



CODE SHEET

VISTA Projects Limited			
VENDOR DRAWING/DOCUMENT SQUAD CHECK			
A	Reviewed without exception. Proceed with fabrication. Issue final drawings/ documents.		
B	Reviewed except as marked and/or noted. Proceed with fabrication and resubmit drawing/document. Shipment will not be released, if any drawings/documents requiring approval, as per purchase order conditions, are at this code.		
C	Not accepted. Revise as marked and resubmit drawing/document for review. Shipment will not be released, if any drawings/documents requiring approval, as per purchase order conditions, are at this code.		
D	Not required for review. Received for information.		
Reviewed only as to general conformity with the design concept and specifications provided. The engineer does not warrant or represent that the information contained on this drawing/document is either accurate or complete. Sole responsibility for correct design, detail and dimensions shall remain with the party submitting the drawing/document.			
SDR CODE	EQUIPMENT TAG	REVIEWED BY	DATE
DB01	AC-5020		2012-01-24

PROJECT NAME: Murphy Cadotte 1780

VENDOR NAME: AXH Air-Coolers 1780-009

DOCUMENT NUMBER: 1780-009-DATABOOK-AC-5020

VENDOR REVISION: 0

DOCUMENT DESCRIPTION: Databook Aerial Coolers AC-5020

VENDOR TRANSMITTAL NUMBER: _____



MAIN MENU – TABLE OF CONTENTS

Customer: Murphy Oil Canada

AXH Job: 118455

Ref: 1780-009(Vista) – 54115097-207(Murphy) Model: 96ZF-R

Tag: AC-5020

End User: Murphy Oil Company Ltd.

● Purchase Orders

- 1780-009 Aerial Coolers Commercial PO
- 1780-009 Aerial Coolers Technical PO

● As-Built Data Sheets

- Specifications Sheet

● As-Built Drawings and Calculations

- Certified Drawing
- As-Built Cooler Drawing
- Shaft Detail Drawing
- CRN Drawing
- ASME Pressure Vessel Code Calculations

● Catalogue Data and Installation/Operating/Maintenance Manuals

- Airtech Products, Inc. – Duraflo Industrial Louvers
- Moore Fans LLC – Class 10000 VT Series 42
- Dodge – TAF Bearing 2-7/16 Pillow Back
- Airtech Products, Inc. – Durastroke Pneumatic Actuators – Series 1500
- Teco Westinghouse Motor – Catalog Number EP0254
- Murphy Shock/Vibration Control Switches – Model VS-2EX-XP
- Gates – Super HC Powerband Belts – 5VX1120
- Air-x-limited Polyester Vinyl Bug Screen Panels – Series 1.2-0704
- Spare Parts List
- AXH Installation and Operation Manual
- AXH Brochure

● Quality Control Documents

- U-1A Manufacturer's Data Reports for Pressure Vessels
- Name Plates
- Inspection and Testing
- Weld Procedures
- Qualifications and Maps
- NDE Testing and Hydro Testing
- Material Records
- Travel Sheets
- Bill of Materials/Packing Slips

Purchase Orders

- 1780-009 Aerial Coolers Commercial PO
- 1780-009 Aerial Coolers Technical PO



PURCHASE ORDER

54115097-207

This number must appear on all correspondence.

54115097-207
AIR-X-LIMITED

Buyer MURPHY OIL CANADA 4000, 520 - 3 Avenue SW Calgary, AB, CA T2P 3Y3 Ryan Dick T: 403-294-8038 E: ryan_dick@murphyoilcorp.com	PO Description		PO Date	
	AERIAL COOLERS			14-Nov-2011
	Project Name Seal CSS Pilot	EPC Company Vista Projects Limited	Invoice Payment Terms Net 45 Days	
Location 13-9-85-17W5M	EPC Project Number 1780		Order Currency USD\$	
Vendor Quotation Reference Quote # 118454	Delivery 05-Mar-2012	Murphy AFE Number 54115097	Shipping Terms FCA, Claremore OK	
Vendor AIR-X-LIMITED 2230 East 49 Street Tulsa, OK, USA 74105 David Freshwater T: 918-743-6111 F: 918-742-7039 E: dfreshwater@alrxlimited.com	Invoice To MURPHY OIL CANADA 4000, 520 - 3 Avenue SW Calgary, AB, CA T2P 3Y3 Facilities Attn: Ryan Dick		Ship To	

AIR-X-LIMITED **AERIAL COOLERS**

Item	Quantity	Description	Major-Minor	Unit Cost	Total
1	1.00 pkg	TAG #: AC-5010 - PRODUCED GAS AERIAL COOLER <i>Included: Murphy vibration switch, warm air circulation system with auto top & roll shutters, manual intake - TIC by others, averaglnh RTD & temperature controller for warm air recirc system, registration for AB, BC & SK, ladder & platform, mechanical run test</i>	9024-447	\$40,110.00	\$40,110.00
2	1.00 pkg	TAG #: AC-5020 - BOILER FEED WATER COOLER <i>Included: Murphy vibration switch, warm air circulation system with auto top & roll shutters, manual intake - TIC by others, averaglnh RTD & temperature controller for warm air recirc system, registration for AB, BC & SK, ladder & platform, mechanical run test</i>	9024-447	\$85,725.00	\$85,725.00

Direct Questions About This PO To
 Brant Lu @ Vista Projects Ltd.
 T: 403-258-4768 E: brant.lu@vistaprojects.com

Sub Total **\$125,835.00**
 (plus GST)

Instructions to Vendor - Show PO Number 54115097-207 on all Invoices and correspondence pertaining to this order - Attach a copy of this Purchase Order to ALL INVOICES when submitting for payment - Attached as Exhibit 'A' are Terms and Conditions which are made a part hereof for all purposes - One (1) copy of this order is to be duly signed and returned upon receipt. Retention for more than ten (10) working days shall constitute acceptance of this order in its entirety - Work performed is not to deviate from the scope of this Purchase Order - No costs are to exceed the amounts indicated on this Purchase Order	Order Prepared By Segna Terenta	Total Value of Purchase Order \$125,835.00 (plus GST)
	Order Approved By Ryan Dick, Jeff Sand, Cal Buchanan	

\$125,835.00
 (plus GST)

54115097-207
 Page 1 of 1



Purchase Order #: 1780-009
 Murphy Oil Company Ltd.
 Murphy Cadotte Pilot CSS Project



Purchase Order Number:	1780-009 (Vista)
	54115097-207 (Murphy)

Aerial Coolers

PO Total Commitment: \$125,835.00 + taxes (USD)
Required Delivery Date: March 22, 2012

CORPORATION
Murphy Oil Company Ltd
PROJECT CONSULTANT
Vista Projects Limited
Attention: Brant Lu
Telephone: (403) 258-4768
Fax: (403) 258-2192
Email: brant.lu@vistaprojects.com

VENDOR NAME
Air-X-Limited
2230 East 49 Street
Tulsa OK 74105, USA
Attention: David Freshwater
Telephone: 918-743-6111
Fax: 918-742-7039
Email: dfreshwater@airxlimited.com

December 1, 2011

PO Issue Date

Seller's Acceptance Please sign and return this cover page	
_____ Seller's Signature Air-X-Limited	_____ Date



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1.0 COMMERCIAL DETAILS

1.1 Legal Agreement

The law applicable to this Purchase Order shall be the law in effect in the Province of Alberta. Except for an appeal from an Alberta Court to the Supreme Court of Canada, no action in respect to this Proposal shall be brought or maintained in any court other than in a court of the appropriate jurisdiction of the Province of Alberta.

Method of payment is governed by Murphy Oil Company Ltd. policy as well as applicable Federal and Provincial Laws.

