shutoff valve open for a longer time than the time necessary to make adjustments. Before starting the engine, purge the inlet system and the exhaust system by disabling the ignition system. Then crank the engine with the gas supply OFF for three to five seconds.

1. Ensure that the throttle linkage is adjusted correctly. Refer to the Service Manual, "Systems Operation Testing And Adjusting Section".
2. Set the pressure from the gas supply line to the zero pressure regulator at 3 kPa (0.45 psi) to 7 kPa (0.95 psi).
3. Remove the cover (12) and the cap (15) from the zero pressure regulator.
4. Open the gas shutoff valve in order to supply gas to the zero pressure regulator.
5. If gas flows out of the valve (11), turn the screw (14) counterclockwise until the flow stops.
6. Turn the screw (14) clockwise in order to begin to lift the regulator valve (11) off the valve seat (13). The flow of gas is now heard in the regulator valve.

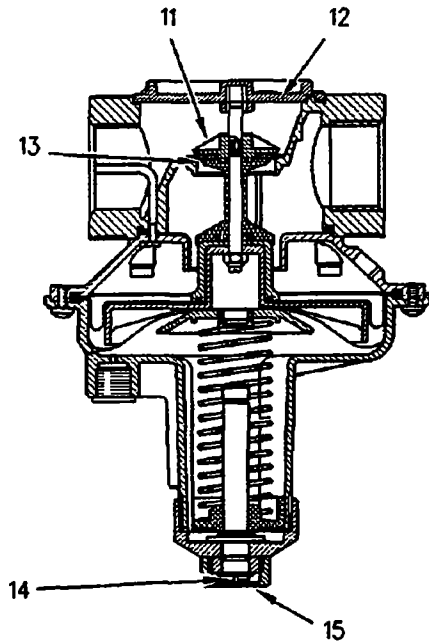


Illustration 8
Zero Pressure Regulator

- (11) Valve
- (12) Cover
- (13) Seat
- (14) Screw
- (15) Cap

7. De-energize the gas shutoff valve.
8. Clean the cover (12) and install the cover.

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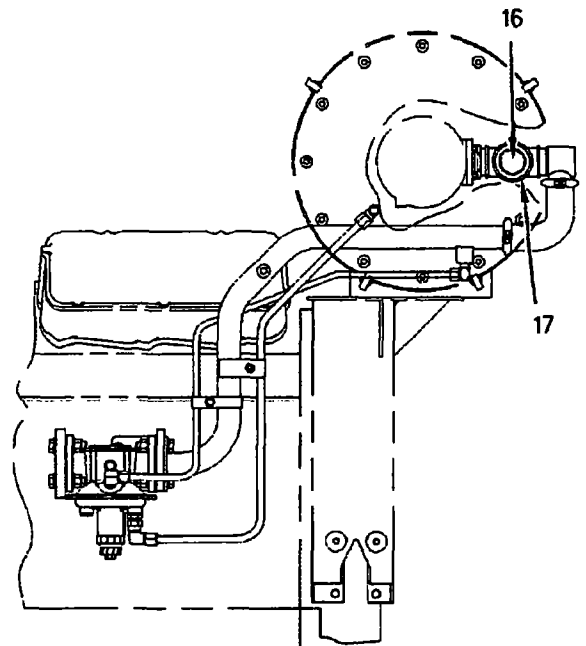


Illustration 9
Deltec Mixer System

- (16) Main Adjusting Screw
- (17) Locknut

9. Loosen the locknut (17). Turn the main adjustment screw (16) clockwise until the screw is fully seated.
10. Turn the main adjustment screw (16) four times in the counterclockwise direction. These turns open the fuel passage. Tighten the locknut (17).
11. If the engine is equipped with a magneto, set the timing with a timing light. Refer to the Service Manual, "Testing And Adjusting" for the correct procedure. Use the DDT to program the desired timing in engines that have the EIS. Refer to "Required Information" and to the Service Manual, "Electronic Troubleshooting".
12. Start the engine. Verify that the supply pressure to the regulator is within 3 kPa (0.45 psi) to 7 kPa (0.95 psi). Continue to run the engine at low load in order to reach the normal operating temperature.

Note: For the best performance at starting, open the gas shutoff valve after the engine has been cranking for three to five seconds.

13. Adjust the exhaust oxygen level with the adjusting screw (16) for the regulator. Make this adjustment while the engine is at low load and high idle. The exhaust oxygen level should be within 3 to 5 percent.
14. Increase the load on the engine to approximately 50 percent of the load. Use the main adjusting screw (16) to adjust the exhaust oxygen level. Adjust the level to the 50 percent rating that is given in the Engine Performance Book.
15. Gradually increase the load until the engine is carrying the desired full load. Do not exceed the maximum load that was determined in "Required Information". Slowly adjust the main adjustment screw (16), if the engine can not reach full load with the throttle in the wide open position. This adjustment increases the gas supply. Monitor the 156-1060 Emissions Analyzer reading while you turn the main adjustment screw (16). Monitor this reading in order to avoid adding too much fuel to the mixture. For engines with an adjustable exhaust bypass valve, adjustment may be necessary. Turn the adjustment screw (10) for the exhaust bypass valve in order to obtain the inlet manifold pressure at full load. This pressure is determined in the information for the prestart.
16. While the engine is at full load, adjust the main adjustment screw (16) in order to obtain the desired NOx level.
17. Operate the engine at low load and high idle rpm. Readjust the main adjustment screw (16) in order to obtain a 3 to 5 percent oxygen level and maximum stability.
18. Operate the engine at full load and readjust the main adjustment screw (16) in order to obtain the desired NOx level.
19. For engines with an adjustable exhaust bypass valve, remove the cap (8) and loosen the locknut (17). Turn the adjustment screw (10) in order to obtain a throttle angle of 60° to 70° at full load. It may be necessary to readjust the main adjustment screw (16) and the exhaust bypass valve several times. This adjustment is made in order to obtain the correct angle of the throttle at full load. This adjustment is also made in order to obtain the correct exhaust oxygen level.

Note: The angle of the throttle can not be observed on engines that are equipped with a Flo-Tech actuator. Adjust the exhaust bypass valve until a signal voltage of 4.0 VDC is generated between the terminals "E" and "B" at full load. Refer to the "Flo-Tech Actuator Position" for details.

20. Stop the engine and start the engine several times. If the engine is difficult to start, it may be necessary to make further adjustments to the regulator adjustment screw (10). Repeat this procedure starting at Step 13 if it is necessary to readjust the zero pressure regulator.

21. Operate the engine throughout the expected load range. Verify the following parameters:

- engine stability
- the angle of the throttle at full load
- the O₂ level

If the engine rpm is unstable, it may be necessary to adjust the governor settings. Refer to the Service Manual for details.

Gas Engine Troubleshooting Data Sheet

This sheet should be completed before you call the local dealer or the Caterpillar Service Engineering Department.

GAS ENGINE TROUBLESHOOTING DATA SHEET

This is a list of data that is necessary when troubleshooting a gas engine. Be sure to include the units the measurements were taken in.

CUSTOMER/INSTALLATION: _____

ENGINE MODEL/DRIVEN COMPONENT: _____

Engine Serial # _____ Application _____ Gen Set _____
 (circle one) Industrial
 SMR _____ Compr. Ratio _____ other _____
 Ignition
 Altitude _____ (ft) (m) above SL Timing _____ deg (BTDC) (ATDC)

FUEL:
 Type (LHV, methane #) _____ Fuel Rate _____
 Gas Regulator
 Pressure (to gas reg.) _____ Differential Pressure _____

OIL:
 Brand & Type _____

ENGINE:
 Speed _____ Load _____ Throttle Angle _____

Detonation (Bars on DDT) _____ Air Inlet Restriction _____

Intake Air _____ temp probe _____
 Mainfold: pressure _____ temperature _____ location _____

Turbo: boost ODD _____ exhaust out ODD _____
 pressure (left bank) temperature (left bank)
 EVEN _____ EVEN _____
 (right bank) (right bank)

Exhaust _____ (wet)
 Stack: pressure _____ temperature _____ O2 % vol _____ (dry)

NOX (ppm) _____ CO (ppm) _____ Analyzer Brand _____

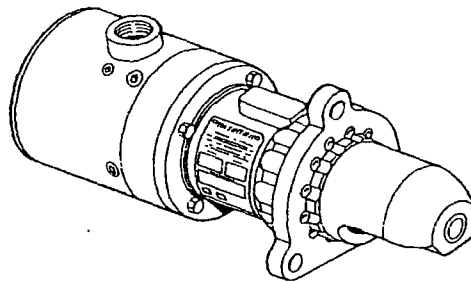
Exhaust (1) _____ (3) _____ (5) _____ (7) _____ (9) _____ (11) _____ (13) _____ (15) _____
 Port

Temps: (2) _____ (4) _____ (6) _____ (8) _____ (10) _____ (12) _____ (14) _____ (16) _____

Aftercooler IN _____ Jacket IN _____ Engine IN _____
 Water Temp: Water Temp: OUT _____ Oil Temp: OUT _____
 OUT _____ Temp: OUT _____

Yab 738

INSTALLATION AND OPERATING MANUAL



MODEL: T30-I *TURBOTWIN* Engine Air Starter

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1.0 GENERAL INFORMATION

This manual provides instructions for the installation and operation of the TDI TurboTwin™ Model T30-I air starters. If there are questions not answered by this manual, please contact your TDI TurboTwin™ distributor or dealer for assistance.

The T30-I model is a turbine driven air starter with inertia engaged drive. They are best suited for diesel engines up to 20 Liters (1220 CID) or gasoline engines up to 28 Liters (1709 CID). The T30-I is designed for installation on engines which use an SAE 3 mounting pad.

The T30 Series starters are suited to operate within a wide range of inlet air pressures and ambient temperatures. The engine size and parasitic loading will determine the exact minimum pressure that will ensure reliable starting.

The T30 Series starters are designed for operation with compressed air or natural gas. Moderate amounts of foreign matter or liquid in the air stream will normally not adversely affect T30 Series starters. As with all other TDI TurboTwin™ models, **no lubrication** is required in the supply air.

You need to review the rest of this manual before installing your TDI TurboTwin™ T30 Series starter.

1.1 WARNINGS, CAUTIONS, & NOTES

Throughout this manual, certain types of information will be highlighted for your attention:

WARNING - used where injury to personnel or damage to the equipment is possible.

CAUTION - used where there is the possibility of damage to the equipment

NOTE - used to point out special interest information.

1.2 INSTALLATION and SERVICE

The TDI TurboTwin™ T30 Series starters provide distinct advantages of size and efficiency compared to electric motor, vane-type, or other turbine-type air 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 of your TDI TurboTwin™ T30 Series starter will assure continued reliable and superior performance for many years.

WARNING

The TDI TurboTwin™ T30 Series starter must be installed and operated in accordance with the instructions given in this manual. Failure to properly install the starter, or failure to operate it according to these instructions may result in damage to the starter or the engine, or cause personal injury.

NOTE

THIS STARTER IS TO BE SERVICED ONLY BY AUTHORIZED TDI TURBOTWIN™ DISTRIBUTORS, DEALERS, AND REPAIR STATIONS. DO NOT OPERATE THIS STARTER UNLESS IT IS PROPERLY ATTACHED TO AN ENGINE.

2.0 ORIENTATION OF THE STARTER

If the factory orientation of the starter's mounting flange (drive housing) assembly, or optional exhaust port does not fit your engine installation, these components can be re-oriented.

2.1 MODEL T30-I ORIENTATION

A. Determine the required orientation of the mounting flange assembly and any optional exhaust port.

B. Note that the mounting flange assembly can be rotated to twelve different positions relative to the gearbox and the gearbox housing assembly can be rotated to four

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positions relative to the inlet port. Additionally, the optional exhaust housing can be rotated to eight positions relative to the inlet port.

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.

2.1.1 Drive Housing / Mounting Flange Re-Orientation

Remove the twelve mounting flange attachment socket head cap screws.

Rotate the mounting flange to the desired position and reinstall the twelve socket head cap screws. Torque the twelve screws to **9.4 Lb-Ft. (12.7 Nm)**.

CAUTION

Ensure that the O-ring on the drive housing remains in position and is not cut.

WARNING

Do not remove the five radial screws that connect the inlet and turbine housing. The inlet and turbine housing assembly must remain in the same position relative to each other.

3.0 INSTALLING THE STARTER

The T30 Series installation is shown in Figures 2 & 3. The components illustrated may vary in shape, but there must at least be a start initiation switch, air supply, and a starter relay valve to correctly install and operate a T30 Series starter.

NOTE

Mounting the air piloted relay valve on the starter is preferred in installations where the space is available.

TDI recommends mounting the air piloted relay valve no more than 3 meters (10 feet) from the starter's inlet port, and as close to the starter as possible. If the starter is being installed on a vehicle where the air tank is within 3 meters (10 feet) of the starter, then the relay valve may be mounted on the tank.

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.

Liberal grease the starter's pinion teeth with chassis lube and then mount the T30 Series starter on the engine. Tighten all mounting hardware as appropriate.

After mounting the starter to the engine, attach the supply air line from the tank, any control air lines, and solenoid to the ignition system and/or palm valve to the air piloted relay valve.

TDI recommends installation of a "Glad Hand" / quick disconnect for auxiliary pressurization of the air tank.

Because turbine starters are sensitive to flow restrictions, care must be taken to use uniform sized 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.

Only type approved metallic hose assemblies are approved in permanently pressurized compressed air lines of starters.

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Non-metallic hose assemblies are allowed only in case the piping system will be emptied after the starting procedure.

Pipe unions must be type approved by GL. Downstream of the pressure regulator a pressure relief valve is to be provided.

WARNING

Recheck all connections for tight fit.

Fill the air system tank. The T30 Series starter is now ready to operate.

4.0 STARTER OPERATION

The maximum operating pressure limit is that pressure measured at the starter inlet pressure check port during the crank cycle. In order to check the starter inlet pressure, an 1/8" NPT pipe tap connection is provided just below the main inlet for attaching a pressure gauge. Refer to Figure 1. **IN NO CASE SHOULD INLET OPERATING PRESSURE EXCEED 10.3 BAR (150 PSIG).**

WARNING

Do not operate the TDI TurboTwin T30 Series air 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 static supply pressure will always be higher than the operating pressure. As a guideline, the maximum pressure limit (proof pressure) that the T30 Series starter may be subjected to is 300 PSIG (20.7 Bar).

System pressure that exceeds the maximum operating limit must use a pressure reducer device to ensure operating pressure limit to the T30 Series starter is maintained.

System pressure that exceeds the 300 PSIG (20.7 Bar) limit must, in addition to a pressure reducer device, incorporate a pressure relief valve, set below 300 PSIG Bar (20.7), in the supply air line.

All appropriate local pressure codes and pressure limitations on other system components must be adhered to and supersede guidelines given in this manual.

Follow the engine manufacturer's instructions for starting the engine.

WARNING

Do not engage the starter while the engine is running.

If the starter fails to function properly when first operated, or its performance deteriorates with use, refer to the Operator's Trouble Shooting Guide, Section 6.0. If you cannot solve the problem, or repair is necessary, contact your local TDI TurboTwin™ distributor or dealer.

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5.0 WARRANTY

TDI TURBOTWIN ENGINE STARTER WARRANTY

Tech Development Inc. (TDI) warrants to the original user of the TDI TurboTwin™ Model T30 Series air starters to be free from defects in material and workmanship for a period of one year from date of purchase by such user. The warranty period shall begin on the actual delivery date to the original user or twelve (12) months from the date of shipment from TDI, whichever comes first. 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 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 by TDI's examination to be defective, or by mutual agreement, refund the user's purchase price in exchange for such starter product. Repairs or replacements 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 arising from the sale or use of such engine starter product.