1.2 Terms and Conditions

This order shall be placed in accordance with:

1. Attached AXH Air Coolers LLC Terms and Conditions of Sale (5 pages)
2. Attached Murphy Oil Canada Terms and Conditions (2 pages)
3. Bid Clarification 1 for 1780-RFQ-009 (2 pages)

1.3 Exceptions to Terms and Conditions

Both AXH Air Coolers LLC Terms and Conditions of Sale and the Murphy Oil Canada Terms and Conditions shall apply for this Purchase Order. In the event of conflict, AXH Air Coolers LLC Terms and Conditions of Sale will supersede the Murphy Oil Canada Terms and Conditions.

1.4 Payment Terms

Invoice(s) for this Purchase Order shall be submitted based on the following milestones below:

	Milestone	Progress	Forecast Date	PO Amount
1	Shall be invoiceable by Seller upon successful completion of final inspection resulting in an Inspection Release form being issued to Seller by Buyer and Seller issuing a Notification of Readiness to ship each of the items/equipment as itemized in this Purchase Order	95%	March 22, 2012	\$119,543.25
2	Shall be invoiceable by Seller upon receipt by Buyer of completed documentation package per item/tag number, engineering data, drawings, as-built drawings and installation and operation manuals in accordance with the Document Requirements Form and the terms of this Purchase Order, all with status "A" or "D".	5%	April 5, 2012	\$6,291.75

The value of payments is subject to change with any new addition or deletions as the order progresses. The current milestone payments are based on a total Purchase Order amount of **\$125,835.00 USD**. All invoices shall be paid Net 45 days from receipt of a correctly submitted invoice.



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Murphy Oil Company Ltd.
Murphy Cadotte Pilot CSS Project



1.5 Payment Schedule

- 1.5.1 The basis for all payments will be net 45 days from receipt of a properly rendered invoice(s) after satisfactory completion of the milestone indicated.
- 1.5.2 Values of payments are subject to change with any new additions or deletions as order progresses.
- 1.5.3 In the event of cancellation of the project and/or excess material due to project changes, there are no applicable return charges.
- 1.5.4 All pricing is fixed firm and free of escalation or currency fluctuations through to completion of Purchase Order.
- 1.5.5 All prices quoted are in **USD**.
- 1.5.6 Invoicing; ensure the following reference numbers are included on all invoices submitted:

Vista PO Number: 1780-009
Murphy Oil PO Number: 54115097-207
Cost Code: 9024-447
AFE Number: 54115097

- 1.5.7 All invoices must be sent to:

Murphy Oil Canada
4000-520 3 Avenue SW
Calgary AB, Canada
T2P 3Y3
Facilities
ATTN: Ryan Dick

- 1.5.8 **All Taxes & Duties Extra**

1.6 Approval Drawings & Documentation

Air-X-Limited shall submit the documents required in the Drawings & Data Required form after award of the Purchase Order. Please see attachment (VISTA-FRM-DC-05) for Vendor Submittal instructions. All drawings that need to be submitted and approved before release for fabrication must be submitted within **3 weeks** of Purchase Order award.

Please forward any detailed drawings and documentation that is subject to Murphy Oil Company Ltd. and Vista review, directly to Vista Projects, at the address noted below.

Vista Projects Limited
Suite #330 – 4000, 4th Street SE
Calgary, Alberta
T2G 2W3

Attention: Document Control
Phone: (403) 258-4744
E-mail: dcvista@vistaprojects.com



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Murphy Oil Company Ltd.
Murphy Cadotte Pilot CSS Project



A copy of transmittals should be cc: to brant.lu@vistaprojects.com

Please forward any **final** detailed drawings, data and data books (e.g. IOM Manuals, QA/QC Data Books) directly to Vista, at the address noted below.

Vista Projects Limited
Suite #330 – 4000, 4th Street SE
Calgary, Alberta
T2G 2W3

Attention: Document Control
Phone: (403) 258-4744
E-mail: dcvista@vistaprojects.com

NOTE: Drawings and data must be supplied in the quantities indicated on the Drawings & Data Required technical attachment. Buyer reserves the right to withhold 5% of the total Purchase Order commitment amount until all required drawings & data are received.

1.7 Packing / Storage / Shipping & Marking Instructions

Seller shall include but not be limited to the following guidelines for preservation, protection and packaging of materials and equipment. These guidelines are in place for the protection of the material and equipment from mechanical damage, freezing and atmospheric corrosion during transit, and to prevent damage due to rough handling and vibration.

It will be the responsibility of the Seller to provide the Buyer with their standard Preservation Procedure as well as any special packaging and storage requirements to ensure full warranty protection as described in the Purchase Order.

Packaging/Storage Guidelines

All materials categorized as dangerous goods to be so identified and shipped in compliance with the Workplace Hazardous Materials Information System (WHMIS).

The packaging will be done in such a manner as to prevent damage due to rough handling, condensation, corrosion and vibration. Should fungus protection be required such treatment will not be applied to electrical contacts or current carrying metal surfaces.

All items shall be clear of debris, dirt and foreign matter (thoroughly clean inside and out prior to shipment preparation), and as a minimum, all items whether shipped in boxes or palletized shall be waterproof.

The Seller shall ensure that loose shipped accessories that are removed from the main equipment or equipment that require field assembly, are placed in separate packages or bundles and then labelled indicating the Purchase Order number, name of the equipment to which the accessory belongs, name of the accessory, accessory (part) number and position number on the assembly drawings.

Any instrumentation or other small attachments subject to damage due to vibration or jarring must be removed, sleeved in polyethylene and sealed or packaged in waterproof barrier packages and clearly marked as to location to be reinstalled. All resulting openings must be



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sealed. All others must be disassembled, tagged, and packed in padded boxes, and come with assembly instructions. Open skids must be tarped for highway transportation.

Special tools shall be separately packaged, shipped, identified as per loose shipped accessories and marked as "Special Tools".

Recommended spare parts shall be separately marked as "Commissioning Spares" or "Operating Spares" as specified by the Buyer. The Seller will also clearly identify the item or items and the equipment component which they are intended for.

Packaged/prefabricated (skid mounted) equipment will be required to have all components properly blocked and braced for shipment. All temporary blocking and bracing will be painted red for clear identification for removal upon installation at site.

All gauges that are deemed stable for transport will have their glass face taped in an "X" manner.

All bolted connections shall be properly tightened as per mechanical requirements prior to shipment.

The Seller shall ensure that all hinged openings are securely located or banded closed to prevent possible opening during shipping.

Items with exposed rubber parts or linings shall be wrapped with an opaque, air tight plastic cover secured with tape. Desiccant shall not be used to protect rubber products.

Equipment shall be bolted to the package (pallet) base whenever possible. Equipment not bolted to the base shall be protected and held in a fixed position by banding, chock blocks, bracing and packing material.

Valves that are strapped to pallets or shipped in boxes shall have ends/openings sealed to prevent moisture or foreign matter from entering, and all valves will be in the closed position and the wheel or handle removed and marked as to correspond with the reinstallation.

Desiccant shall be required in all types of protection and packaging when condensation or vapour diffusion across vapour barriers would create a condition in the interior of the package harmful to the contents. Desiccant shall be fully contained in bags (to prevent dispersion), securely fixed in place and easily removed. The package shall indicate that desiccants shall be checked weekly and changed as necessary.

Internal surfaces subject to rusting shall be protected by vapour phase inhibitors, rust preventatives or by a suitable desiccant. After treatment, all openings must be plugged or otherwise sealed.

All items shall be clean before application of any anti-corrosive material. Machined and bright surfaces shall be coated with an anti-corrosive material.

Components with non-drainage crevices or chambers shall be covered and protected at all times from entrance of water and debris.

Rust inhibitors shall be compatible with the normal charge of oil or easily removed by flushing when used on lubricated parts. Oil recommended for normal operation or a compatible substitute shall be used when filling or flushing.



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The Seller will re-use the original packing materials received from free issue suppliers to ship loose items. Neither Vista Projects Limited nor Murphy Oil Company Ltd. will pay for replacement of packaging materials due to discarding of original packaging.

In cases where the Seller is responsible to load equipment/materials as per the delivery/freight terms of the Purchase Order, the Seller shall ensure that items which are susceptible to damage by rubbing are separated by wooden strips. The Seller and Buyer's representative (when present) will ensure that padding is placed under chains that contact the materials. In all cases the Seller will ensure that the transporter secures (chains down) the equipment at locations that will not cause undue stress and damage during transport (i.e. nozzles or flanged are not to be used).

When specified by Buyer, goods are to be tarped prior to transporter leaving Seller premises.

Sharp corners and small protuberances shall be protected against being knocked off during transport, loading and unloading.

Shipping saddles, cradles, bolsters, and chock blocks shall be contoured to the outside curvature of equipment and located so that local bending or damage of the equipment will not occur. Steel wrapper plates shall be used when necessary to distribute the load and protect the equipment.

Cylindrical equipment shall be mounted on shipping saddles. When possible, installation saddles on equipment should be used as shipping saddles.

Packing Categories:

Main Piece(s) of Equipment
Equipment Accessories
Spare Parts
Special Tools
Tools and Spare Parts for One Year Operation

Seller may not ship until they receive a written release from Buyer's Expeditor.

Shipping Instructions

Based on the Purchase Order date of November 14, 2011 all items listed within this Purchase Order shall be ready to ship on or before the dates listed within Section 3 of this Purchase Order on each line item per the INCO terms:

FCA, Seller's Facility, Claremore OK

**AXH Air-Coolers
401 East Lowry Road
Claremore OK 74017**

Ship via: Buyer's Truck

Seller shall contact Brant Lu (Buyer/Expeditor) and obtain approval before shipping to destination.

A copy of these instructions must be included and shall also apply to each of your Purchase Orders directed to sub-suppliers making shipment directly to the jobsite, located near the Cadotte area in Northern Alberta.



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If freight is extra to your Purchase Order, pre-pay all freight charges to jobsite and invoice at cost as a separate item. Charges must be supported by a copy of the Carrier's document.

C.O.D. shipments will not be accepted and will be returned to the Seller with all associated costs to the Seller's account.

As a minimum, the Buyer's Project name, Purchase Order number, item number, equipment and tag number(s) must appear on all equipment, crates, containers, shipping papers and packing lists.

The packing list must be attached in a visible waterproof envelope and affixed to the outside of each container with one (1) copy attached to the bill of lading.

Packing list must clearly identify each item, indicating quantity of items shipped and quantity of items being back ordered. One data book must also accompany any shipment to site.

At least five (5) working days prior to readiness of shipment, provide via email, the following information to the Expeditor:

Purchase Order Number
Item number
Quantity being shipped
Number, size, gross weight of packages
Method of transport
Special arrangements required for handling
Estimated time of arrival at destination.

This is to allow the Expeditor the necessary time to arrange for unloading and storage of the goods.

On Purchase Orders where Buyer's right to Quality Surveillance is exercised, no shipment shall be made without the Buyer's Quality Surveillance Inspector's "Release to Ship".

Lifting/Handling Requirements

Packing shall be done in such a manner to enable cargo handling by forklift, cranes, slings, bogies, skids, or manual manipulation as size and weight permits. If site is remote, and if there is an absence of heavy lifting facilities at all points of transit, packing case size and weights shall be taken into consideration.

Should the equipment weigh two (2) or more than two (2) metric tons, the weight, center of gravity and hoisting position shall be marked with international trade transportation practice marks and illustrative marks on the two sides of each case so as to facilitate loading, unloading and handling.

In accordance with the characteristics and different requirements in loading, unloading and shipping different Purchase Order equipment the package shall be clearly marked with "Handle with Care", "Right Side Up", "Keep Dry", etc. and with appropriate international trade practice marks and illustrative marks.

Shipping Identification Marks

Each case, box, crate, piece, etc. must have stencilled label on two sides in clear, legible characters. On bundles the marks are to be "embossed on metal tags", which shall be wired securely to the bundle at the end and in the middle.



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Shipping marks are as follows (colour coding, if required):

Project:
P.O. Number:
Equipment Description:
Tag Number(s):
Gross/Net Weight (lbs):
Dimensions (inches):
Case Number/Bale Number: _____ of _____

Any container or boxed shipments should clearly indicate right side up.

Equipment Tagging

Each item of equipment is to be furnished with either a paper, aluminum or stainless steel name plate (as detailed in the PO), identified with the Purchase Order number, tag number and other data as required by the specifications and/or data sheets.

Any other tagged components (i.e. Instruments, valves, etc.) supplied with the equipment are to be provided with a stainless steel tag, securely fastened and stamped with the Buyer's number.

1.8 Expediting Instructions & Requirements

This Order and all Sellers' sub-orders for major equipment and material, including Seller furnished drawings and data, are subject to expediting action by Vista Projects Limited and/or Murphy Oil Company Ltd. The Seller shall grant free access to his plant or plants (including sub-supplier plants) to the Vista Projects Limited and/or Murphy Oil Company Ltd. Expeditor for the purpose of establishing delivery dates.

In addition to, and without limiting the expediting and delivery requirements described in the General Conditions, the following requirements are applicable:

Fabrication Schedule

Prior to the start of fabrication, the Seller shall provide Buyer's Expeditor with a complete and detailed bar chart (or similar type) schedule which at a minimum identifies the following milestones:

- Scheduled start and completion dates for engineering activities
- PO's issued to sub vendors for material required;
- Fabrication;
- Packaging;
- Testing and inspection;
- Final documentation.

The detailed bar chart schedule shall be submitted to Buyer's Expeditor no later than two weeks or (10) working days after award of the formal Purchase Order. In addition, Seller shall furnish a progress report every fourteen (14) days thereafter in sufficient detail to allow a realistic evaluation of progress towards order completion. The progress report should cover all technical, procurement and scheduling updates.

It is imperative that Seller notify the Buyer's Expeditor, in writing, of any actual or anticipated delays immediately upon their discovery. Such notice will include estimated period of delay,



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cause of delay and corrective actions being taken by Seller and/or required by Buyer for expedited resolution.

Shipping Release Requirements

Buyer's Expeditor will issue Seller a copy of Vista Projects Limited's "Advanced Shipping Notice" prior to the scheduled shipment dates. The Seller will be responsible to provide shipping weights, dimensions and confirmation of ship date. This is a mandatory expediting requirement and any shipment without proper release notifications are subject to additional logistical charges being incurred to the Seller.

The requirements of the above marked paragraphs shall be submitted to:

Murphy Oil Company Ltd.
c/o Vista Projects Limited
Suite #330 - 4000, 4th Street SE
Calgary, AB
T2G 2W3
Attention: **Brant Lu**
Reference: **Vista P.O. # 1780-009**

2.0 SCOPE OF WORK

2.1 Scope of Work

The scope of work covers the materials, design and engineering, fabrication, test and supply of two (2) Aerial Coolers as per the attached technical attachments. The tags are as follows:

- AC-5010 – Produced Gas Aerial Cooler
- AC-5020 – Boiler Feed Water Aerial Cooler

The equipment shall be delivered under FCA, Seller's Facility loaded onto Buyer's truck in Claremore, Oklahoma.