6.0 OPERATOR'S TROUBLESHOOTING GUIDE

TROUBLE	PROBABLE CAUSE	SOLUTION
1. Air always flow through exhaust	A. Relay valve im properly installed.	A. Check typical installation diagram and correct
	B. Relay valve not sealing properly.	B. Check for damaged sealing ring, replace relay valve or damaged parts.
	C. Control valve not sealing, pressure remains in APP port of relay valve.	C. Check control valve and replace if necessary.
2. Starter engages but does not run.	A. Bad relay valve	A. Replace relay valve.
3. Starter does not run, small air flow from turbine exhaust.	A. Nozzle blockage.	A. Remove blockage or obstruction from nozzles.
4. Starter does not run. Normal air flow from exhaust.	A. Excessive bends in the supply line.	A. Shorten length or straighten supply air line.
5. Pinion does not engage	A. Air pressure is too low	A. Increase air pressure to 40 -150 psig.
	B. Damaged pinion teeth.	B. Replace pinion or starter drive as necessary.
6. Starter runs but engine cranks slowly or not at all.	A. Air pressure too low	A. Increase air pressure to 40 -150 psig.
	B. Excessive back pressure.	B. Increase inlet pressure or reduce back pressure.
	C. Worn or broken starter drive.	C. Replace starter drive.
	D. Worn Starter Drive	D. Replace Starter Drive
	E. Nozzle blocked or damaged.	D. Remove blockage or replace damaged parts.
7. Starter continues to operate after start button is released.	A. Control valve is not sealing correctly.	A. See 1C. above
	B. Relay valve is not sealing correctly.	B. See 1B. above
8. Air tank pressure decays after extended shut down.	A. Air connections are too tight.	A. Tighten loose fittings. Repair or replace damaged fittings.
	B. Damaged air lines: crushed, frayed, kinked.	B. Replace damaged lines.
	C. Relay valve is not sealing correctly.	C. See 1B. above
	D. Control valve is stuck open.	D. See 1C. above

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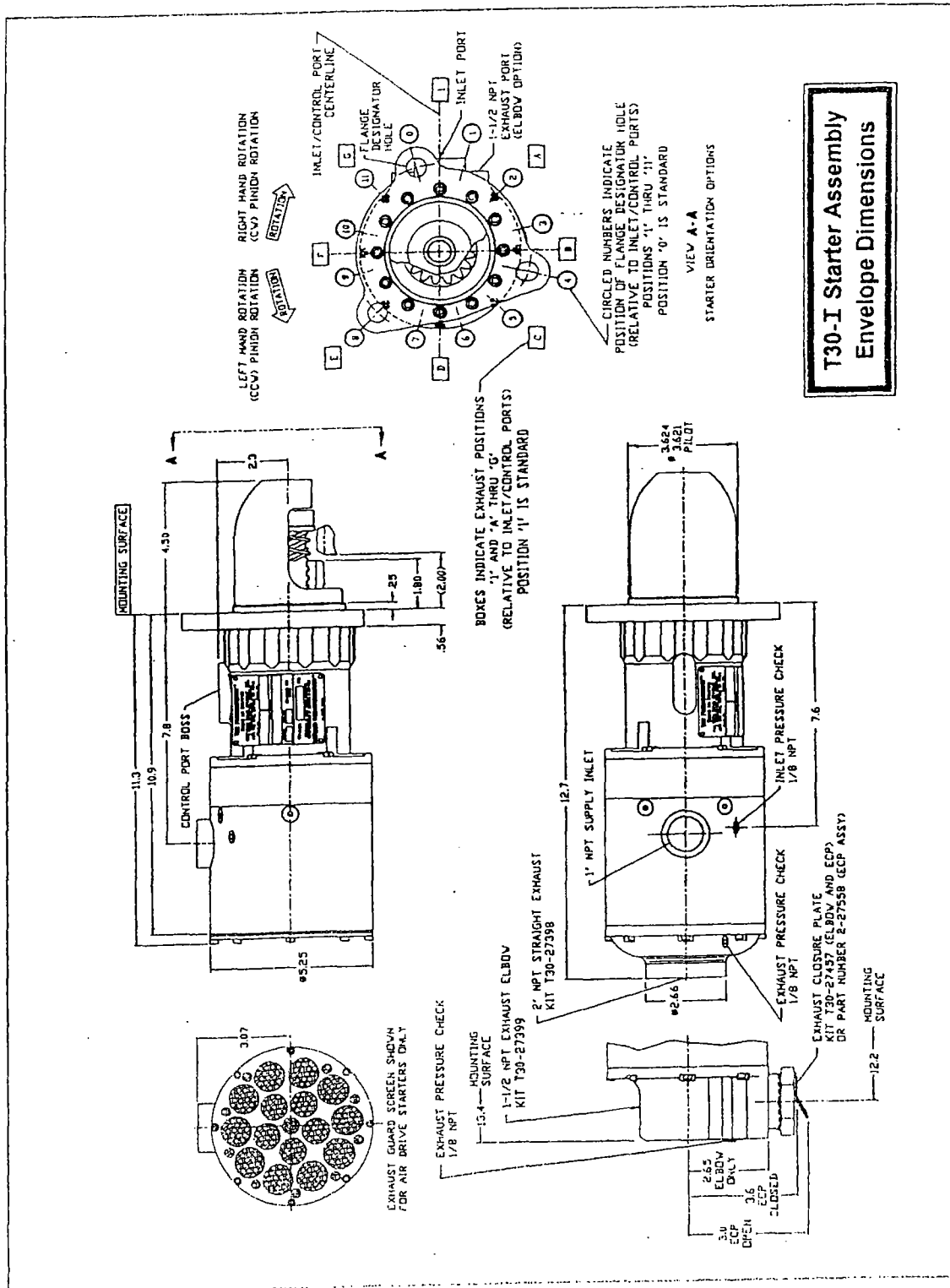
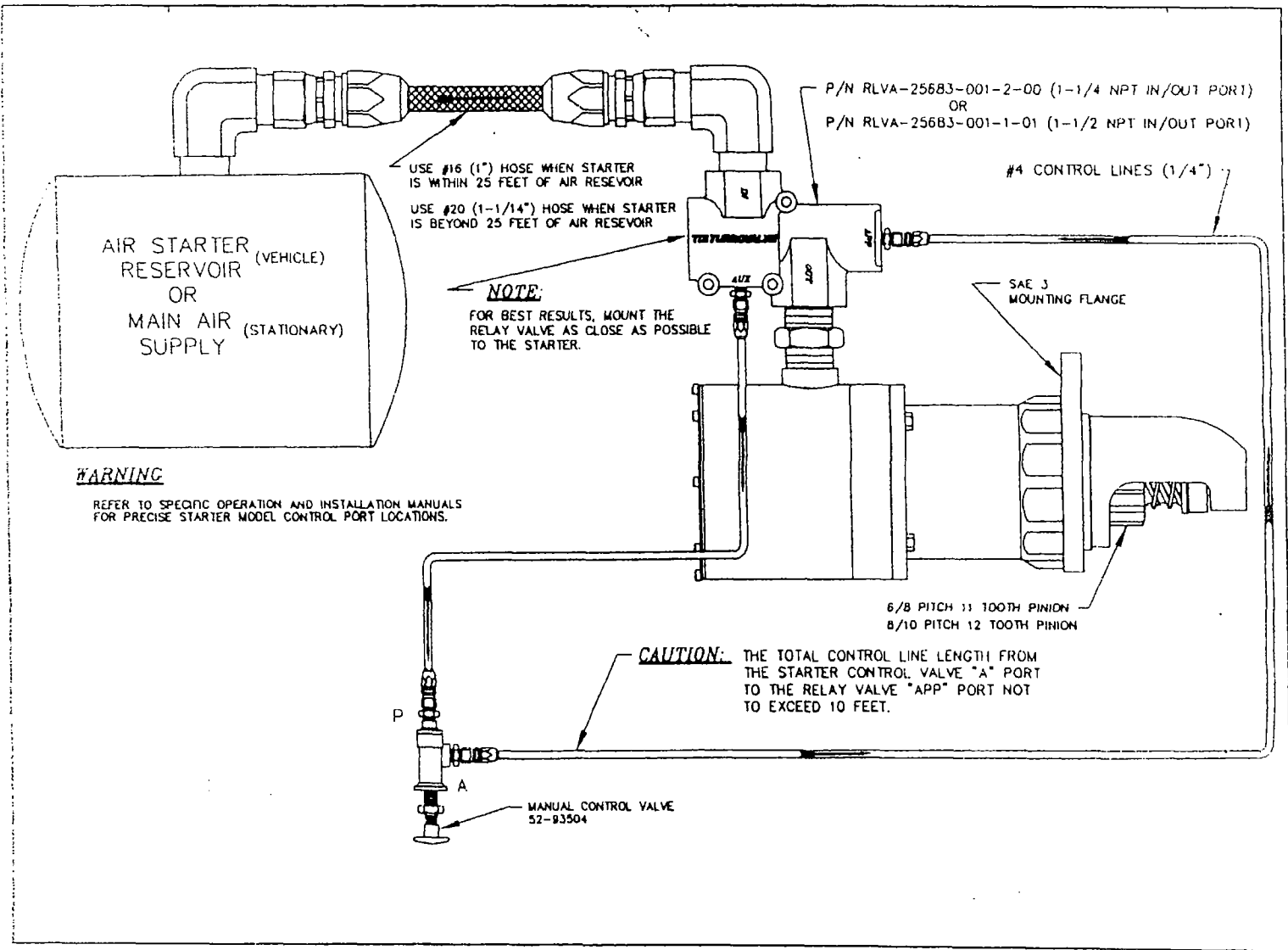


Figure 1. T30-I Turbo Twin Air Starter Envelope Drawing



WARNING

REFER TO SPECIFIC OPERATION AND INSTALLATION MANUALS FOR PRECISE STARTER MODEL CONTROL PORT LOCATIONS.

Figure 2 (304) TurboTwin Air Starter Installation Diagram (Mechanical)

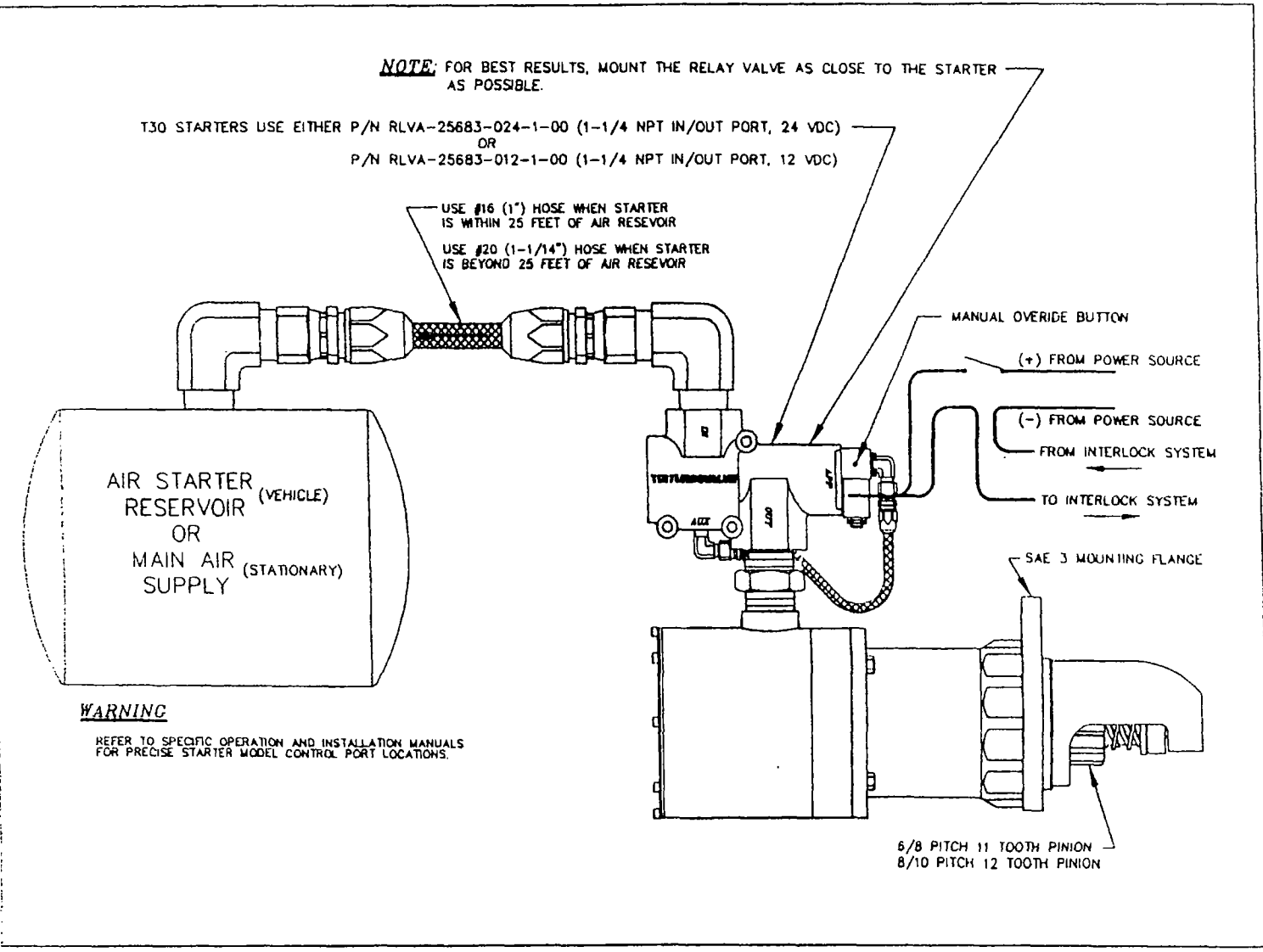
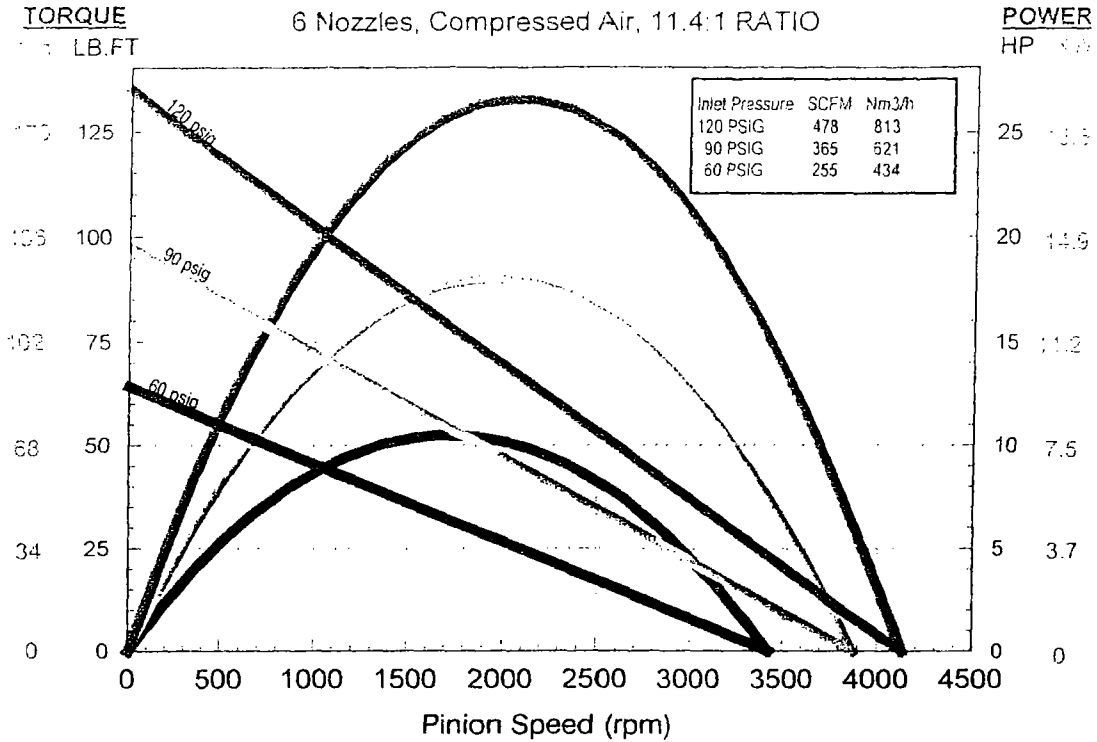
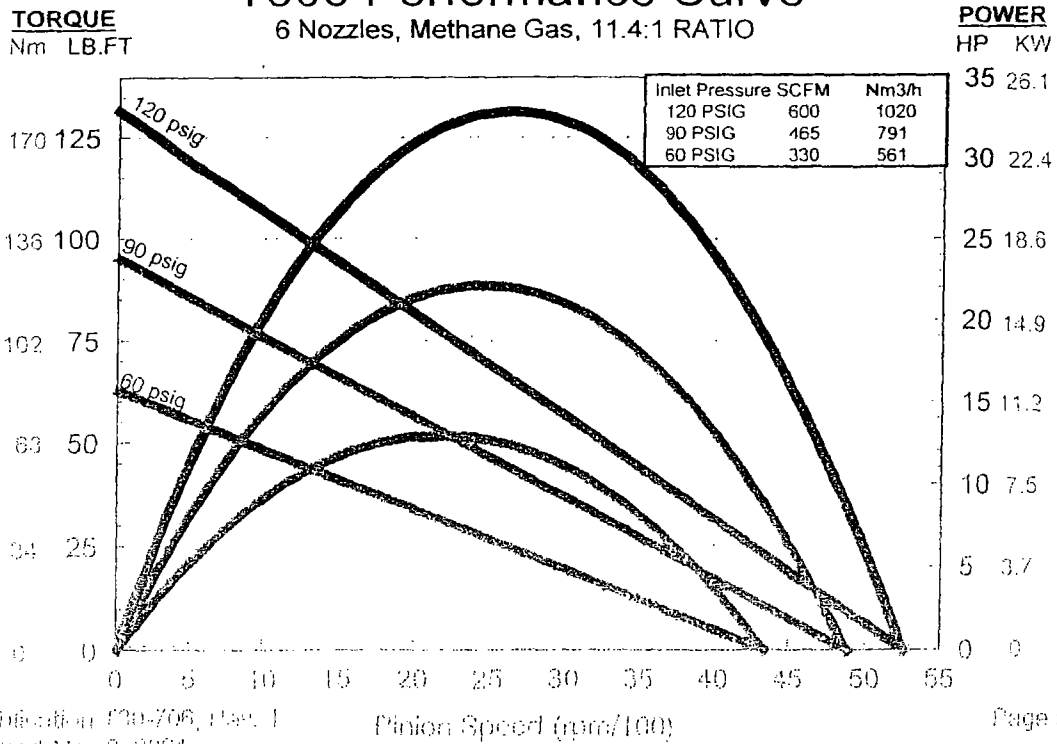


Figure 3. TDI Turbo Twin Air Starter Installation Diagram (Electrical)

T306 Performance Curve



T306 Performance Curve



Shock/Vibration Control Switches Installation Instructions

Models: VS2, VS2C, VS2EX, VS2EXR, VS2EXRB and VS94



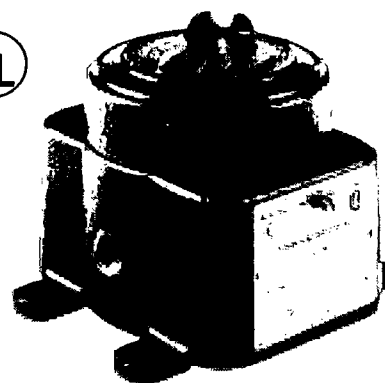
Please read the following instructions before installing. A visual inspection of this product for damage during shipping is recommended before mounting. It is your responsibility to have a qualified person install the unit, and make sure installation conforms with NEC and local codes.