2.2 Responsibilities

Review by Murphy Oil Company Ltd. and /or Vista Projects Limited of supplier documents, or release of the Aerial Coolers by Purchaser's authorized representative shall not relieve the vendor of his responsibility for compliance with this specification nor alter the conditions of the guarantee.

2.3 Substitutions and Deviations

Any deviation from the requirements of the specification requires prior written approval of the Vista Projects Limited representative in a form of a Change Order.

2.4 Conflicts and Requirements

This scope of work is intended to take precedence over referenced documents. However, In the event of any conflicting requirements between various referenced documents, it shall be brought



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to the attention of the Vista Projects Limited for resolution, and a ruling in writing shall be obtained by the Supplier before any work is taken up.

2.5 Drawings, Certification, and Documentation

Documentation requirements are listed in the attached Document Requirements form in the technical attachments.

2.6 Attachments

Commercial Attachments

Doc #	Doc Name	Pgs	Rev
N/A	Exhibit "A" Terms & Conditions to Murphy Oil Canada Purchase Order	2	N/A
N/A	AXH Air Coolers LLC Terms and Conditions of Sale	5	N/A
NA	Bid Clarifications 1 for 1780-RFQ-009	2	N/A
VISTA-FRM-DC-05	Documentation Requirements for Vendors	7	0
N/A	Transmittal Template	1	N/A

Technical Attachments

Doc #	Doc Name	Pgs	Rev
N/A	Technical Documents	1	0
1780-DS-AC5010	Produced Gas Aerial Cooler Data Sheet	2	0
1780-DS-AC5020	Boiler Feed Water Aerial Cooler Data Sheet	2	0
1780-DS-ACM5010	Produced Gas Aerial Cooler Fan Motor Data Sheet	3	0
1780-DS-ACM5020	Boiler Feed Water Aerial Cooler Fan Motor Data Sheet	3	0
N/A	Scope of Supply	1	0
N/A	Document Requirements	2	0
N/A	SDR Code List	2	N/A
N/A	Level of Inspection	1	0
N/A	Mechanical Inspection Requirements	1	0
N/A	Instrumentation Inspection Requirements	1	0
N/A	Weld Procedure Summary (WPS)	1	0

Please ensure all attachments are included in the Purchase Order package. Please notify the buyer immediately if there are attachments missing.

3.0 Pricing

3.1 Pricing details

Item	Qty	UOM	Description	Total Amount	Delivery
1	1	Pkg	Tag: AC-5010 – Produced Gas Aerial Cooler	\$40,110.00	2012-Mar-22



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			Included: -Murphy Vibration Switch -Warm air circulation system with auto top & roll shutters, manual intake – TIC by others -Averaging RTD and temperature controller for warm air recirc system -Registration for AB, BC, & SK -Ladder & Platform -Mechanical Run Test		
2	1	Pkg	Tag: AC-5020 – Boiler Feed Water Aerial Cooler Included: -Murphy Vibration Switch -Warm air circulation system with auto top & roll shutters, manual intake – TIC by others -Averaging RTD and temperature controller for warm air recirc system -Registration for AB, BC, & SK -Ladder & Platform -Mechanical Run Test	\$85,725.00	2012-Mar-22
			TOTAL PO COMMITMENT	\$ 125,835.00	USD

EXHIBIT "A" TERMS & CONDITIONS TO MURPHY OIL CANADA PURCHASE ORDER

1. Price

No price increases and no charges, including taxes or customs and excise duties, in addition to those shown on this order will be permitted without Murphy's written authorization.

2. Invoices and Shipments

(a) Sellers invoices must show Murphy's purchase order number and are to be mailed to the address shown on the face of this order.

(b) Payment of invoices shall be no later than the last business day of the third month following the performance of the work or provisions of the material and shall be subject to holdback of funds as stipulated by the *Builders Lien Act, Worker's Compensation Board Act, Canada Pension Plan Act, Employment Insurance Act and Income Tax Act* or similar statute in the Province or Territory where the work or material is supplied by Seller.

(c) C.O.D. shipments will not be accepted without Murphy's prior authorization.

(d) Payment by Murphy will not limit its right to audit, protest or question the invoice.

3. Indemnities

(a) Seller is an independent contractor (any relationship of principal and agent, master and servant and employer and employee are expressly denied) and will defend Murphy at Seller's expense and will indemnify and save harmless Murphy from all claims arising out of patents, copyrights, or similar or alleged infringements thereof and from compensation and violation of any law or anything having the force of law in connection with materials or services supplied by Seller under this purchase order.

(b) If Seller performs services or constructs, erects, inspects or delivers hereunder on premises owned or controlled by Murphy, Seller will indemnify and save harmless Murphy from any or all loss arising out of any or all claims, suits and demands by reason of but not limited to accident, injury or damages to persons or properties that may result in connection therewith.

(c) Murphy shall not be responsible for tools, equipment or personal property of Seller or any subcontractor or employee of Seller while on the premises owned or controlled by Murphy or otherwise. Seller agrees to indemnify Murphy for any claims, suits or demands with respect to such tools, equipment or personal property, made against Murphy by third parties.

4. Warranties

(a) Seller warrants for the benefit of Murphy and its affiliates that the materials and services supplied hereunder are of the kind and quality specified herein, free from fault in design, workmanship and material, are of good quality, and will perform the service required of it in accordance with the operating conditions and performance data specified. All materials and services shall at all times be subject to Murphy's inspection but neither Murphy's inspection nor failure to inspect shall relieve Seller of any obligations hereunder. Seller further warrants, that unless otherwise specified herein, all materials supplied hereunder are new and have not been previously used. If any materials or services, in Murphy's opinion fail to conform to specifications or are otherwise defective, Murphy may reject all of the materials or services purchased under this order or any portion thereof, and they may be held or returned at Seller's risk and expense and Murphy shall be entitled to a refund in full or at Murphy's option. Seller shall promptly replace same at Seller's sole expense.

(b) Excluding rental equipment, Seller warrants that Murphy will receive clear and unencumbered title to the materials supplied herein.

(c) No payment or acceptance by Murphy hereunder shall constitute a waiver with respect to any of the provisions of this purchase order, nor shall anything herein contained be construed to exclude or limit any warranties or conditions implied by law. All warranties shall continue in full force and effect notwithstanding any termination of this order by Murphy and shall extend for a period of twelve months from the date of start up or the date of successful field performance testing, whichever first occurs.

(d) The materials or services which are repaired, replaced or reperfomed under the warranties herein, shall be warranted for a twelve month period (or such other time period as agreed between the parties) from the date of such repair, replacement or reperformance and the original warranty for the materials or services will be extended by the time period such materials or services cannot be used or are delayed due to such repairs, replacements or reperformance.

(e) Notwithstanding clauses 4(c) and 4(d), if Seller's standard warranty period is for a longer period than the warranty period set out herein, Seller's warranty period shall apply.

(f) Seller shall bear all costs, including without limitation, removal, labour and delivery costs from and to Murphy's site as designated on the face of this purchase order, for repair, replacement or reperformance of materials or services under the warranty provisions.

(g) These express representations and warranties cannot be waived without separate written consent from Murphy and, in particular, shall not be waived by reason of acceptance or payment by Murphy.

5. Health, Safety and Environment

All service or work activity performed as required in full or in part by this purchase order must adhere to Murphy's Health, Safety and Environment (HSE) Policies. Murphy will provide copies of any or all applicable policies upon request.

With respect to any hazardous material ordered:

(a) Seller shall supply material safety data sheets for each and every controlled hazardous product sold to Murphy detailing the hazardous effects on human health and the environment, including recommendations for safe handling use and storage;

(b) Seller shall be solely responsible for the choice of carrier;

(c) Any losses, damages, claims, suits or demands arising from the shipment of such dangerous or hazardous goods shall be the responsibility of Seller; and

(d) Seller shall indemnify Murphy with respect to same.

(e) Complete packing slip must accompany each shipment. Collect shipments must be accompanied by an original bill of lading or express receipt. On prepaid shipments, attach bill of lading or receipted freight or express bill to Seller's invoice.

6. Compliance with Laws

(a) Seller shall comply with all safety and security regulations imposed by Murphy and with all occupational health and safety laws imposed

EXHIBIT "A" TERMS & CONDITIONS TO MURPHY OIL CANADA PURCHASE ORDER

by the municipal, provincial or federal governments. Seller shall ensure that its employees, contractors and agents are made aware of and comply with these regulations and laws.

(b) Seller shall comply fully with all applicable laws, ordinance, rules and regulations whether federal, provincial or local. Seller shall secure and keep in effect all permits and licences required by public bodies in connection with the performance of the services and the supply of materials under this purchase order.

(c) Illegal drugs, intoxicating beverages, pyrotechnics, firearms, weapons, stolen property and other contraband shall not be brought by Seller or its subcontractors or its or their representatives on premises owned or controlled by Murphy.

7. Right to Audit

Seller shall maintain during the course of the work, and retain for not less than two years after the end of the calendar year of final completion thereof, complete and accurate records of all of Seller's costs and documentation of items which are chargeable to Murphy under this purchase order and Murphy shall have the right at any reasonable time to inspect and audit those records by authorized representatives of its own or any public accounting firm selected by it. The records to be maintained and retained by Seller shall include (without limitation):

(a) payroll records, including social insurance numbers and labour classifications, accounting for total time distribution of Seller's employees working full or part time on the work, as well as cancelled payroll cheques or signed receipt for payroll payments in cash;

(b) invoices for purchases, receiving and issuing documents, and all other unit inventory records for Seller's stocks or capital items; and

(c) paid invoices and cancelled cheques for materials purchased and for subcontractor's and any other third parties charges. Without limiting the foregoing, Murphy may audit any and all records of Seller and any subcontractor or vendor in connection with the work to be performed hereunder and all transactions related thereto for the purpose of determining whether there has been compliance with this purchase order.

8. Confidentiality

(a) Seller acknowledges that in the course of this purchase order, it may have access to proprietary information important to the business and competitive position of Murphy. Seller agrees that it will not use for itself or others, divulge or convey to others, or aid or abet others to divulge or to convey to others, any information, knowledge, data or property relating to the business of Murphy or any of its affiliates in any way obtained by Seller during its association with Murphy or in any way obtained by Seller from employees of Murphy or Murphy's affiliates. This clause shall continue to apply with respect to each particular item of information, data, or knowledge unless and until that item has become public information.

(b) All drawings, blueprints, specifications, dies, patterns, tools, etc., whether supplied by Murphy or prepared or constructed by Seller as required for the completion of this purchase order, and paid for by Murphy, shall be the property of Murphy and information therefrom shall be considered confidential and shall not be disclosed to any third party, without written approval of Murphy, and upon completion of deliveries hereunder, or upon termination of this purchase order, shall be delivered to Murphy unless otherwise agreed to in writing. All performance or quality assurance test result data must be retained by Seller or turned over to Murphy.

9. Assignment and Set-off

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(a) This purchase order is placed upon the condition that Seller shall not assign it or any interest therein without Murphy's prior written consent.

(b) Murphy shall be entitled at all times to set-off any account owing from Seller to Murphy or any of its affiliates against any amount due or owing to Seller with respect to this order.

(c) Murphy shall have the right, but no duty, to withhold any monies payable by it hereunder and apply same to the payment of any obligations of Seller to Murphy or any other parties arising in any manner from this order or its performance.

10. Default

Failure of Seller to comply with any express or implied provision of this purchase order, the insolvency, voluntary or involuntary bankruptcy, receivership or an assignment for the benefit of creditors shall entitle Murphy (without limiting any other rights or remedies Murphy may have) to terminate all or part of this purchase order without penalty. Upon such termination, Murphy shall be relieved of all further obligations hereunder except the obligation to reimburse Seller for Seller's actual direct out-of-pocket costs incurred to the effective date of termination and reasonably attributable to this purchase order and Seller shall be liable to Murphy for all costs incurred by Murphy in completing and procuring the completion of performance in excess of the prices specified herein.

11. Termination

Murphy may at any time terminate this purchase order in whole or in part by written notice to Seller if Murphy's need for articles, materials or services to be supplied hereunder is reduced or eliminated or if such action becomes necessary or in the interests of Murphy. Upon receipt of such notice, Seller shall cease all operations hereunder except as directed by Murphy. Upon such termination Murphy shall reimburse Seller for Seller's actual direct out-of-pocket costs incurred to the effective date of termination and reasonably attributable to this purchase order and such other costs as may be mutually agreed to.

12. General

(a) No waiver of or exception to any of the terms, conditions and provisions contained in this purchase order shall be valid unless specifically agreed to in writing by Murphy. The acceptance of or acquiescence in the course of performance by Seller shall not be relevant in determining and shall not operate as a waiver of the obligations of Seller.

(b) This purchase order, when accepted by Seller, shall constitute the entire agreement with reference to its subject matter and shall not be altered, amended, supplemented or cancelled without Murphy's written approval. The shipment of any article for commencement of performance hereunder, or the commencement of the performance of services, shall constitute acceptance of this purchase order and no contrary or additional terms and conditions shall apply, notwithstanding any oral or written statement made by Seller.

(c) The validity and interpretation of this purchase order and the legal relations of the parties shall be governed by the laws of the Province of Alberta.

(d) This agreement shall enure to and be binding upon the parties and their respective heirs, executors, successors and assigns.

AXH AIR-COOLERS, LLC

TERMS AND CONDITIONS OF SALE

The following terms and conditions form part of each contract for sale by AXH Air-Coolers, LLC. (the "Seller") for the sale of any products, including equipment and parts, or services provided to a purchasing company or individual (the "Purchaser") and any contract or agreement made by and between the Seller and the Purchaser shall include these terms and conditions if provided to the Purchaser at the time of order acceptance.

1. **ENTIRE AGREEMENT:** Any term or condition of Purchaser's which is in any way additional to or different from these terms and conditions is taken exception to and shall not be applicable hereto or binding upon Seller. Any specific objection by Purchaser to the terms and conditions herein must be communicated to Seller in writing. Unless authorized by an officer of Seller in writing, no change to or waiver in respect of the terms and conditions contained herein will be recognized.

2. **QUOTATION AND PRICES:** Quotations are subject to change without notice, supersede all previous quotations rendered, and are ex-works at Seller's shop at Claremore, Oklahoma, USA, unless expressly stated otherwise in writing. All quotations expire thirty (30) days from the date of the quotation if not cancelled prior to that time or superseded by another quotation or by notice of cancellation. Prices quoted for products sold by Seller are based on receiving complete orders for the quantities specified in Seller's quotation. Seller will not be responsible for any costs incurred for any changes, modifications or additions effected by Purchaser without the prior written consent of Seller.

3. **PRICE AND TAXES:** All taxes on the completed product, including any and all applicable Sales Tax, Use Tax, Value Added Tax, Personal Property Tax, Excise Tax, Duties, Goods and Services Tax or any other direct and similar tax of any nature and kind whatsoever imposed by Federal, State or Local authorities, shall become an addition to the price payable by Purchaser.