GENERAL INFORMATION

WARNING

BEFORE BEGINNING INSTALLATION OF THIS MURPHY PRODUCT

- ✓ Disconnect all electrical power to the machine.
- ✓ Make sure the machine cannot operate during installation.
- ✓ Follow all safety warnings of the machine manufacturer.
- ✓ Read and follow all installation instructions.



Model VS2EX

Description

The Murphy shock and vibration switches are available in a variety of models for applications on machinery or equipment where excessive vibration or shock can damage the equipment or otherwise poses a threat to safe operation. A set of contacts is held in a latched position through a mechanical latch and magnet mechanism. As the level of vibration or shock increases an inertia mass exerts force against the latch arm and forces it away from the magnetic latch causing the latch arm to operate the contacts. Sensitivity is obtained by adjusting the amount of the air gap between the magnet and the latch arm plate.

Applications include all types of rotating or reciprocating machinery such as cooling fans, engines, pumps, compressors, pump jacks, etc.

Models

VS2: Base mount; non hazardous locations.

VS2C: C-clamp mount; non hazardous locations.

VS2EX: Explosion-proof; Class I, Div. 1, Groups C and D*

VS2EXR: Explosion-proof with remote reset.

VS2EXRB: Explosion-proof; Class I, Div. 1, Group B* ; with remote reset.

VS94: Base mount; non hazardous locations, NEMA 4.

Remote Reset Option (VS2EXR, VS2EXRB and VS94 only)

Includes built-in electric solenoid which allows reset of tripped unit from a remote location. Standard on VS2EXR and VS2EXRB. Optional on VS94 (options listed below).

-R15: Remote reset for 115 VAC

-R24: Remote reset for 24 VDC

Time Delay Option (VS94 only)

Overrides trip operation on start-up. For VS94 series models, the delay time is field-adjustable from 5 seconds up to 6-1/2 minutes with a 20-turn potentiometer (15 seconds per turn approximately). Options listed below:

-T15: Time delay for 115 VAC

-T24: Time delay for 24 VDC

Space Heater Options (VS94 only)

This optional space heater board prevents moisture from condensing inside the VS94 Series case. Options listed below:

-H15: Space heater for 115 VAC

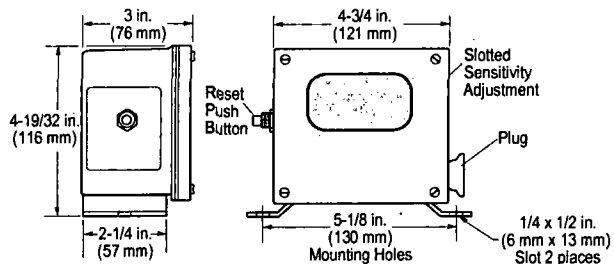
-H24: Space heater for 24 VDC

Warranty

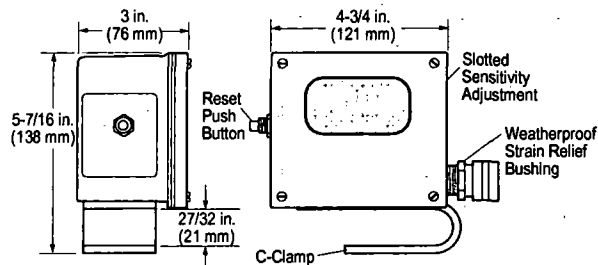
A two-year limited warranty on materials and workmanship is provided with this Murphy product. Details are available on request and are packed with each unit.

DIMENSIONS

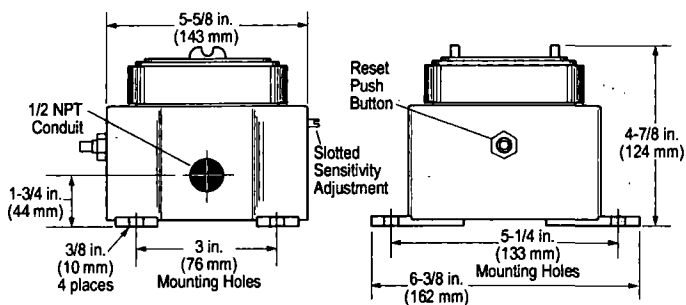
VS2



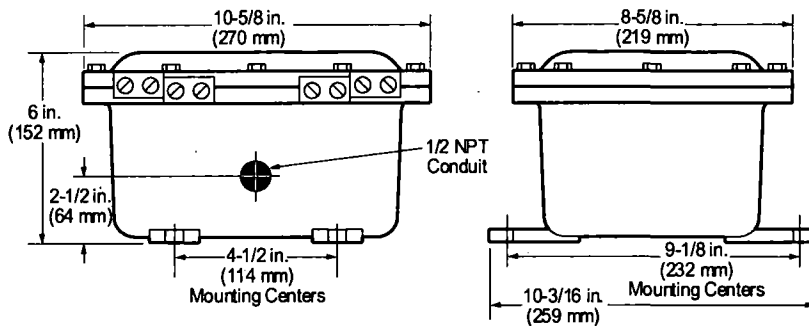
VS2C



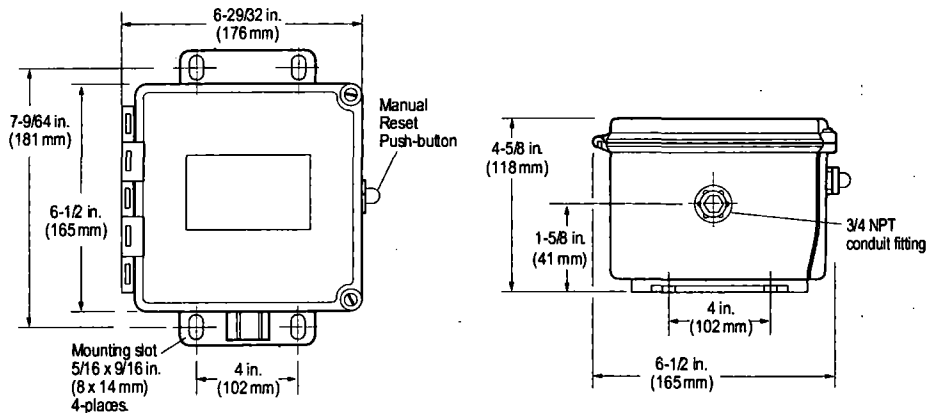
VS2EX and VS2EXR



VS2EXRB



VS94



SPECIFICATIONS

VS2 and VS2C

- **Case:** Weatherproof (equal to NEMA 3R) suitable for non-hazardous areas.
VS2: *Base mount*
VS2C: *C-clamp mount. Includes 45 feet (13.7 meters), 2-conductor 16 AWG, 30 strands/0.25 mm strand dia. (1.5 mm²) cable, and five cable hold down clamps.*
- **Contacts:** SPDT double make leaf contacts, 5A @ 480 VAC.
- **Range adjustment:** 0 - 7 G's; 0 - 100 Hz/0.100 in. displacement

VS2EX

- **Case:** Explosion-proof and weatherproof aluminum alloy housing; meets NEMA 7 specifications; Class I, Division 1, Groups C & D; UL and CSA listed*
VS2EX: *base mount.*
- **Snap-switches:** 2-SPDT snap-switches; 5A @ 480 VAC;*
2A resistive, 1A inductive, up to 30 VDC.
• **Range adjustment:** 0 - 7 G's; 0 - 100 Hz/0.100 in. displacement

VS2EXR

- **Case:** Same as VS2EX.
- **Snap-switch:** 1-SPDT snap-switch and reset coil; 5A @ 480 VAC;* 2A resistive, 1A inductive, up to 30 VDC.
- **Remote Reset (optional):**

<i>Option</i>	<i>Operating Current</i>
-R15:	350 mA @ 115 VAC
-R24:	350 mA @ 24 VDC
- **Range adjustment:** 0 - 7 G's; 0 - 100 Hz/0.100 in. displacement

VS2EXRB

- **Case:** Explosion-proof aluminum alloy housing; rated Class I, Division 1, Group B hazardous areas.
- **Snap-switch:** 1-SPDT snap-switch with reset coil (option available for additional SPDT switch); 5A @ 480 VAC; 2A resistive, 1A inductive, up to 30 VDC.

Remote Reset:(optional):

<i>Option</i>	<i>Operating Current</i>
-R15:	350 mA @ 115 VAC
-R24:	350 mA @ 24 VDC

- **Range adjustment:** 0 - 7 G's; 0 - 100 Hz/0.100 in. displacement

VS94

- **Case:** Polyester fiberglass reinforced; NEMA type 4 and 4X; IP66; CSA types 4 and 12.
- **Conduit Fitting:** 3/4 NPT conduit fitting connection.
- **Normal Operating Ambient Temperature:**
0 to 140°F (-18 to 60°C).
- **Snap-switches:** 2-SPDT snap acting switches; 5A @ 480 VAC; 2A resistive, 1A inductive, up to 30 VDC.
- **Range adjustment:** 0 - 7 G's; 0 - 100 Hz/0.100 in. displacement
- **Heater (optional):**

<i>Option</i>	<i>Operating Current</i>
H15	.023 A @ 115 VAC
H24	.12 A @ 24 VDC
- **Remote Reset (optional):**

<i>Option</i>	<i>Operating Current</i>
R15	.17 A @ 115 VAC
R24	.36 A @ 24 VDC
- **Time Delay (optional):**

<i>Option</i>	<i>Operating Current</i>	<i>Standby Current</i>
T15	.360 A @ 115 VAC	.01 A @ 115 VAC
T24	1.15 A @ 24 VDC	.01 A @ 24 VDC
- **Time Delay/Remote Reset:** Adjustable 20-turn potentiometer from 5 seconds to 6-1/2 minutes (15 seconds per turn approximately).

*CSA and UL listed with 480 VAC rating.

INSTALLATION



WARNING: STOP THE MACHINE AND DISCONNECT ALL ELECTRICAL POWER BEFORE BEGINNING INSTALLATION.

The VS2 and VS94 series shock switches are sensitive to shock and vibration in all three planes of motion - up/down, front/back and side/side. Front/back is the most sensitive (The reset pushbutton is located on the "front" of the unit). For maximum sensitivity mount the unit so that the front faces into the direction of rotation of the machine. (See Dimensions on page 2 for sensitivity adjustment location).

The VS2 and VS94 Series must be firmly attached/mounted to the machine so that all mounting surfaces are in rigid contact with the mounting surface of the machine. For best results, mount the instrument in-line with the direction of rotating shafts and/or near bearings. In other words, the reset push button should be mounted pointing into the direction of shaft rotation (see page 5). It may be necessary to provide a mounting plate or bracket to attach the VS2 and VS94 Series to the machine. The mounting bracket should be thick enough to prevent induced acceleration/vibration upon the VS2 or VS94 Series. Typically 1/2 in. (13mm) thick plate is sufficient. See illustrations on page 5 for typical mounting locations.



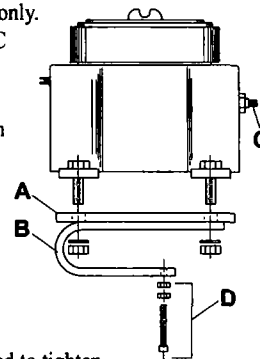
CAUTION: A dust boot is provided on the reset pushbutton for all series to prevent moisture or dust intrusion. The sensitivity adjustment for model VS2EX is not sealed; therefore, mounting

orientation should be on a horizontal plane or with the sensitivity adjustment pointing down. Sensitivity adjustment for model VS2 is covered by a plug. The plug must be in place and tight to prevent moisture or dust intrusion.

C-Clamp Installation (VS2C model only)

A C-Clamp is supplied with the VS2C model only. The C-Clamp is shipped installed on the VS2C but must be installed on the VS2EX and VS2EXR switches.

1. The C-Clamp (B) will already be installed on a 1/4 in. (6 mm) thick steel mounting plate (A). Bolt the VS2 switch to the mounting plate as illustrated — with four 5/16 in. bolts, nuts, and washers.
2. The mounting location should provide convenient access to the TATTLETALE® push button (C).
3. The hardened set screw and nuts (D) are used to tighten the switch to an I-Beam or cross member such as a Sampson post of an oilwell pumpjack.



Continued on next page.

All Models



WARNING: STOP THE MACHINE AND DISCONNECT ALL ELECTRICAL POWER BEFORE BEGINNING INSTALLATION.

1. Firmly secure the unit to the equipment using the base foot mount or C-Clamp if applicable. See *C-Clamp Installation* page 3.
For oilwell pumpjacks attach the VS2 and VS94 Series to the Sampson post or walking beam. See *Typical Mounting Locations* page 5.
2. Make the necessary electrical connections to the vibration switch. See *Internal Switches*, page 6 for electrical terminal locations and page 7 for typical wiring diagrams. **DO NOT EXCEED VOLTAGE OR CURRENT RATINGS OF THE CONTACTS.** Follow appropriate electrical codes/methods when making electrical connections. Be sure that the run of electrical cable is secured to the machine and is well insulated from electrical shorting. Use of conduit is recommended.

NOTE: If the electrical cable crosses a pivot point such as at the pivot of the walking beam, be sure to allow enough slack in the cable so that no stress is placed on the cable when the beam moves.

If conduit is not used for the entire length of wiring, conduit should be used from the electrical supply box to a height above ground level that prevents damage to the exposed cable from the elements, rodents, etc. or as otherwise required by applicable electrical codes. If conduit is not attached directly to the VS2 and VS94 Series switch, use a strain relief bushing and a weatherproof cap on the exposed end of the conduit. A "drip loop" should be provided in the cable to prevent moisture from draining down the cable into the conduit should the weathercap fail.

Sensitivity Adjustment

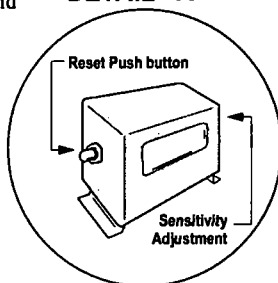


WARNING: REMOVE ALL POWER BEFORE OPENING THE ENCLOSURE. IT IS YOUR RESPONSIBILITY TO HAVE A QUALIFIED PERSON PERFORM ADJUSTMENTS, AND MAKE SURE IT CONFORMS WITH NEC AND LOCAL CODES. DO NOT ADJUST SENSITIVITY WHILE THE MACHINE IS RUNNING. STAND CLEAR OF THE MACHINE AT ALL TIMES WHEN IT IS OPERATING.

All models of the VS2 and VS94 Series cover a wide range of sensitivity. Each model is adjusted to the specific piece of machinery on which it is installed. After the switch has been installed in a satisfactory location (see page 5) the sensitivity adjustment will be increased or decreased so that the switch does not trip during start-up or under normal operating conditions. This is typically done as follows:

1. REPLACE ALL COVERS, LIDS, AND ELECTRICAL ENCLOSURES.
2. Press the reset push button to engage the magnetic latch. To be sure the magnetic latch has engaged, observe latch through the window on the VS2 and VS2C (see DETAIL "A"). On the VS2EX, VS94 series the reset button will remain depressed meaning the magnetic latch has engaged.
3. Start the machine.
4. If the instrument trips on start-up,

DETAIL "A"



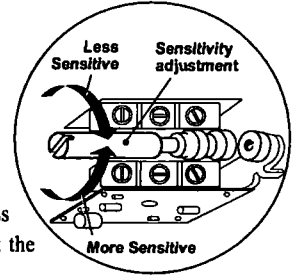
allow the machine to stop. Turn the sensitivity adjustment 1/4 turn clockwise, (adjustment for VS94 and VS2EXRB models is located within the box, see DETAIL "B").



WARNING: MAKE THE AREA NON-HAZARDOUS BEFORE OPENING THE EXPLOSION-PROOF (-EX) ENCLOSURES.

Depress the reset button and restart the machine. Repeat this process until the unit does not trip on start-up.

DETAIL "B"



5. If the instrument does NOT trip on start-up, stop the machine. Turn the sensitivity adjustment 1/4 turn counter-clockwise. Repeat the start-up/stop process until the instrument trips on start-up. Turn the sensitivity adjustment 1/4 turn clockwise (less sensitive). Restart the machine to verify that the instrument will not trip on start-up.
6. Verify that the unit will trip when abnormal shock/vibration exists.

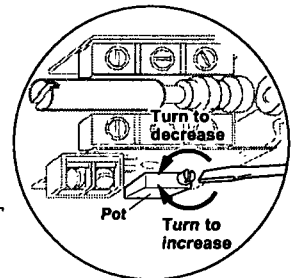
VS94 Time Delay Adjustment



WARNING: REMOVE ALL POWER BEFORE OPENING ACCESS DOOR. IT IS YOUR RESPONSIBILITY TO HAVE A QUALIFIED PERSON ADJUST THE UNIT, AND MAKE SURE IT CONFORMS WITH NEC AND LOCAL CODES.

1. Apply power to the time delay circuit. (see page 7 for time delay circuit). The time delay function will be initiated.
2. Time the length of the delay with a watch. Let time delay expire. After it expires, the override circuit will de-energize the solenoid, allowing the latch arm to trip. A clicking noise is heard.
3. TURN THE POWER OFF TO RESET THE TIME DELAY CIRCUIT.

DETAIL "C"



NOTE: Allow 30 seconds bleed-time between turning the power "OFF" and "ON."

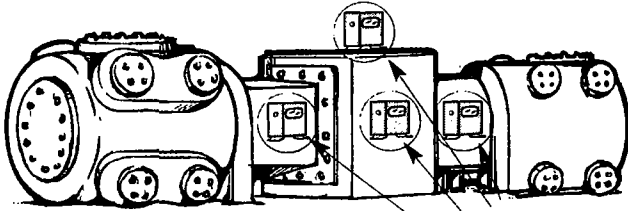
4. Locate the time adjustment pot (DETAIL "C"). The time is factory-set at the lowest setting (5 seconds approximately). To increase time, rotate the 20-turn pot clockwise as needed (15 seconds per turn approximately).
5. Repeat the above steps as necessary to obtain desired time delay.

NOTE: An external time delay can be used with the remote reset feature of the VS2EXR series to provide a remote reset and override of the trip operation on start-up. Time delay must automatically disconnect after

TYPICAL MOUNTING LOCATIONS

NOTE: These are typical mounting locations for best operation. Other mountings are possible. See *Installation* section on page 3.

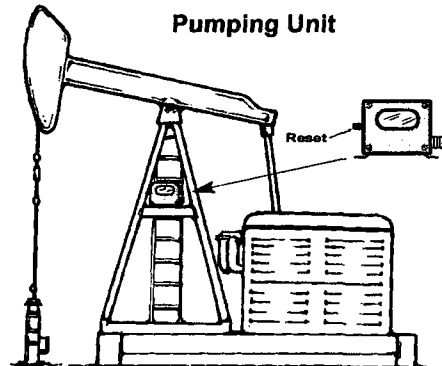
2-Throw Balance-Opposed Compressor



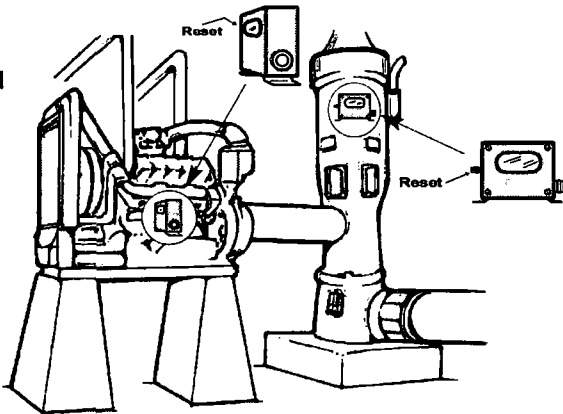
NOTE: If installing on cylinders, 2 vibration/shock switches are recommended- 1 for each cylinder.



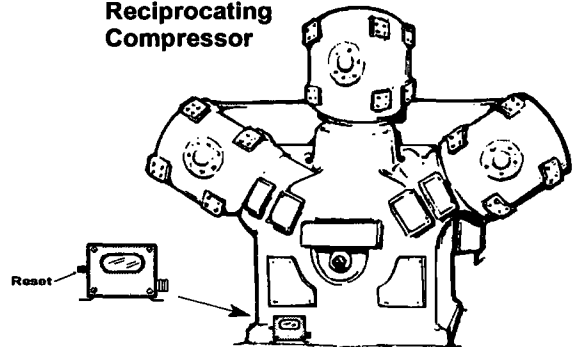
Pumping Unit



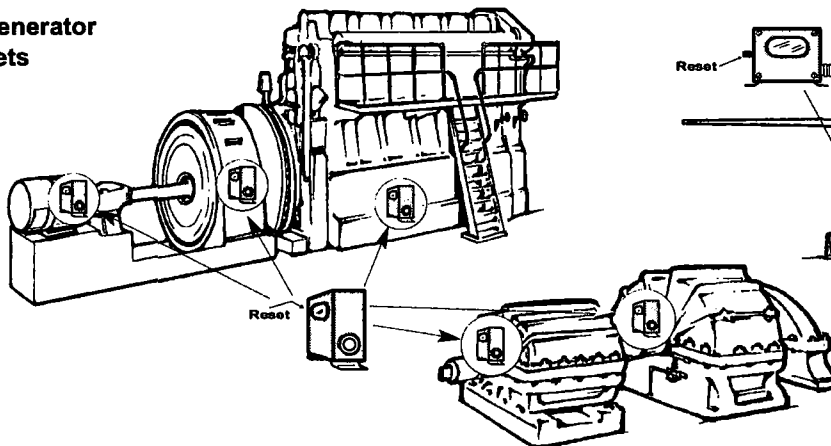
Engine and Vertical Shaft Pump



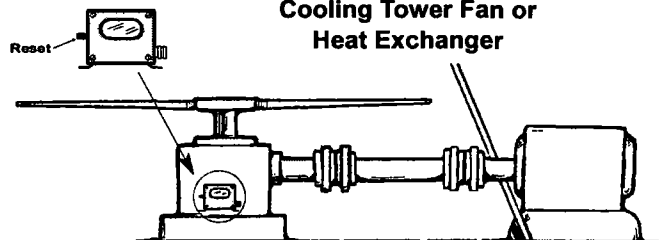
"Y" Type Reciprocating Compressor



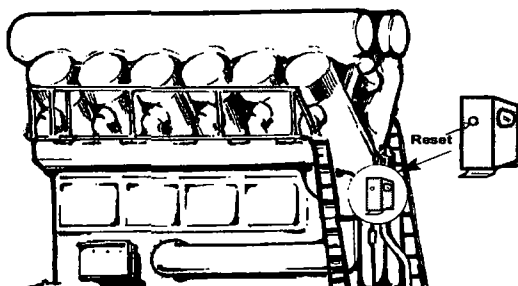
Generator Sets



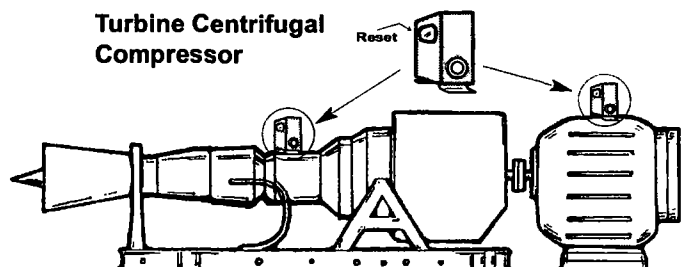
Cooling Tower Fan or Heat Exchanger



Engine Compressor

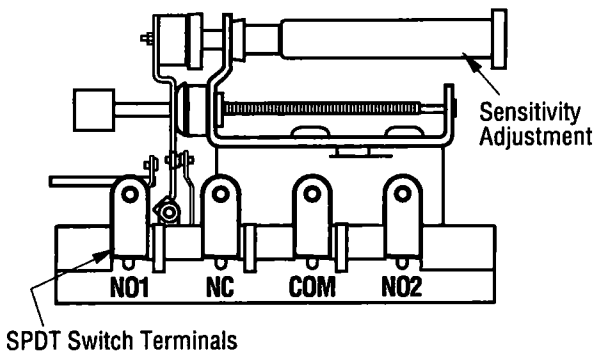


Turbine Centrifugal Compressor

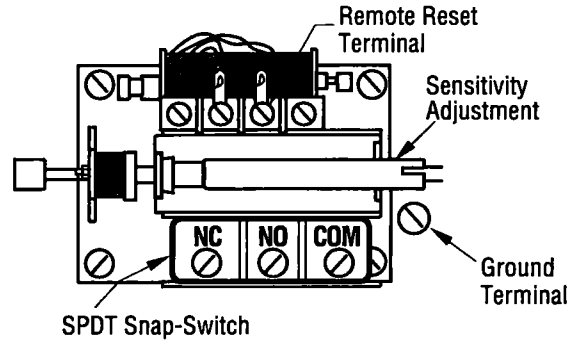


INTERNAL SWITCHES

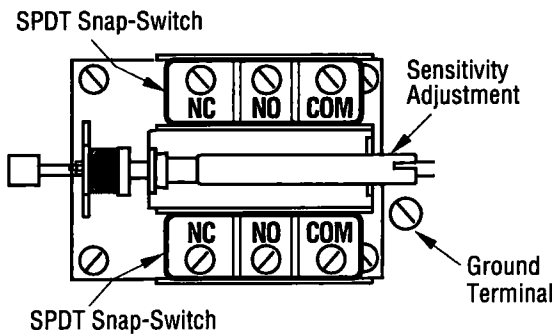
VS2 and VS2C



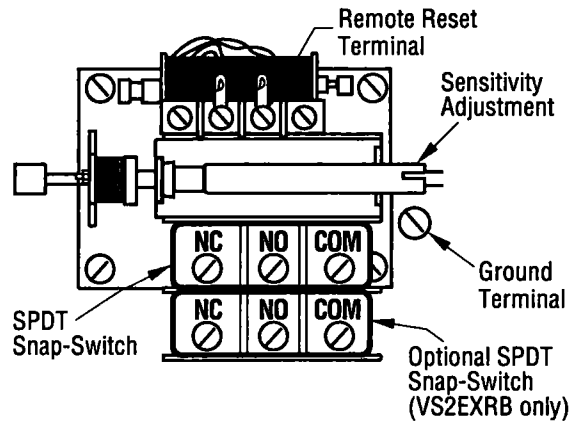
VS2EXR



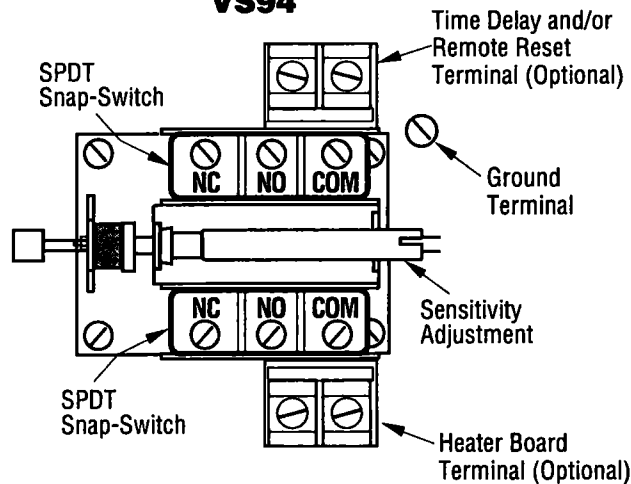
VS2EX



VS2EXB and VS2EXRB



VS94

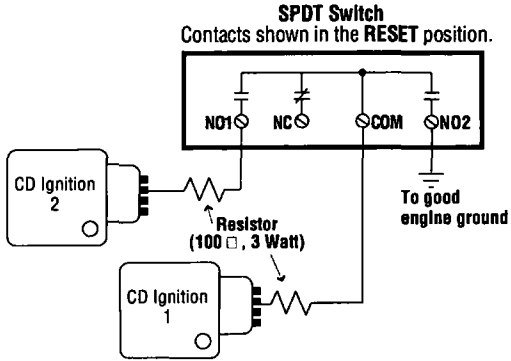


ELECTRICAL

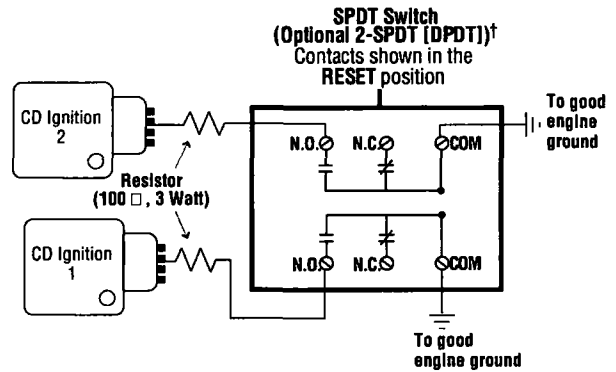


WARNING: REMOVE POWER BEFORE OPENING THE UNIT (ACCESS DOOR). STOP THE MACHINE AND DISCONNECT ALL ELECTRICAL POWER BEFORE BEGINNING THE WIRING OPERATION. IT IS YOUR RESPONSIBILITY TO HAVE A QUALIFIED PERSON INSTALL AND WIRE THE UNIT, AND MAKE SURE IT CONFORMS WITH NEC AND APPLICABLE CODES.

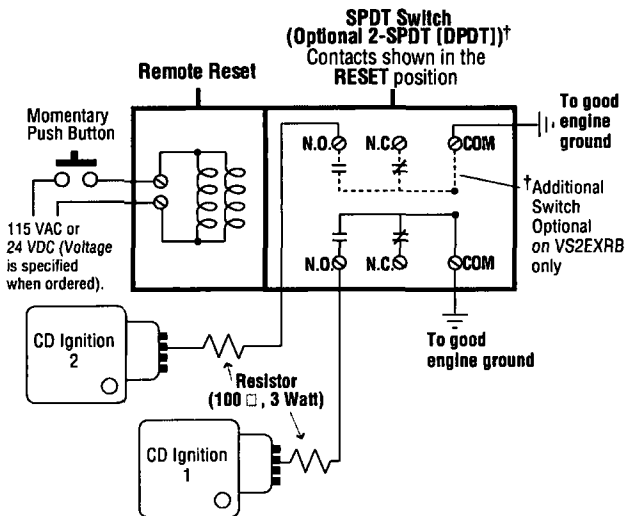
VS2 and VS2C
Typical Wiring Diagram for Single or Dual CD Ignition



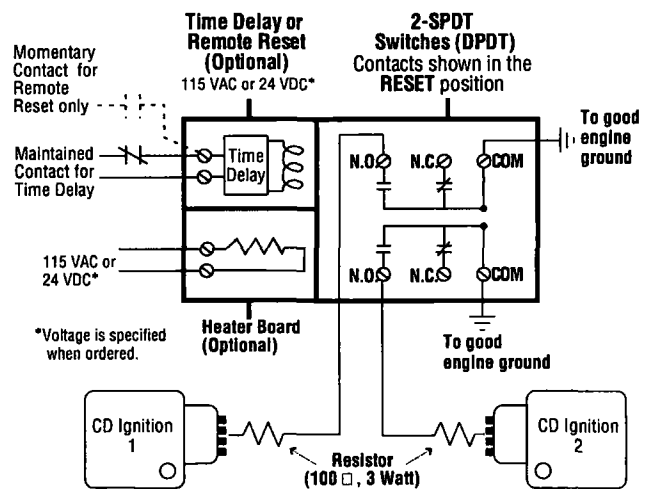
VS2EX
Typical Wiring Diagram for Single or Dual CD Ignitions



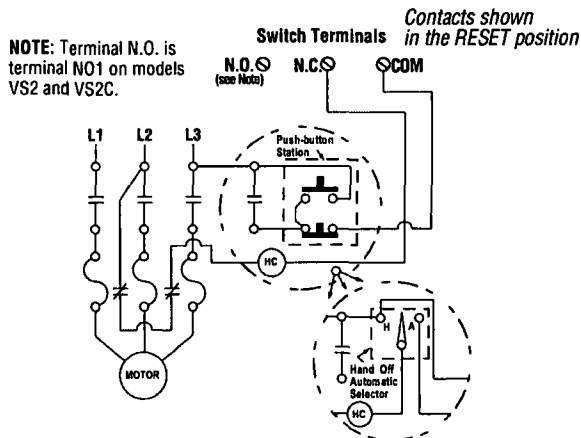
VS2EXR and VS2EXRB
Typical Wiring Diagram for Single or Dual CD Ignitions



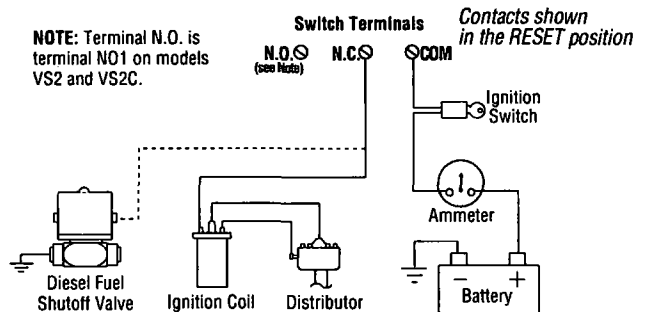
VS94
Typical Wiring Diagram for Single or Dual CD Ignitions



VS2, VS2C, VS2EX, VS2EXR, VS2EXRB and VS94
Typical Wiring Diagram for Electric Motors



VS2, VS2C, VS2EX, VS2EXR, VS2EXRB and VS94
Typical Wiring Diagram for Distributor Ignition or Diesel



SERVICE PARTS

PART NO. DESCRIPTION

VS2

20000030 Movement assembly
 20000031 Glass and gasket assembly
 20000032 Reset push button assembly

VS2C

20000030 Movement assembly
 20000031 Glass and gasket assembly
 20000032 Reset push button assembly
 20050021 Mounting clamp
 20000185 VS2C 5-clamp hardware package assembly.
 20050465 2-Conductor electrical cable, 45 feet (13.7 meters)

VS2EX

20010091 Movement assembly
 20050087 Cover
 00000309 Cover gasket
 20010090 Snap-switch and insulator kit (1 switch per kit) prior to September 1, 1995.*
 20000288 Snap-switch and insulator kit (1 switch per kit) for models manufactured on September 1, 1995 or later.*
 20000289 C-clamp conversion mounting kit

VS2EXR

20000262 Movement assembly
 20050087 Cover
 00000309 Cover gasket
 20010090 Snap-switch and insulator kit (1 switch per kit) prior to September 1, 1995.*
 20000288 Snap-switch and insulator kit (1 switch per kit) for models manufactured on September 1, 1995 or later.*
 20000049 Reset solenoid assembly (115 VAC)
 20000234 Reset solenoid assembly (24 VDC)
 20000289 C-clamp conversion mounting kit

PART NO. DESCRIPTION

VS2EXRB

20010090 Snap-switch and insulator kit (1 switch per kit) prior to September 1, 1995.*
 20000288 Snap-switch and insulator kit (1 switch per kit) for models manufactured on September 1, 1995 or later.*
 20000057 Inside snap-switch and insulator kit (1 switch per kit) for model VS2EXRB-D prior to September 1, 1995.*
 20000058 Outside snap-switch and insulator kit (1 switch per kit) for model VS2EXRB-D prior to September 1, 1995.*
 20000287 Inside snap-switch and insulator kit (1 switch per kit) for model VS2EXRB-D manufactured on September 1, 1995 or later.*
 20000290 Outside snap-switch and insulator kit (1 switch per kit) for model VS2EXRB-D manufactured on September 1, 1995 or later.*
 20050077 Adjustment shaft
 20000262 Movement assembly
 20000049 Reset solenoid assembly (115 VAC)
 20000234 Reset solenoid assembly (24 VDC)

VS94 Series

25050506 Dust boot
 00000232 Conduit fitting
 20010090 Snap-switch and insulator kit (1 switch per assembly) prior to September 1, 1995.**
 20000288 Snap-switch and insulator kit (1 switch per assembly) for models manufactured on September 1, 1995 or later.***

* If no date code is found, refer to the old switch. Models with date 0895 and before use old switch. Dated 0995 after, use straight snap-switch arm, no rollers.