4. **SHIPMENT AND FREIGHT:** Shipment date(s) are approximate only and are computed from the date of receipt of Purchaser's order and Release for fabrication on a best efforts basis. Shipment date(s) are subject to revision at the time of entry of the order by Seller, and the shipment date(s) provided at that time are approximate and subject to any action Seller must take in connection with other orders. Seller shall in no event be liable for any special, indirect, incidental or consequential damages arising from delay or non-delivery irrespective of the reason thereof unless expressly stated in the Seller's quotation. All packaged, prefabricated or skid mounted assemblies shall be assembled in Seller's shop to the extent possible or practicable. All such assembled units may be partially disassembled prior to shipping as necessary. All field assembly necessary to place units in operable condition shall be done by and at Purchaser's expense, unless otherwise stated in Seller's quotation. No products, including parts, will be intentionally shipped "short" without obtaining the Buyer's prior authorization to do so. The Seller's sole liability to Purchaser shall be to ship correct products at the ex-works point of shipment as soon as such products are available unless otherwise agreed upon in writing. All products are sold ex-works at Seller's shop with loading included. Transportation costs and transportation insurance is not included, unless otherwise quoted. When Seller has agreed to shipment terms other than ex-works at Seller's shop, freight or other transportation expense is based on the rate effective at time of quotation or at the time of shipment if greater, and subject to change per rate change or routing specified by Purchaser. Seller accepts no responsibility for any in-transit damage or that caused by road, salt, mud, gravel, hail, wind, water or other conditions, which are beyond the scope of Seller's or transporter's insurance coverage. At the request of Purchaser, Seller will assist Purchaser with its best efforts in administering and expediting Purchaser's claims under warranties offered by third party transporters.

5. **TERMS OF PAYMENT:** Terms of payment shall be net thirty (30) days from date of invoice, unless otherwise stated in Seller's quotation. Invoices will be issued upon either completion or shipment of each

product(s). Payments not received by the due date shall be subject to interest at the rate of 1.0% per month on the outstanding balance until payment is received. Purchaser is not entitled to reduce its payment to Seller by any amount of holdback monies or retention of any type, unless otherwise agreed in writing by Seller. Seller reserves the right to require Purchaser to provide Seller with payment security for any holdback monies or retention of any type which Seller agrees to be retained by Purchaser, in the form of an irrevocable letter of credit approved and acceptable to Seller. If in the opinion of Seller, Purchaser's credit or financial condition is unsatisfactory to Seller, or if Purchaser fails to comply with the specified payment terms, Seller reserves the right to terminate and/or suspend work on any order(s) accepted by it, or to require cash payment or security satisfactory to Seller before shipment, at any time without any further obligation or liability to Purchaser. If Seller places a delinquent account with legal counsel or agent for collection, Purchaser shall pay, in addition to the amount owing, Seller's reasonable legal counsel or agent's fees and disbursements.

6. DELAYS: Where the shipment of product is prevented or delayed by the Purchaser, under such circumstances, storage and maintenance of such goods shall be at the Purchaser's expense and risk.

7. SECURITY INTEREST: Purchaser agrees that Products shall remain the property of the Seller until the price is fully paid, in which event the Purchaser agrees to hereby grant to Seller a security interest in the products (and all proceeds thereof) to secure the Purchaser's obligation to pay for the products. The Purchaser shall have the right to receive a copy of any financing statement, financing change statement or verification statement relating to the security interest granted herein. In the event of a default of any payment, the unpaid balance of the price shall become due and payable immediately and the Seller may enter the premises where the Products are located and repossess them without further demand or notice to the Purchaser, and may resell them, notwithstanding that a portion of the price may have been paid. The Purchaser shall remain liable for any remaining unpaid balance; however, Purchaser shall be credited with the proceeds from the resale less Seller's carrying costs and the costs of removal and resale of the Products. In such event the Purchaser waives the benefits of any laws which restrict the Seller from exercising the remedies outlined herein. Seller may be entitled to exercise any additional rights and remedies available to it at law, or in equity, or under the Universal Commercial Code, or otherwise arising. Until the price is paid in full the Purchaser covenants (a) to keep the products (or any proceeds thereof) free and clear of all security interests, mortgages, charges, liens and other encumbrances, except as otherwise approved by Seller in writing prior to their creation or assumption, (b) to not sell, lease or otherwise dispose of the products or any proceeds thereof, except as otherwise approved in writing by Seller prior to such disposition, (c) to pay Seller all reasonable costs and expenses incurred by Seller in connection with enforcing Seller's security interest in the Products, or other remedies which Seller is entitled to exercise.

8.0 LIMITED WARRANTY: Seller, except as otherwise hereinafter provided, warrants that new products of its own manufacture will be free of defects in material or workmanship and to conform with and to perform in accordance with the design conditions and specifications contained in Seller's quotation, under normal and proper use in service until the expiration of the lesser of either twelve (12) months from the date of start-up or (18) months from the date of shipment by Seller, and only when subjected to operating conditions which are no more severe than and are consistent with those presented in Purchaser's specifications and Seller's resultant quotation, including any revisions thereto, when order is placed by the original purchaser. Seller also, except as otherwise provided hereinafter, warrants parts and service provided by Seller to be free of defects in material or workmanship, under normal and proper use in service until the greater of the expiration of the original warranty or (12) months from the date of service or parts shipment. These warranties are subject to the following provisions:

8.1 Repair & Replacement: Seller's liability under this warranty is expressly limited to the repair or replacement of defective Products by Seller, an agent of Seller or at an establishment authorized in writing by Seller. Seller will, upon inspection and at its sole discretion, correct that portion of the product which during the term of the warranty is found by Seller to violate the above warranty to an extent which would affect the reliable operation of the product, either by suitable repair to such product, or by furnishing replacement product(s), as necessary, at the original ex-works point of shipment, including

ground transportation to the Products installation site within North America or to the nearest port of export. Seller's normal and accepted method of testing shall be used to determine the existence of any such defect. Seller shall pay any ground transportation costs involved to and from Seller's repair facility. Purchaser shall be responsible to pay Seller's out of pocket costs for transportation, including without limitation, service truck(s) mileage charges, costs for rental vehicles, airline tickets and freight charges to ship products, and subsistence and additional premium labor for any repairs taking place if the warranty claim is found to be invalid or unless otherwise agreed upon in writing. Purchaser shall provide Seller with prompt, timely written notice of any claim pursuant to this warranty within ten (10) calendar days after the claim arises and within the specified warranty period. Purchaser shall provide Seller with all reasonable access to information, facilities and personnel as may be required to inspect the Product(s) in order to determine the nature and cause of the defect. Seller shall not be liable for the cost of any repair, replacement or adjustment to the products made by anyone other than Seller, or for labor performed by Purchaser or other parties, done without Seller's expressed written approval. Any repair or replacement of defective Product(s) by Seller shall only extend the warranty period of the replaced or repaired Products but not of the balance of the Product(s) not repaired or replaced beyond the "downtime" period involved or required to repair or replace any defect. Defective Products for which Seller provides replacement shall become the property of Seller and shall be returned to the Seller upon request.

8.2 Limitation of Warranty: Seller's obligations under this warranty do not extend to repair or replacement of products necessitated by loss of or damage to the products resulting from:

- 1) Normal or routine wear and tear; or
- 2) Erosive or corrosive action of any fluid or gas; or
- 3) Any accident, improper storage or misuse or any other condition or event not within the control of Seller; or
- 4) Vibration related problems resulting from other equipment not provided by the Seller; or
- 5) Failure due the affects of any associated products equipment during commissioning, start-up and operation not provided by the Seller; or
- 6) Unauthorized modifications or repairs to the equipment or product; or
- 7) The actions or negligence of Purchaser, its employees, contractors or agents, including but not limited to any use, operation, installation, application, maintenance or service practice not in accordance with standard industry practice or guidelines, specifications and design limitations established by Seller, or the actions or negligence of any third party, including the original manufacturer, if other than Seller, of the Products.