** Models dated Q1 thru Q8 (formed snap-switch arm and rollers).

***Models date coded Q9 thru Q12 and R1 thru R12 (straight snap-switch arm, no rollers).



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078792

Installation Instructions for Level Maintainers

Model Series LM300



Read the following instructions before installing. A visual inspection of this product for damage during shipping is recommended before mounting. These installation instructions are intended for all LM300 series models.

GENERAL INFORMATION

WARNING

BEFORE BEGINNING INSTALLATION OF THIS MURPHY PRODUCT

- ✓ Disconnect all electrical power to the machine.
- ✓ Make sure the machine cannot operate during installation.
- ✓ Follow all safety warnings of the machine manufacturer.
- ✓ Read and follow all installation instructions.

LM300: Level Maintainer only (noswitches).

LM301: Low switch contacts for low level shutdown or alarm. Four wires, SPDT.

LM302: Two switches for low and high level shutdown or alarm. Four wires, DPST, wired N.O. in normal operating ranges.

LM303: Two switches for low and high level shutdown or alarm. Four wires, DPST, wired N.C. in normal operating ranges.

LM304: Two switches. Alarm before shutdown on low level and shutdown on low-low level. Four wires, DPST, wired N.O. in normal operating ranges.

LM305: Two switches. Alarm before shutdown on low level and shutdown on low-low level. Four wires, DPST, wired N.C. in normal operating ranges.

Specifications

Case/Cover: Die cast aluminum.

Switch Housing: Aluminum.

Approval Rating: LM301 thru LM305 : CSA certified^{††} for non hazardous locations. Enclosure Type 4 certified.

LM301-EX thru LM305-EX: CSA certified^{††} for Class I, Groups C and D; Class II, Groups F and G hazardous locations. Enclosure Type 4 certified.

Float: Rigid polyurethane foam. Polyurethane coated.

Maximum Ambient Temperature: 250°F (121°C)

Oil Inlet Connection: Top entry 1/2-14 NPT with built-in filter screen (removable for cleaning).

Inlet Orifices: 1/4 in. (6 mm) standard. 1/8 in. (3 mm) available.

Wire (switch models): 18 AWG x 13 in. (1.0 mm² x 330 mm).

Maximum Inlet Pressure (MIP):

Max. Differential: 2 in. (51 mm) between running and stationary oil level. 30 psi (207 kPa) [2.07 bar].

with 1/8 in. (3 mm) orifice.

15 ft. oil (4.6 m oil)

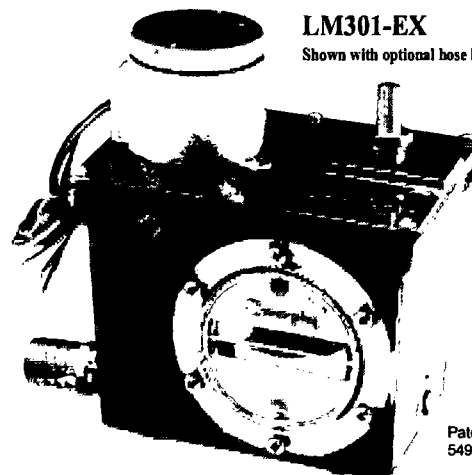
with 1/4 in. (6 mm) orifice.

Maximum Case Pressure (MCP): 15 psi (103 kPa) [1.03 bar].

Orifice Seal[†]: Buna-N Thumb-Valve™

Switch Contact: Silver, SPDT snap acting, 10A @ 125, 250VAC; 10A @ 30VDC.

(1 only for low level; 2 only for high & low; or 2 only for low with alarm before shutdown)



LM301-EX

Shown with optional hose kit fittings



Patent
5493086

Outlet Connection: 3/4-14 NPT left side, right side, and bottom.

Crankcase Balance Vent Fitting: 1/2-14 NPT.

Mounting: Accepts Murphy pipe mounting or universal mounting brackets.

Lens: Clear "Frog Eye" non-staining, high impact, high temperature nylon; UV and heat stabilized.

Dial: High visibility white background with green and white "index" lines for normal level indication.

Test Knob: Rotate to test switch operation. Turn clockwise for low level test and turn counterclockwise for high level test.

Flow Rate Test: Using SAE 30 @ 32°F (0°C).

Orifice Diameter	Pressure	Flow Rates
1/4 in.* (6 mm)	4 ft. oil - 15 ft. oil (1.2 m oil - 4.6 m oil)	4.7 GPH - 31.0 GPH (17.8 LPH - 117.3 LPH)
1/8 in. (3 mm)	10 psig - 30 psig (68.9 kPa - 207 kPa) [.69 - 2.07 bar]	16.9 GPH - 32.1 GPH (63.7 LPH - 121.5 LPH)

*Standard

NOTE: Friction losses due to piping NOT considered.

Optional Hose Kit: 15000355

Quantity Description

1	1/2 in. (13 mm) I.D. x 3 ft. (914 mm) long hose
1	1 in. (25 mm) I.D. x 3 ft. (914 mm) long hose
2	1/2 in. (13 mm) worm gear clamp
2	1 in. (25 mm) worm gear clamp
2	1/2 NPT x 1/2 in. (13 mm) barbed fitting
2	3/4 NPT x 1 in. (25 mm) barbed fitting

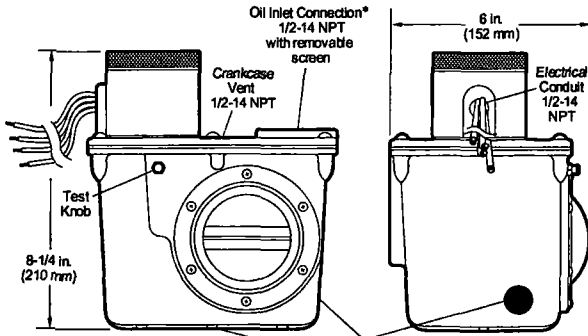
††CSA certified with switch contacts rated at 10 A @ 250 VAC (standard).

** Products covered by this bulletin comply with EMC Council directive 89/336/EEC regarding electromagnetic compatibility except as noted.

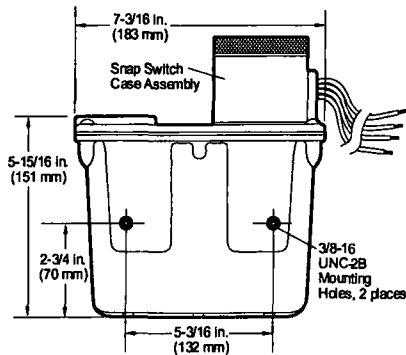
DIMENSIONS

LM300 Series Enclosures

The dimensions below are for the optional -EX model enclosure. The standard model enclosure dimensions are the same except the height and width which are: 7 in. (178 mm) H, 7-7/8 in. (200 mm) W.



*Applies to level maintaining models only.

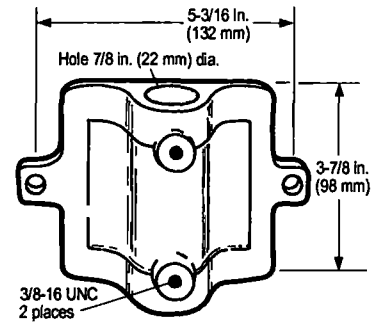


Mounting Brackets with Hardware

15000371 pipe bracket

Additional Hardware Supplied

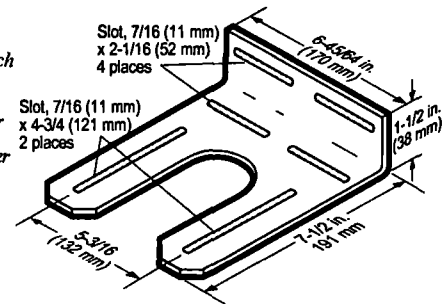
- (4) 3/8-16 UNC x 1 inch (25 mm) screws
- (4) 3/8-16 nut
- (4) 3/8 I.D. lock washer
- (2) 3/8 I.D. flat washer



15000370 universal bracket

Additional Hardware Supplied

- (2) 3/8-16 UNC x 1 inch (25 mm) screws
- (4) 3/8 I.D. flat washer
- (2) 3/8 I.D. lock washer
- (2) 3/8-16 nut



TYPICAL INSTALLATION

Mounting (all LM300 Series models)

NOTE: Mount the LM300 series level maintainers as close as possible to the crankcase. Also, excessive vibration can cause overflow. Be sure mounting brackets are supported.

The following instructions are based on the usage of the pipe and universal mounting brackets shown above.

Pipe Bracket Mounting

1. Mount a nominal 1/2 inch (21 mm) diameter pipe to the deck of the engine.
2. Install the pipe bracket to the LM300 using two 3/8-16 UNC x 1 inch bolts supplied. See Figure 1A.
3. Slip the LM300 onto the pipe and install the two adjustment bolts. Each adjustment bolt consists of a 3/8-16 UNC x 1 inch bolt and two nuts. See Figure 1B. **DO NOT** tighten the adjustment screws too tightly because you will have to adjust the LM300 later in the installation process.

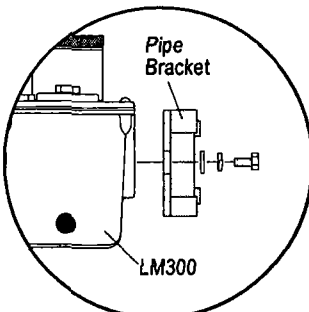


Figure 1A

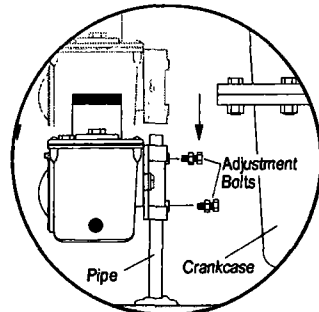


Figure 1B

Mounting with Universal Bracket

The universal bracket has two mounting methods: deck mounting and pan mounting.

Deck Mounting

1. Install the universal bracket to the deck as shown in Figure 2A with two flat washers and two 3/8 inch (10 mm) diameter bolts (not supplied).

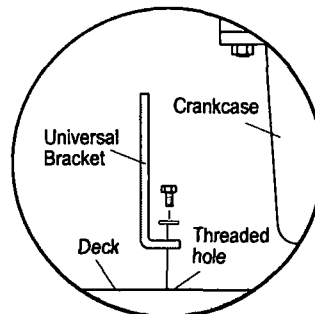


Figure 2A

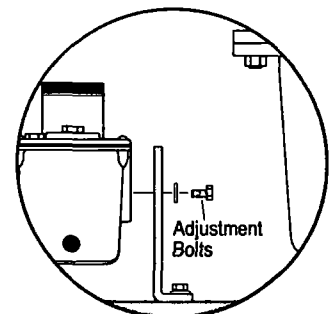


Figure 2B

2. Mount the LM300 to the universal bracket using two 3/8-16 UNC x 1 inch (25 mm) bolts supplied (Figure 2B). **DO NOT** tighten the adjustment screws too tightly. You will have to adjust the LM300 later in the installation process.

Crankcase (Oil Pan) Mounting

1. Install the universal bracket to the crankcase using the existing crankcase bolts (Figure 3A). Crankcase bolt diameter must be no larger than 7/16 inch (11 mm).

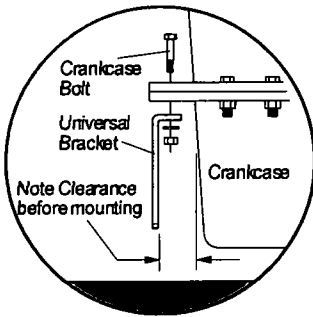


Figure 3A

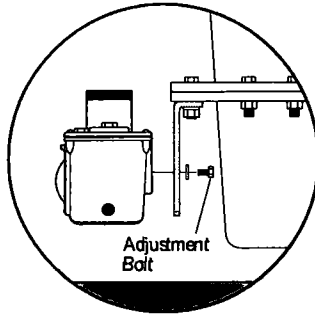


Figure 3B

NOTE: Check clearance between crankcase and mounting bracket before installing the mounting bracket. If space between the crankcase and mounting bracket does not allow installation and access to the adjustment bolts advance to Step 3.

2. Mount the LM300 to the universal bracket using two 3/8-16 UNC x 1 inch bolts supplied. **DO NOT** tighten the adjustment bolts too tight. You will have to adjust the LM300 later in the installation process.
3. If space between the crankcase and mounting bracket is narrow, install the universal mounting bracket to the LM300 before installing to the crankcase oil pan.

Connecting Fittings and Hoses

The following instructions are for all LM300 series level maintainers. All steps that reference oil inlet or oil supply tank **DO NOT** apply to non-level-maintaining models. Also, these instructions are based on the Murphy optional hose kit described on page 1. If you did not order the optional hose kit, gather the hoses, clamps and fittings as specified in the optional hose kit.

1. Install the LM300 fittings in their proper locations. **NOTE:** Apply a sealant such as teflon, to all threaded connections.
2. Attach the 1 inch (25 mm) diameter, flexible monitoring hose to the crankcase and the monitoring port on the LM300. See Figure 4. **CAUTION:** The hose must slope slightly downward from the LM300 and **MUST NOT** have any droop or low spots.

NOTE: If the drain plug on the crankcase is used for the connection, we recommend installation of a tee to allow draining of the crankcase for service.

3. Install the 1/2 inch (13 mm) I.D. x 3 ft. (914 mm) hose to the vent connection on the LM300 to the vent connection on the crankcase. See Figure 4. **The vent connection on the crankcase must be well above the regulated oil level.** All hoses must be clear of obstructions.

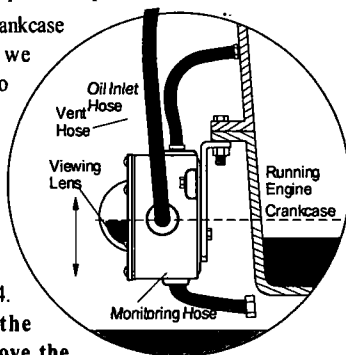


Figure 4

BEFORE CONTINUING, VERIFY THAT ALL HOSE CLAMPS ARE TIGHT.

4. Fill the crankcase to the proper oil levels. With the engine running and warm, loosen the mounting bracket adjustment bolts and adjust the LM300 so that the oil level in the sight gauge is aligned with the white "index line" on the dial (Figure 4). Tighten the adjustment bolts securely.

Connecting the LM300 to an Oil Supply Tank (level maintaining models only)

1. Remove the caplug from the oil inlet connection. Be sure the filter, inside the connection, is clear of debris. Install the oil inlet connection.

2. Connect a 1/2 inch I.D. (13 mm) or larger hose to oil inlet fitting on the LM300 and to the shutoff valve on the oil supply tank. See Figure 5. The hose must maintain a downward slope and not have low spots or droops. Maximum head pressure rating using standard 1/4 in. (6 mm) orifice is 15 ft. (4.6 meters). See Flow Rate test on page 1 for additional orifice pressure ratings.

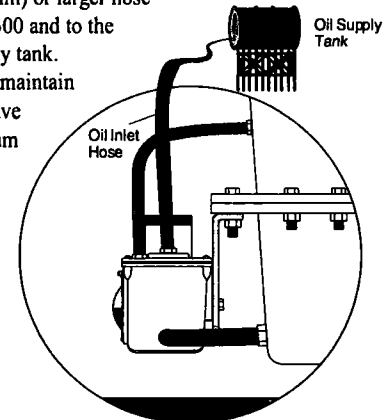


Figure 5

3. Before filling the supply tank with oil, be sure the tank is clean and dry and the shutoff valve is closed. Also, be sure all hoses and clamps are tight. Fill the tank with **CLEAN** oil.