8.3 Third Party Warranties: The warranty of products designed and manufactured by any third party suppliers and distributed or resold separately or as part of the product or equipment by Seller is limited to the Seller's warranty with the exception of electric motors which are subject to the motor manufacture's warranty. Where products not designed and manufactured by Seller are recommended for use by it, such recommendation does not expressly or implicitly constitute a representative or warranty with respect to such products. Seller will assist Purchaser in administering and expediting Purchaser's claims under warranties offered by third party suppliers and any credit or charges arising there from are for the Purchaser's account. Copies of formal written warranty policies of third party suppliers to Seller will be made available to Purchaser upon request. Any material or components specified by Purchaser shall be subject to the 3rd suppliers warranty.

8.4 Assignment: This warranty is assignable by the Purchaser to any other party, owner or user of the equipment without the prior written consent of Seller pursuant to the terms of the Seller's warranty contained herein.

8.5 Exclusion: Except as expressly provided for herein, there are no representations, terms, conditions or warranties, either express or implied, made by Seller, respecting the nature, quality, merchantability or fitness for a particular purpose, with respect to the use, operations, replacement or repair of the products sold by Seller, and all terms, conditions and warranties implied by statute, common law, equity or otherwise are hereby expressly excluded.

9. LIMITATION OF SELLER'S LIABILITY: The repair or replacement of the defective products or service under this warranty shall constitute Seller's sole obligation and Purchaser's sole and exclusive remedy for all claims or defects regarding the products and service hereunder, whether such claims are based in contract, warranty, tort (including product liability, negligence and strict liability), or other theories. In no event shall Seller be liable for any indirect, special, incidental or consequential damages, including but not limited to loss of use, loss of profits or revenue, business interruption, interest, lost goodwill, work stoppage, impairment of other goods, loss by reason of shutdown or non-operations, increased expenses of operation, replacement of other equipment and property, the escape, release, discharge or emission of any substance which causes or may cause any harmful or deleterious effect to any person, animal, plant or property or to the environment, cost for removing any products to be repaired or replaced, transportation and installation charges in connection with the repair or servicing of any such products, and claims by or payments to customers, suppliers or other parties who have a relationship with the Purchaser. Seller is not liable for any punitive damages that may arise due to damage or loss. Seller shall not be liable for and Purchaser assumes full liability for all personal injury and property damage connected with the handling, transportation, possession, use, further manufacture or resale of the Products. In no event shall Seller's maximum liability to Purchaser in connection with this contract, including without limitation resulting from breach of contract or any other performance or non-performance of this contract, exceed the purchase price of the Product(s) in respect of which such causes arises.

10. INDEMNITY: Purchaser and Seller mutually agree to indemnify and hold harmless the other Party and its officers and employees from and against any actions, suits, claims, demands, loss, cost, damage and/or expense sustained by either Party arising out of an act or failure to act of the other Party or its employees, contractors, or agents, or arising from or incidental to the use by the other Party, its employees, contractors or agents of the products sold herein, including but not limited to any damage or bodily injury (including death) or whatsoever kind in nature, the escape, release, discharge or emission of any substance which causes or may cause a harmful or deleterious effect to any person, animal, plant or property or the environment.

11. CANCELLATION BY PURCHASER: The contract shall be subject to cancellation by Purchaser upon written notification to the Seller. In the event any termination by Purchaser, Purchaser shall pay to Seller the greater of; a minimum of 10% or the unpaid balance of the order price for the work completed by Seller at the date of termination including reimbursement of all costs irrevocably and reasonably incurred and paid or committed to in good faith in respect of the part of the order not completed on such termination (including but not limited to administrative expense), loss of profits and damages resulting from the termination.

12. ASSIGNMENT OR SUBSTITUTIONS: Seller, at its option, may subcontract any part of an order accepted by it, without the consent of Purchaser. Seller, at its option, may substitute any equivalent make and model component sold by Seller, which it has purchased from others, with other make and model of product of equal or higher in quality, without the consent of Purchaser as required to complete the product within the agreed time frame and without added cost to the Purchaser, unless mutually agreed to in writing.

13. INSPECTION AND TESTING: All components, material, parts and workmanship, constituting the product shall be, at the option of Seller, subject to Seller's normal inspection and testing during manufacture. Any additional inspection, testing or acceptance of products required by Purchaser shall be at Seller's point of manufacture. Any expenses incurred for any tests other than that which would be normally performed by Seller, or for any test performed at the request of, or to suit the convenience of Purchaser shall be at the expense of the Purchaser unless included in the order specifications and quotation.

14. DRAWINGS: Drawings and prints provided by Seller shall not be reproduced or copied in any manner by Purchaser without the prior written consent of Seller and shall not be used for manufacture by persons other than Seller unless otherwise agreed to by Seller in writing. Any drawings and general

information furnished by Seller which are outside of the general scope of the order and are to be used to aid Purchaser in installation of products sold by Seller and are furnished gratis and form no part of this agreement. Such drawings should not be used by Purchaser until checked and "approved" by Purchaser, Purchaser's engineers or such other persons or agents as Purchaser may select.

15. RADIOGRAPHIC FILMS & DOUMENTATION: Radiographic films shall be the property of the Seller and retained on a permanent basis and/or as required by ASME Code requirements and shall be made available for inspection by Purchaser at Seller's shop by any accredited representative of Purchaser. Radiographic "read reports" shall be provided to Purchaser including other NDT reports including ultrasonic testing, heat treating, or hydrotest charts, as required by the Purchase Order and in accordance with Sellers normal documentation procedures and generally accepted industry standards.

16. SPECIAL COATINGS: If the Seller is requested to undertake the application of special coatings, other than AXH's standard paint finish and/or galvanizing, it is to be in accordance with practices and standards recommended by the manufacturers of the coating material. Seller invites inspection during the application or after it is completed, prior to shipment from Seller's ex-works point of manufacture. In the event that said inspection, either by Purchaser or by Seller, reveals that the method of application is below standard Seller shall bring the application up to standard. Seller's undertaking covers the proper method of application only, and does not cover the quality of requested special coating materials. Third party inspectors, if required, and the resultant expense incurred thereof, shall be at the Purchaser's expense.

17. PATENTS: Seller shall indemnify the Purchaser against any patent infringements or for the design, of products manufactured by Seller according to designs and specifications of Purchaser. All shop drawings shall be considered to be part of Seller's designs and specifications and shall belong to and be retained by Seller. Seller shall have no responsibility for patent infringement by equipment sold by Seller which is manufactured by others.

18. FORCE MAJEURE: Any events such as War, Civil unrest, strikes, lockouts, disruptions of operations, export restrictions or commercial restrictions caused by changes of government status or government intervention beyond the control of either Party which make it impossible for either Party to execute or complete the contract shall be considered a force majeure, for the period of time the events take place, and shall exempt either Party from their obligations for timely performance.

19. GOVERNING LAW: Any agreement between the Seller and the Purchaser shall be governed by and construed in accordance with the laws of the State of Oklahoma, Tulsa County, USA. Exclusive jurisdiction shall be the either the Federal Courts of the United States or the courts of the State of Oklahoma with respect of any disputes hereunder.