WARNING: Overfill condition can be caused by excessive inlet pressure, (maximum inlet pressure depends on orifice), and/or improper "vent to crankcase" installation. See Flow Rate Test on page 1 for maximum pressure.

4. After oil supply tank is full, open the shutoff valve.

Next, make the proper electrical connections for the application. See contact ratings on page 1 and schematics on page 4.

Switch Test (switch models only)

To test the shutdown and/or alarm functions perform the following:

1. Unscrew protective boot from test knob. **IMPORTANT:** Always replace boot after testing.
2. Turn the test knob 1/4 turn to the right (clockwise), for low test indication (Figure 6).
3. Turn the knob 1/4 turn to the left (counterclockwise), for high test indication. **DO NOT FORCE THE TEST KNOB TO TURN.**

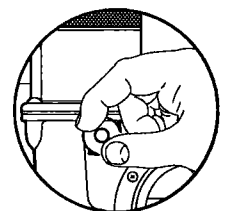


Figure 6

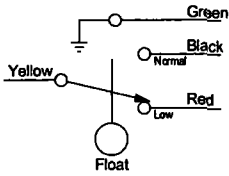
NOTE: After the engine shuts down, you will notice that the oil in the sight gauge glass will rise above normal running level, possibly showing an overfill condition. This is a result of "drain-back" to the engine crankcase and it is normal. Therefore, on models LM302 and LM303 it may be necessary to wire the high level shutdowns into a class "B" or "C" (bypass until first time safe) lockout, so as to allow a permissive start. After the engine is re-started the level will pull down to the normal running level and the shutdown features will be active. A modulating valve (Thumb-Valve™) in the level maintaining models will allow oil usage to be made-up continuously during operation.

SWITCH WIRING DIAGRAMS

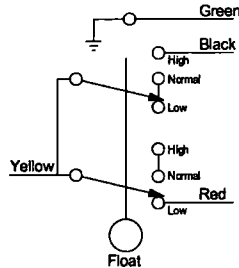


WARNING: DISCONNECT ALL ELECTRICAL POWER BEFORE CONNECTING ANY WIRES.

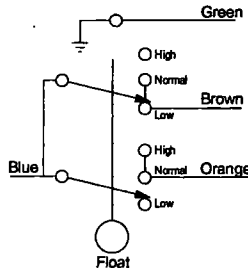
LM301
SPDT



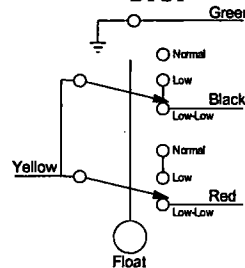
LM302
High/Low N.O.
DPST



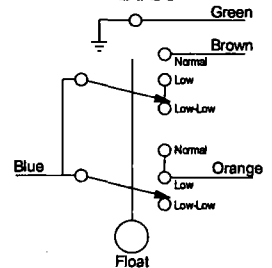
LM303
High/Low N.C.
DPST



LM304
Alarm before
shutdown N.O.
DPST



LM305
Alarm before
shutdown N.C.
DPST



OPERATING RANGES OF SWITCHES

This section applies only to models that have built-in switches. The illustrations below and to the right show the dials and their operating ranges of the switches. If levels are within the designated zones the switch(es) will activate. Notice that a switch is capable of activating approximately 3/8 in. (10 mm) from the top of the high zone and 3/8 in. (10 mm) from the bottom of the low zone. The dial in Figure 9 shows that if level continues to drop into the low-low zone, a shutdown will occur.

NOTE: Color zones on dial face show approximate normal operating zones. Actual conditions may vary depending upon operating characteristics of the engine. Placement of the LM300 according to the above instructions will compensate for these conditions.

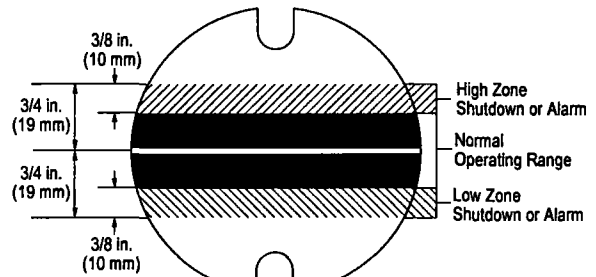


Figure 8: LM302/LM303

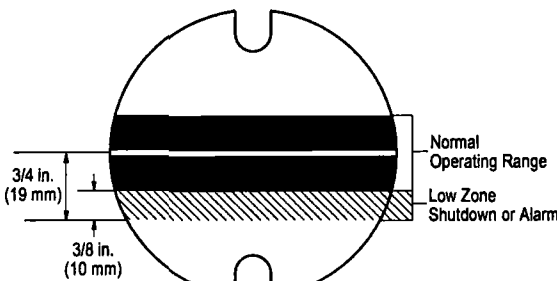


Figure 7: LM301

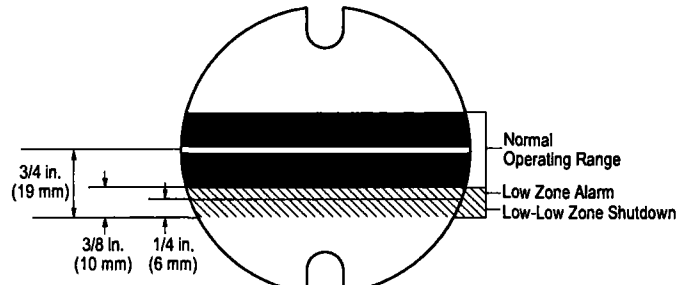


Figure 9: LM304/LM305

Warranty

A two-year limited warranty on materials and workmanship is given with this Murphy product. Details are available on request and are packed with each unit.



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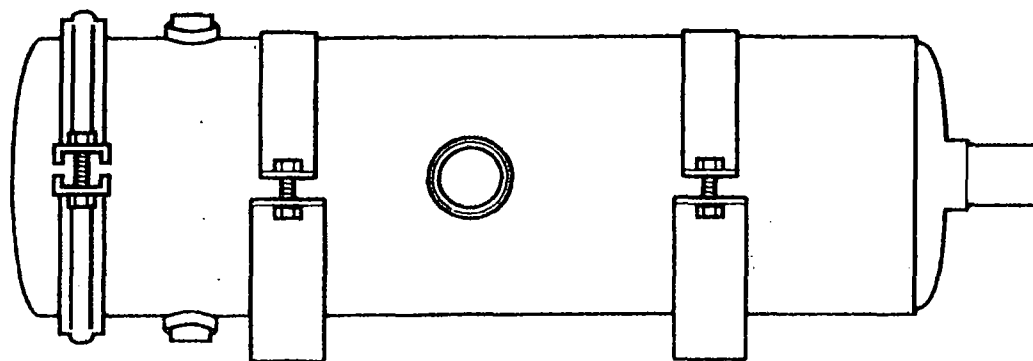
EcoVent™

Recirculator

Installation

Manual

SM-337



About This Product

Nelson's EcoVent Recirculator removes 99.9% of oil mist and airborne particles coming from the engine crankcase breather vent. Because the separation of crankcase fumes and oil is accomplished by means of a static absorbent filter, there are no moving parts. There is also no need for periodic cleaning—you only have to change the filter element!

The EcoVent Recirculator makes it possible to duct clean blowby fumes into the air cleaner, for a completely closed system, thereby removing 100% of the blowby mists and gases from the atmosphere without danger to the engine. This provides for a cleaner, healthier and safer environment while reducing engine room maintenance costs.

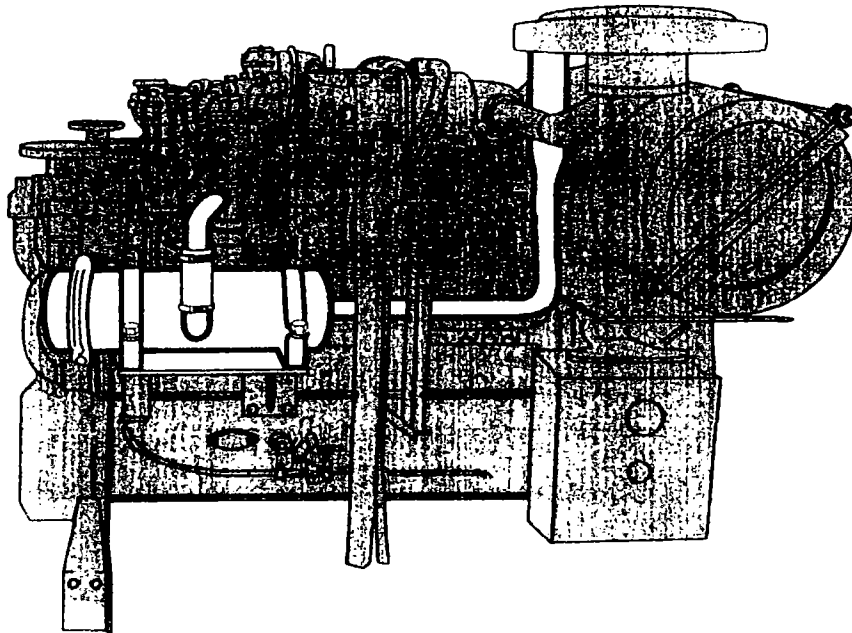


Figure 1 • The EcoVent Recirculator attached to an engine.



WARNING

Read the entire Service Manual before attempting the installation!



Installation

You can install the EcoVent Recirculator in one of two ways: with the outlet connected to the engine's air inlet flow before the air filter (Option 1) or directly to the engine's air intake ducting (Option 2). Please follow the instructions for your specific situation.

Option 1: Connecting the Outlet to the Air Inlet Flow

See Figures 2 or 3 for an illustration of a correctly installed EcoVent Recirculator.

NOTE

In all cases, you can substitute a rigid pipe where the instructions call for a heat-resistant hose.

1. Use the two mounting brackets we have provided to mount the EcoVent on or adjacent to the engine. You must mount the EcoVent horizontally and above the engine crankcase oil level.
2. Follow the manufacturer's instructions to attach the U-tube manometer gauge (which we have supplied) to the manometer gauge connection on the EcoVent.
3. Attach the proper size of heat-resistant hose to the EcoVent's inlet connection and secure with a hose clamp.
4. Attach the end of the hose used in Step 3 to the engine's crankcase breather vent tube and secure with a hose clamp.
5. Attach another length of heat-resistant hose to the EcoVent's outlet connection and secure with a hose clamp.
6. Attach the end of the hose used in Step 5 to the engine's air intake filter near the air inlet flow and secure with a hose clamp.

CAUTION

If you connect the EcoVent's outlet hose to the air inlet flow **before** the air intake filter, position the end of the hose so that the vacuum created by the air flow produces a 0" to 0.3" H₂O positive pressure reading on the U-tube manometer. See figure 7. At normal engine operating speed a new EcoVent unit must not have more than 0.3" H₂O positive pressure!

If You Are Returning the Oil to the Engine

If the engine does not use natural gas or fuels that contain sulfur or halogen chemicals, you can return the oil collected directly to the engine oil sump.



CAUTION

If the engine uses natural gas or fuels that contain sulfur or halogen chemicals, **do not** return the collected oil to the engine. If this applies to your installation, please turn to the next section for more information.

7. Connect a drain tube to the drain port on the underside of the EcoVent.
8. Place the other end of the drain tube into the engine oil sump, *below* the oil level line.

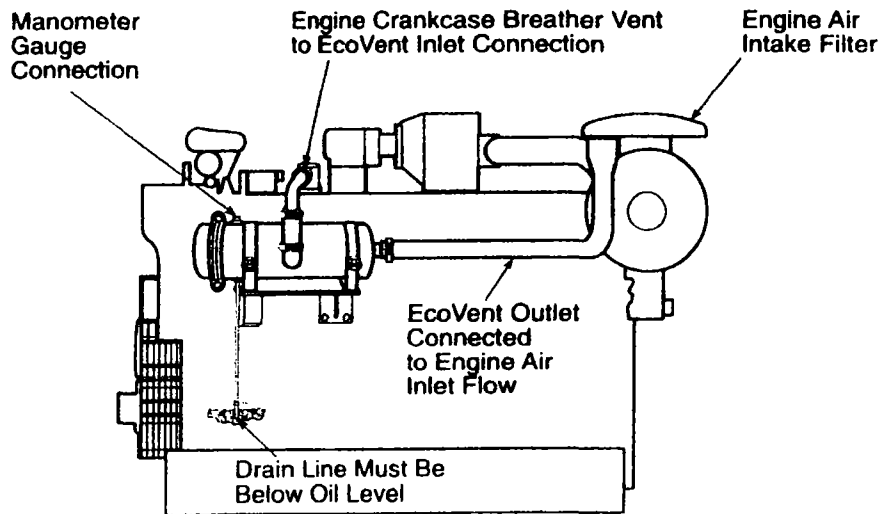


Figure 2 • Completed installation, showing the oil being returned to the engine.

9. Check the adjustment of the EcoVent by starting the engine and running it at normal operating speed. The U-tube manometer gauge should have a 0" to 0.3" H₂O positive pressure reading. See figure 7. If not, adjust the air flow until it does. See the Section entitled Adjusting the Air Flow for more information.

If the Engine Uses Natural Gas or Fuels Containing Sulfur or Halogen Chemicals

7. Connect a drain tube to the drain port on the underside of the EcoVent.

8. Connect a drain tube to the drain port on the underside of the EcoVent.

Nelson EcoVent Recirculator

- Place an oil reservoir at the end of the drain tube. How often you drain the EcoVent depends upon the amount of oil in the engine crankcase fumes and the condition of the engine.

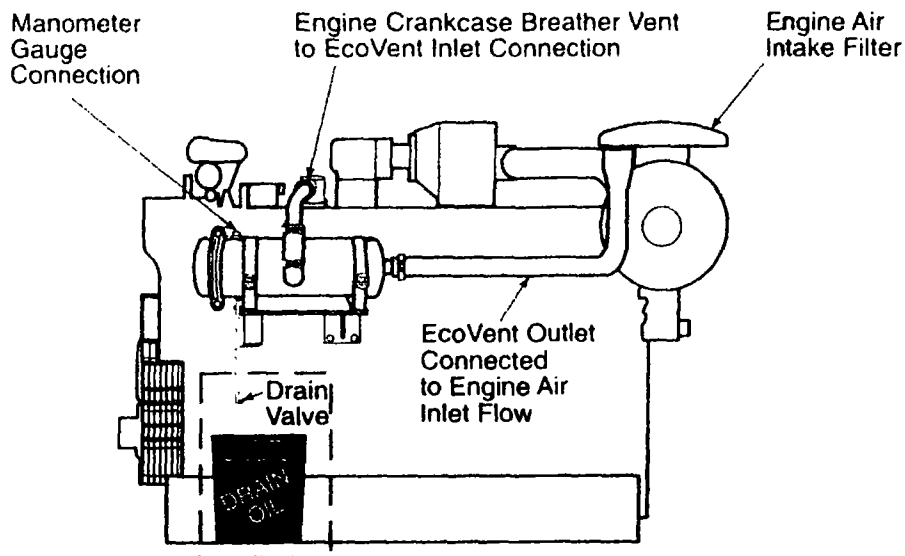


Figure 3 • Completed installation, showing oil being drained to an oil reservoir.

- Check the adjustment of the EcoVent by starting the engine and running it at normal operating speed. The U-tube manometer gauge should have a 0" to 0.3" H₂O positive pressure reading. If not, adjust the air flow until it does. See the Section entitled Adjusting the Air Flow for more information.

Option 2: Connecting the Outlet Directly to the Air Intake Ducting

See Figures 4 or 5 for an illustration of a correctly installed EcoVent Recirculator.

NOTE

In all cases, you can substitute a rigid pipe where the instructions call for a heat-resistant hose.

- Use the two mounting brackets we have provided to mount the EcoVent on or adjacent to the engine. You must mount the EcoVent horizontally and above the engine crankcase oil level.
- Follow the manufacturer's instructions to attach the U-tube manometer gauge (which we have supplied) to the manometer gauge connection on the EcoVent.

3. Attach the proper size of heat-resistant hose to the EcoVent's inlet connection and secure with a hose clamp.
4. Attach the end of the hose used in Step 3 to the engine's crankcase breather vent tube and secure with a hose clamp.
5. Attach another length of heat-resistant hose to the EcoVent's outlet connection and secure with a hose clamp.
6. Install a control valve on the hose used in Step 5, then attach the end of the hose directly to the engine's air intake ducting and secure with a hose clamp. You can attach the hose either before or after the engine's air filter. The control valve is used to regulate the maximum 0" to 0.3" H₂O positive pressure reading for the new EcoVent element. See figure 7. Do not adjust this valve after you have properly set it to achieve the 0" to 0.3" H₂O positive pressure reading.

**CAUTION**

With the EcoVent's outlet hose connected, along with the control valve, directly to the engine air intake ducting, simply adjust the control valve so that the vacuum created by the air flow is 0" to 0.3" H₂O positive pressure reading on the U-tube manometer gauge. See figure 7. At normal operating speed a new EcoVent unit must not have more than 0.3" H₂O positive pressure!

If You Are Returning the Oil to the Engine

If the engine does not use natural gas or fuels that contain sulfur or halogen chemicals, you can return the oil collected directly to the engine oil sump.

**CAUTION**

If the engine uses natural gas or fuels that contain sulfur or halogen chemicals, **do not** return the collected oil to the engine. Please turn to the next section for information on completing the installation if this applies to your installation.

7. Connect a drain tube to the drain port on the underside of the EcoVent.
8. Locate the other end of the drain tube into the engine oil sump, *below* the oil level line.
9. Check the adjustment of the EcoVent by starting the engine and running it at normal operating speed. The U-tube manometer gauge should have a 0" to 0.3" H₂O positive pressure reading. If not, adjust the air flow until it does. See the Section entitled Adjusting the Air Flow for more information.

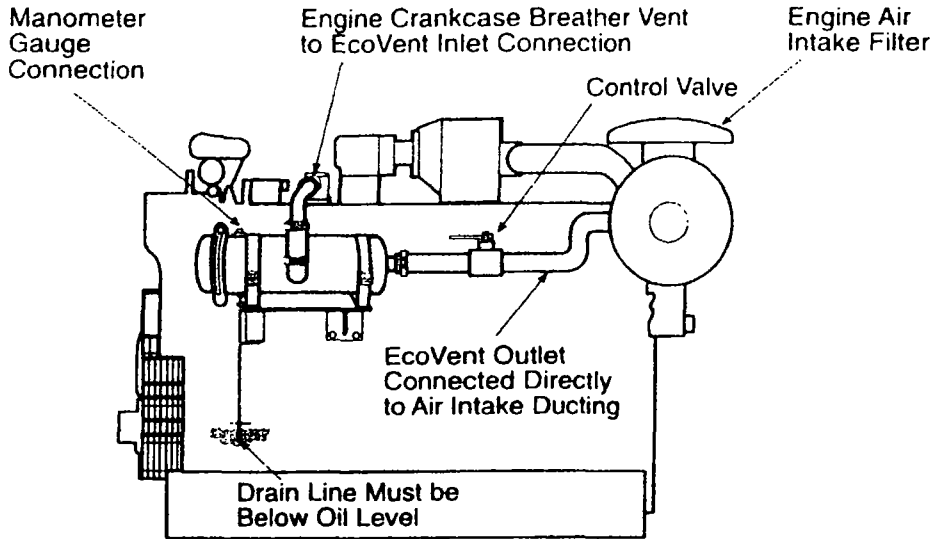


Figure 4 • Completed installation, showing the oil being returned to the engine.

If the Engine Uses Natural Gas or Fuels Containing Sulfur or Halogen Chemicals

7. Connect a drain tube to the drain port on the underside of the EcoVent.
8. Connect a drain valve to the drain tube.
9. Place an oil reservoir at the end of the drain tube. How often you drain the EcoVent depends upon the amount of oil in the engine crankcase fumes and the condition of the engine.
10. Check the adjustment of the EcoVent by starting the engine and running it at normal operating speed. The U-tube manometer gauge should have a 0" to 0.3" H₂O positive pressure reading. If not, adjust the air flow until it does. See the Section entitled Adjusting the Air Flow for more information.

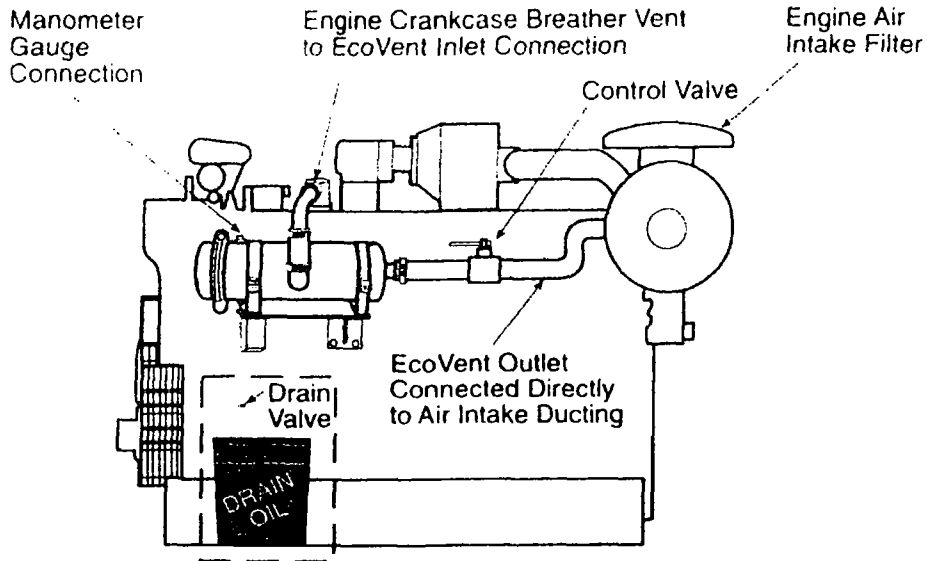


Figure 5 • Completed installation, showing oil being drained.

Adjusting the Air Flow

If, at normal engine operating speed the U-tube manometer gauge does not show a 0" to 0.3" H₂O positive pressure reading, perform the proper adjustment to correct it.

1. If the EcoVent's outlet hose is connected near the air inlet flow, move the open end of the hose into or out of the flow until the manometer shows the proper reading, then secure it with a hose clamp.

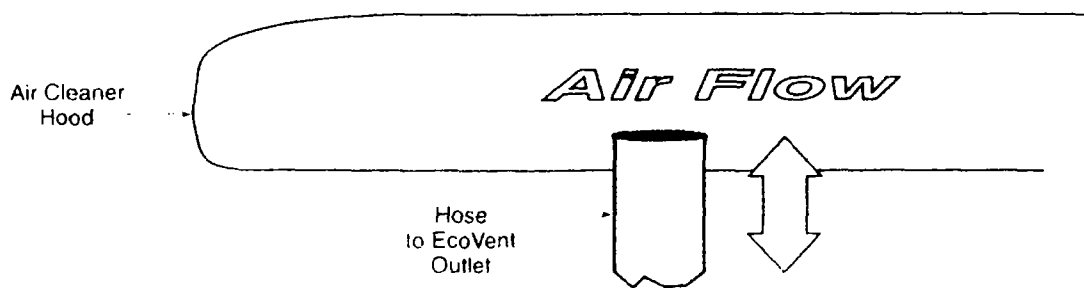


Figure 6 • Move the outlet hose into or out of the air flow to adjust the pressure.

2. If the EcoVent's outlet hose is connected directly to the air intake ducting, adjust the control valve on the outlet hose until the manometer shows the proper reading.

Once the initial proper gauge reading has been established, do not adjust the location of the hose or the control valve during the life of the EcoVent element.

Nelson EcoVent Recirculator

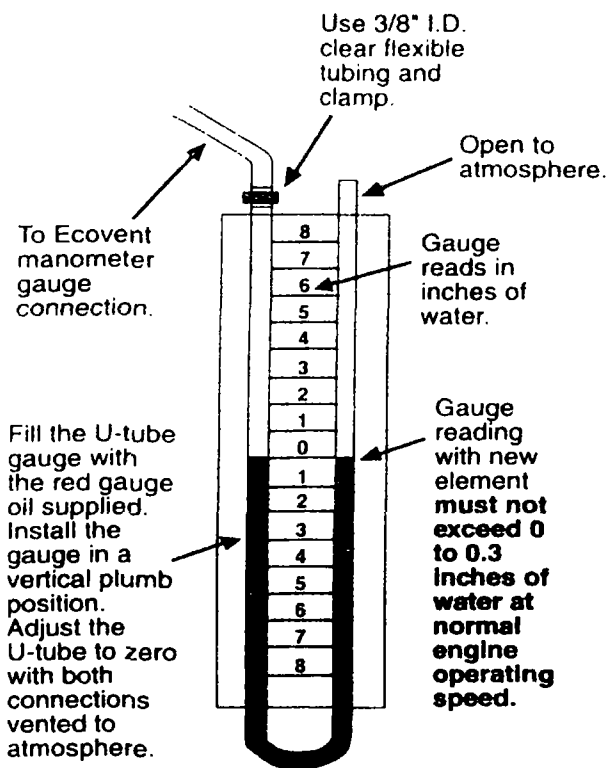


Figure 7 • U-tube Manometer Gauge Reading With New Filter Element

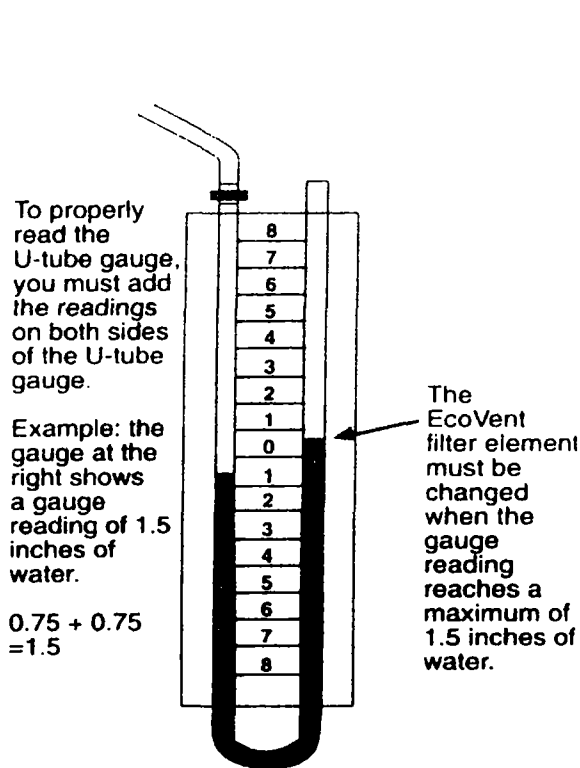


Figure 8 • U-tube Manometer Gauge Reading At Filter Element Changeout

Operating Instructions

Once you have installed and adjusted the EcoVent, operating instructions are very simple:

- Monitor the reading on the manometer. When it reaches a reading of 1.5" H₂O positive pressure (see figure 8) replace the EcoVent element, as shown in the Maintenance Section.
- If you are not returning the oil to the engine, drain the oil from the EcoVent as needed.

Maintenance Instructions

Whenever the manometer shows a reading of 1.5" H₂O positive pressure, you must replace the EcoVent filter element.

1. With the engine shut off and cooled, remove the EcoVent's cover clamp, cover and cover gasket.
2. Remove the hex nut, element seal plate and element.
3. Replace the element with the proper new element. Inspect the cover gasket and grommet on the element seal plate and replace if cut, damaged or swollen.
4. Replace the parts in the same order in which you removed them.
5. Start the engine and check the manometer. If it is not showing a 0" to 0.3" H₂O positive pressure reading, follow the adjustment instructions on pages 9 and 10 to adjust the air flow.

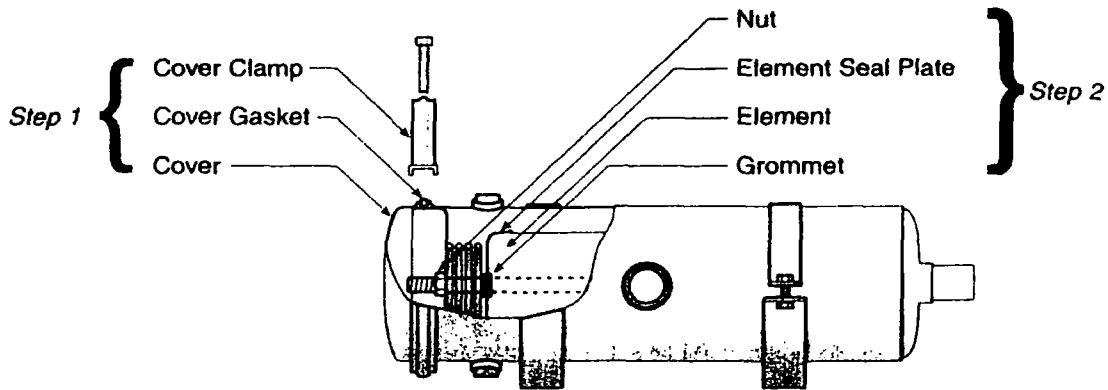


Figure 9 • Parts to be removed during maintenance.

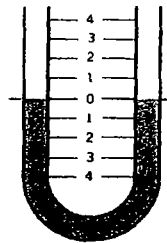
Parts List

Description	Part Number			
EcoVent	93196A	93195A	93194A	93192A
Filter Element	88468A	88467A	88365A	88465A
Cover Gasket	Q58510	Q58510	Q58403	Q58403
Grommet	Q58521	Q58521	Q58521	Q58521
Nut	Q53714	Q53714	Q01428	Q01428



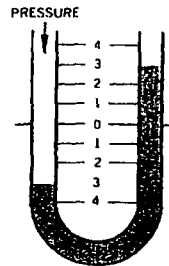
Flex-Tube® Manometer Operating Instructions

1220/1230 Series U-Tube and Well-Type Manometers



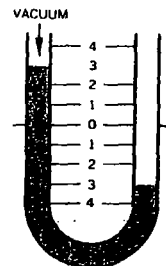
With both ends of the tube open, the liquid is at the same height in each leg.

Fig. 1



The difference in height, "h", which is the sum of the readings above and below zero, indicates pressure.

Fig. 2



The difference in height, "h", which is the sum of the readings above and below zero, indicates the amount of vacuum.

Fig. 3

Measuring Pressure, Vacuum and Differential Pressure with Dwyer Manometers

Dwyer manometers are all available in two different styles. The W/M models use either water for readings in inches of water or mercury for readings in inches of mercury. The D models use Dwyer .826 specific gravity red gage oil for readings in inches of water. The scales on the two styles are different lengths, therefore it is important that you use the correct fluid.

Mounting Dwyer U-Tube Manometers

1221 – Mount to vertical surface through holes in scale.

1222 – Attach magnets to steel surface or remove magnets and mount through holes in scale.

1223 – Attach magnets to steel surface or through hole in safety trap housing.

1227 – Because of angled connections, 1227 must be filled with indicating tube at an angle. After filling, check zero in vertical position.

Note: Read vertical range on right leg with manometer vertical. Incline manometer to zero for low range reading.

Mounting Dwyer Well Manometers

1230 – Mount to vertical surface with flat-head screws through holes in panel.

1235 – Mount behind panel cut out to show only tube and scale. Attach by drilling holes through manometer back plate and panels. Make panel cut out for length and width of tube and scale.

LITHO IN U.S.A. 4/97

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e-mail: info@dwyer-inst.com

Filling U-Tube Manometers 1221 - 1222

Open both fittings to atmosphere. Slide scale to mid-point of travel. Add liquid to zero on scale.

Filling 1223 - 1230 and 1235 Manometers

Remove large fitting from well using 3/4" open end wrench. Also remove cork, disc, and O-ring. Be sure other side is vented to atmosphere. Adjust zero to middle of travel. Add fluid to well up to zero on scale. Replace cork, disc and O-ring before replacing fitting. To order red gage oil, order part #A-101 (3/4 oz.). To order fluorescein green color concentrate, order part #A-126 (3/4 oz.)

Operation of 1221, 1222 and 1223

Connect either side to pressure or vacuum, leaving other side open to atmosphere. Add together readings above and below zero. It is normal for the two sides to have different readings and has no effect on accuracy. For differential pressure, connect both high and low fittings. Add readings above and below zero on scale.

Operation of 1230 and 1235

Positive Pressure: Connect well reservoir fitting to pressure source, leaving other side open to atmosphere.

Negative Pressure: Connect top fitting to vacuum source, leaving well side open to atmosphere.

Differential Pressure: Connect higher pressure to well reservoir fitting and lower pressure to upper fitting.

Note: When finished, close fitting to prevent spilling or evaporation.

Maintenance

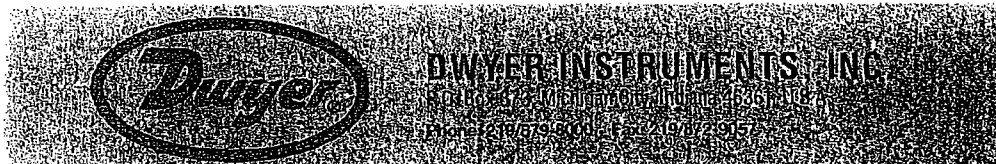
With proper care, Dwyer Flex-Tube® manometers will continue to give accurate readings. If cleaning is necessary, remove fittings, drain fluid and rinse with mild soap and water. A cleaning brush (part #A-366) may be used to remove oxidation.

Avoid harsh soap and solvents which may damage manometer and void warranty.

When replacing O-rings, apply a thin coat of petroleum jelly to assure a good seal. Do not coat O-ring used in the overpressure safety trap.

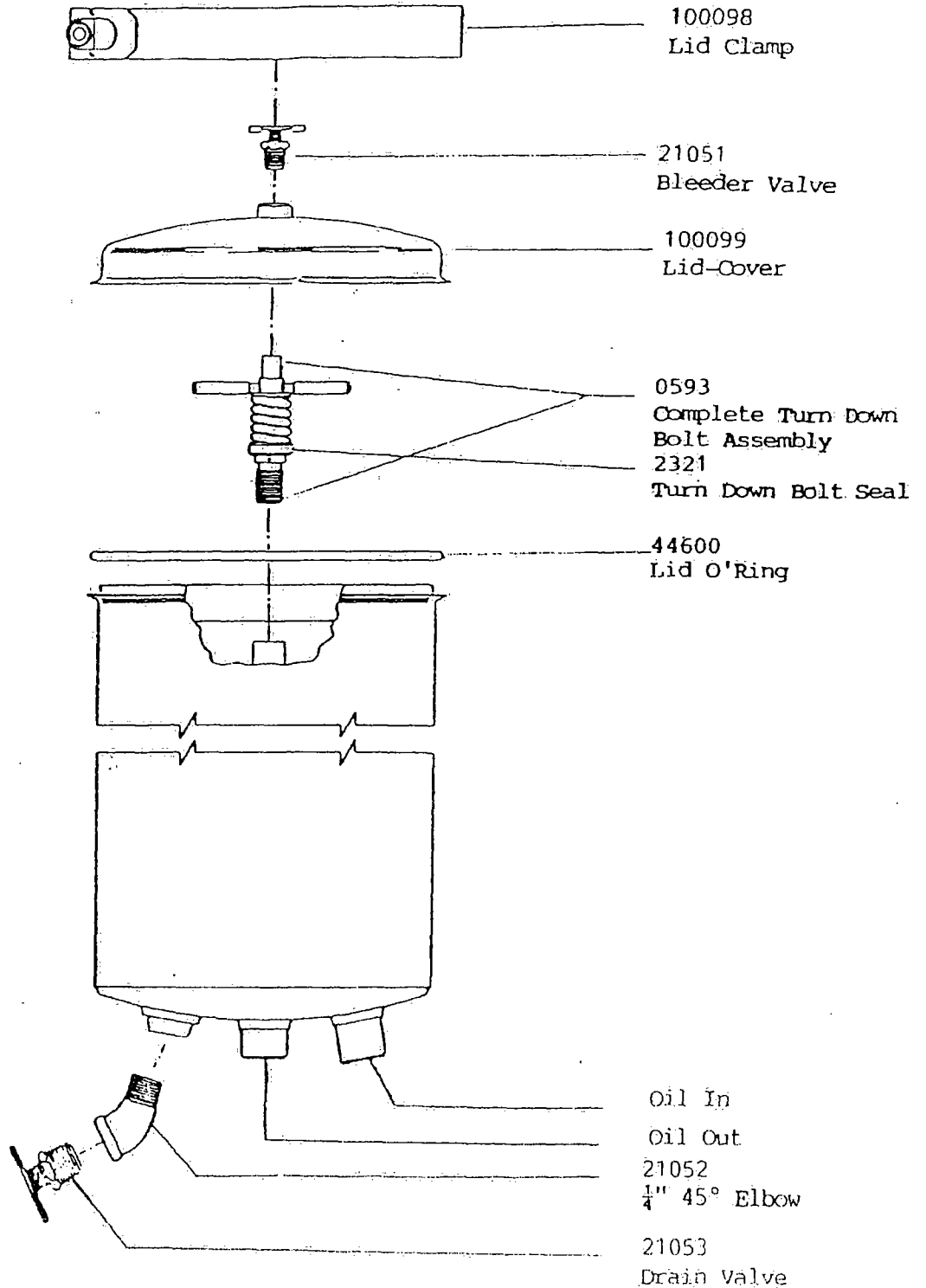
Avoid using fluids other than those specified. Corrosive fluids may damage manometer.

FR No. 44-440475-00



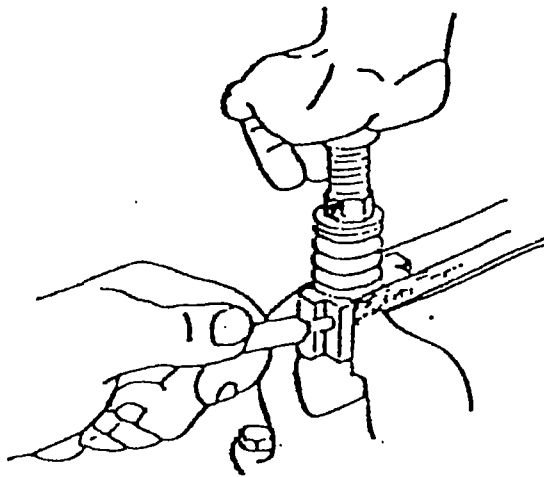
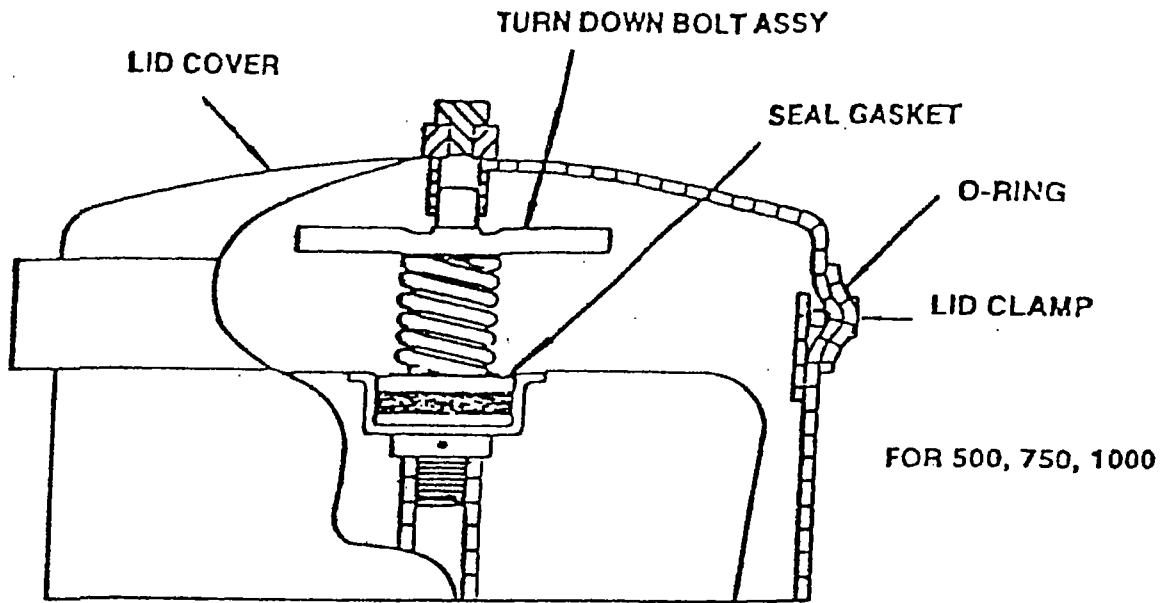
Filmax

Equipment Housing Assembly



Filmax

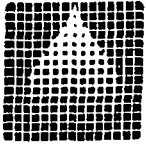
T-Handle Seal Gasket Replacement



T-HANDLE SEAL GASKET REPLACEMENT

Replacement is easy with the aid of a vise. Pull the handle through the shaft. Remove the retainer washer, spring, and back up washer. Change the seal #2321V and reassemble.

FIGURE 1



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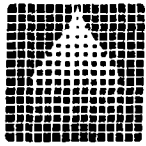
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INSTALLATION INSTRUCTIONS

Filmax HP-1012, 0712, 0512, 0112
Single / Multiple Canister Applications

**REVIEW THESE INSTRUCTIONS THOROUGHLY
BEFORE ATTEMPTING INSTALLATION OR
PRODUCT DAMAGE COULD OCCUR**



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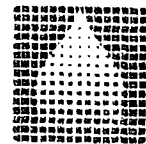
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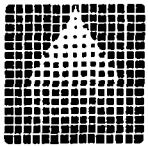
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1. Unpacking and Inspection

Upon receiving shipment, open packages and inspect for damage/shortage. Canisters should be complete with lid, lid O-ring, clamp, and T-handle (inside). Canisters also come with two sets of mounting brackets with bolts, and warning stickers. Elements should be inspected closely for damage to the cloth sock and to the plastic ends. Also ensure the O-ring on the bottom is present and intact. If you have ordered the pressure gauge with air bleed valve, verify that they have also been received in good condition.

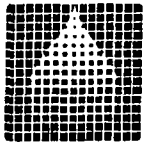
2. Installation

Mount the canister(s) as close to the system being filtered as conveniently possible. Remember to leave enough room for servicing and element changes. Canister(s) may be mounted either vertically or horizontally, although vertical is easiest for servicing.

Install 1/2" elbows (90 deg) into the ports on the underside of the canister. Install 1/2" ball valves onto the elbows and attach your inlet and outlet lines. **The inlet is the outer port, and the outlet is in the center of the canister.** The 1/4" port opposite is the drain. Hoses should be 1/2" ID minimum, and be rated for the oil pressure and temperature of the unit being filtered. On installations where the hoses exceed 15' in length, line size should be increased to 3/4". For additional canisters, install 1/2" Tees in the inlets and outlets, increase



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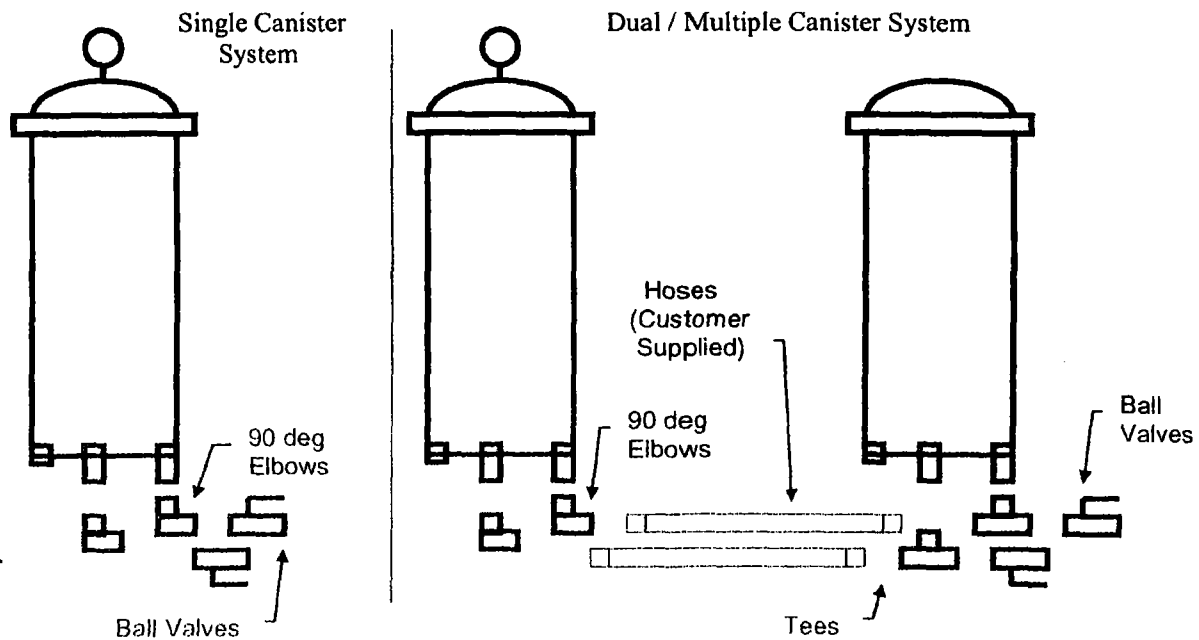
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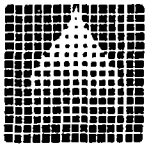
the inlet line(only) to 3/4" and use short pieces of hose to connect the canisters in parallel (inlet to inlet, outlet to outlet). Install the ball valves before the first canister, so the elements can be changed without shutting down the unit being filtered.



Filmax housings should not be operated above 80 psi. The inlet line should be attached to a high volume/ flow port on the system being filtered. Return should be made to a very low pressure area such as the



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oil sump or reservoir. Both hoses should be secured to prevent damage from vibration.

Remove the element from its plastic cover, and carefully lower it into the canister with the O-ring on the bottom. Refer to the attached chart and make sure your T-handle has the correct number of holes. Tighten the T-handle as far as it will go. The element should be held firmly in place and should be difficult (but not impossible) to turn.

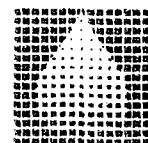
Install the pressure gauge(s) in the vent on the top of the lid. Position gauge for easy viewing and access to the air bleed valve.

Place the supplied warning stickers to the most visible area of the canister.

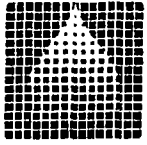
3. Operation

Startup

Fill the canister with new oil to the top of the filter. Lightly wipe the lid O-ring with oil (to ensure a good seal), replace the lid and tighten the clamp. With both ball valves closed, start up the unit being filtered. Open the outlet valve wide, and gradually open the inlet valve until the canister gauge shows 10 psi. Carefully open the air bleed valve until all air is removed and a steady stream of oil exits the valve. Repeat with any additional canisters. Now open the inlet valve slowly until the gauge shows 50 % of system pressure or minimum 20 psi. Record this number. Check all lines for warmth to ensure you are getting adequate flow, and check for leaks. Also check oil level of the reservoir being filtered (refer to "Specifications Table" for canister capacities) and top up accordingly. Re-check reservoir level after system has been running for 5-10 minutes (complete element saturation).



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4. Troubleshooting

No oil pressure on gauge after running a while:

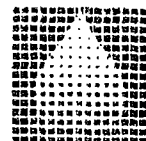
- A: Hooked up to a no pressure point on engine. Find pressurized point and retry.
- B: Oil feed line is blocked or kinked.
- C: Gauge is blocked. Clean orifice on gauge and re-install.
- D: Housing is mounted too high (no oil reaching canister).

Oil return line does not get warm while engine is running:

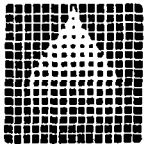
- A: Return line is hooked up to a pressure point. Return must always be made to the reservoir (zero pressure area)

Oil level in reservoir appears over-full after engine has been shut down

- A: The check valve on the inlet port of the canister is malfunctioning and allowing the oil in the canister to drain back into the reservoir through the inlet line. Examine the valve and replace if necessary.



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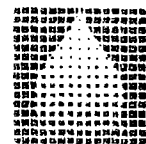
5. Changing Oil / Oil and Filters

Changing Oil Only

Close both the inlet and outlet valves. Follow your normal oil change procedures. After restarting the unit, open the return valve fully. Then open the inlet valve until the gauge reads 10 psi. Now bleed all the air out of the canister using the bleed valve. Open the inlet valve slowly until 50 % of system pressure or minimum 20 psi is reached.

Changing Filters

The filters should be changed when the pressure reading on the gauge is 10-15 psi higher than the initial reading at the same RPM. For example, if the initial reading was 30 psi, and the gauge now reads 45 psi, the filters are beginning to plug, and should be changed. Close inlet and outlet valves and drain the canister using the drain plug. Remove the lid and unscrew the T-handle. Remove the element and clean the canister. Carefully install a new element and replace the T-handle, tightening it all the way. Refill the canister with new oil and re-install the lid O-ring (lightly oiled) and lid. After starting the unit, open the outlet valve fully and slowly open the inlet valve until the pressure reaches 10 psi. Bleed the air from the canister using the bleed valve. Now open the inlet valve until the pressure reaches 50 % of system pressure or minimum 20 psi.



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6. Specifications

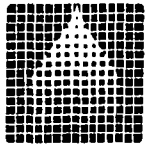
Model	Height	Diameter	Width(installed)	Port Sizes	Capacity
HP-1012	22"	8 5/8"	11"	1/2"	22 L (20 qt)
HP-0712	17 3/8"	8 5/8"	11"	1/2"	18 L (16 qt)
HP-0512	12 1/2"	8 5/8"	11"	1/2"	13 L (12 qt)
HP-0412	17"	6"	7 1/4"	1/2", 1/4"	8 L (7.5 qt)
HP-0112	11 1/2"	6"	7 1/4"	1/2"	5.5 L (5 qt)

7. Parts and Part Numbers

FGO100	Filmax 0-100 psi Glycerin Filled 2 1/2" Pressure Gauge
21058	Filmax Canister Mounting Bracket Set HP1012, 0712, 0512.
100099	Filmax Canister Lid HP1012, 0712, 0512
44600	Filmax Lid O-ring (Buna) HP1012, 0712, 0512
2321	Filmax Seals for T-handle (Viton)
0593	Filmax T-handle for HP1012, 0712, 0512
100098	R.G. Ray Stainless Steel Lid Clamp for HP1012, 0712, 0512
EL1000	Filmax Element Lifter (Used to control swelling when cleaning extremely wet oils)



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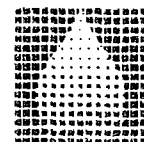
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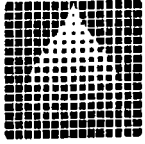
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8. Element Application Guide

<u>Fluid Type</u>	<u>Holes (3/32") in T-handle</u>	<u>Element</u>
Transmission, Hydraulic, Synthetic Oil, Quench Oil	4	HY4004/HY2002
Diesel Engine	1	DE4011/DE2011
Nat.Gas Engine, Diesel Fuel Blending	4	DE4011/DE2011
Insulating Oil, Transformer Oil	4	DF4110
Turbine Oil, Diesel Fuel, Petroleum Based Fire Resistant Fluids	4	DF4110/HY4004
Antifreeze, Oily Waste Water	2	WG4047/WG4049
Cutting Fluids, Honing Fluids (Viscosity Dependent)		DF4110/HY4004
Compressor Oil, Refrigeration Oil	4	HY4004
Gear Oil	6*	HY6006/DE6011
Food Grade Oil	6	HY2002/HY4004
EDM Oils	2	EDM 4012
Glycol Based Hydraulic	4	WG4047/WG4049



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* When filtering very heavy gear oils, it may be necessary to enlarge the 6 holes in the T-handle to 7/64" to achieve proper flow rate. Consult your salesman if you have any questions regarding installation of these systems.

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