BID CLARIFICATION 1



No.	Clarification/Description	Vendor's Remarks
Commercial Clarifications		
	Vendor: Air-X Limited	Quote Date: 2011-Oct-14
	Vendor Quotation #: 118454 & 118455	Clarification Date: 2011-Oct-28
	Vista File #: 1780-RFQ-009	Clarification Due Date: 2011-Nov-01
1	Please confirm pricing will be FIRM when a PO is placed and will be free from escalation during the lifetime of the PO.	Our quoted price is firm until November 14, 2011. If we are successful in being awarded this project, we will hold the price throughout the duration of the project (approximately 12-14 weeks). If the project were placed on an extended hold period then adjustments may be necessary if we were to experience increases in material costs.
2	Are any other spare parts recommended other than the spare gaskets? 1 year operating / start-up spares?	Typical recommended spare parts are: Fan, Fan shaft, motor, v-belts & bearings
3	Please see the attached T&C's word Doc. Murphy requires that the Terms being used on all PO's be off their T&C's. Once reviewed, please confirm acceptance, or if there are any modifications, please make them directly on the Word .doc using the track changes function.	Please refer to attached AXH terms & conditions and confirm that these are acceptable. Due to relatively small size of this project we cannot justify legal expenses to negotiate customer Ts & Cs.
4	Confirm Murphy Payment terms of Net 45 days is acceptable with a 10% holdback on final documentation.	Our standard terms of payment are net 30 days from the date of our invoice. A hold back of 10% for documentation is not acceptable.
5	Please see the attached Document Requirements form. Please fill in how many weeks after receipt of order each document will be submitted. If anything is Not Applicable, please make note of that. Confirm that 3 Hardcopies (1 for approval, 2 for final submission) and 2 Electronic (1 for Approval, 1 for final submission) of the Data Books will be submitted and included in the quote for documentation.	Refer to attached.
6	Freight terms should be FCA, Seller's Facility, please confirm.	We will agree to FCA AXH air-coolers plant in Claremore, Oklahoma
7	How many weeks after the award of PO will Air-X be able to submit documents? Is this time included in the quoted 12-14 weeks delivery? Assume 2 weeks for Vista drawing approval.	Approval drawings are typically submitted 2-3 weeks after acceptance of the PO. We will require drawing approval within 5 calendar days in order to stay within our quoted schedule.
Technical Clarifications		
1	Please provide optional cost to have Aerial coolers to be provided with CRN registered in the province of Alberta, Saskatchewan and British-Columbia	Add \$400 per cooler to include registration in AB, BC & SK.
2	Air-X-Limited data sheets indicates a minimum air temperature of -20 F for both air coolers; however, Vista data sheets requires a minimum ambient air temperature of -45C (-49F). Please confirm a minimum ambient air temperature of -49F will be used.	The pressure containing components for both cooling sections are rated for -49°F as indicated on our specification sheets. The cooler structures have always been & will continue to be rated for -20°F.
3	Air-X-Limited data sheets indicates a design temperature of 350 F for V-5010; however, Vista data sheets specifies a design temperature of 200 C (392F). Please confirm a design temperature of 392 F will be used.	We will revise the design temperature to 392°F.
4	For V-5010, please confirm if a vent and drain connections are included.	We have included (4) couplings. 3/4" coupling in each nozzle neck. A 1" drain coupling and a 1" coupling opposite the discharge nozzle for use as a vent or a thermowell connection.
5	Air-X-Limited quotation indicates "TIC by others" next to "automatic discharge shutters over the gas with durastroke actuator with I/P transducer". Please clarify the level of installation done by Air-X-Limited and what is required to be done by others.	Temperature controllers are not included in our scope. The TC will have to be mounted in the process piping to measure temperature with any required wiring to be performed by others. The pneumatic actuators with I/P will be shipped loose to prevent damage during shipment.
6	Air-X-Limited quotation indicates "TIC by others" next to "Warm air recirculation system with auto top & roll shutters, manual intake". Please clarify the level of installation done by Air-X-Limited and what is required to be done by others.	Same as item 5 above.
7	Please provide optional cost for a vendor standard ladder and platform at one end of each aerial cooler.	118454 - Add \$1,500 US (galvanized ladder & platform) 118454 - Add \$2,500 US (galvanized ladder & platform)

BID CLARIFICATION 1



No.	Clarification/Description	Vendor's Remarks
Vendor : Air-X Limited		Quote Date: 2011-Oct-14
Vendor Quotation #: 118454 & 118455		Clarification Date: 2011-Oct-28
Vista File # : 1780-RFQ-009		Clarification Due Date: 2011-Nov-01
8	Please include the cost for supply and installation of an electric heater in the plenum of suitable size to prevent freezing of the tubes for both tags.	To be provided & installed by others.
9	Vibration switch and temperature controller will be required. If not already included in optional price, please adjust the cost of junction boxes and terminal strips for both tags.	No junction boxes or terminal strips will be included in our scope. This is to be provided & installed by others.
10	Please confirm if Air-X-Limited design has motor lifting devices for both tags.	We have included motor removal beams in the plenum of each cooler.
11	Please confirm for V-5010, the design will be in compliance with NACE MR-0175 2009 Ed.	NACE MR0175 2003 edition
12	Please confirm that hydrotest is included in the scope of supply for both tags.	Yes, hydrotest is included for each cooler.
13	Please confirm plate material for header box of V-5010 is normalized for sour service and impact tested to -45C.	Header plate will be normalized if required by ASME code.
14	Please confirm if the V-5010 will be stress relieved.	The headers for V-5010 will be stress relieved.
15	Confirm if a mechanical run test will be performed for both tags.	Yes, we will perform our standard run test prior to shipment.
16	Air-X-Limited data sheets indicates a design pressure of 245 PSIG for V-5020; however, Vista data sheets specifies a design pressure of 1770 kPag (257 PSIG). Please confirm a design pressure of 257 PSIG will be used.	Your data sheets specified 150# flanges which are limited to 245 psig at 250°F. Given the low operating pressure of only 73 psig we assumed that you would wish to remain in 150# class flanges. Please advise if you would like us to revise our design utilizing 300# flanges & a design pressure of 257 psig (1770 kPag).
17	Please confirm plate material for header box of V-5020 is impact tested to -45C.	V-5020 header plate will be impacted tested to -49°F if required by ASME code.
18	Please specify level of NDT to be performed on V-5020 included in Air-X scope (RT, hydro, etc.).	We will provide spot x-ray, stress relief & hydrotest for V-5020.

TECHNICAL DOCUMENTS

MURPHY OIL CORPORATION
 CADOTTE GSS PILOT
 PROJECT NO. 1780



REQUISITION NO.: 1780-RFQ-009
 AERIAL COOLERS
 TAG NO. AC-5010, AC-5020

REV	DATE	DESCRIPTION	BY
A	2011-09-13	Issued for Quotation	DL
0	2011-11-28	Issued for Purchase	DL

DOCUMENT NO.	DOC. REV.	TITLE/DESCRIPTION	REV
VISTA PROJECTS LIMITED TECHNICAL DOCUMENTATION			
Specifications & Data Sheets			
1780-DS-AC5010	0	Produced Gas Aerial Cooler	0
1780-DS-AC5020	0	Boiler Feed Water Aerial Cooler	0
1780-DS-ACM5010	0	Produced Gas Aerial Cooler Fan Motor	0
1780-DS-ACM5020	0	Boiler Feed Water Aerial Cooler Fan Motor	0
Drawings			
N/A			
General			
		Scope of Supply	0
		Document Requirements	0
		Supplier Document Requirement (SDR) Code List	0
QA/QC			
		Level of Inspection	0
		Mechanical Inspection Requirements	0
		Electrical Inspection Requirements	0
		Instrumentation Inspection Requirements	0
		Weld Procedure Summary (WPS)	0
Specification Waivers			
Civil Engineering			
Electrical Engineering			
General			
Instrument and Control			
Materials, Welding, Corrosion &			
Mechanical Equipment			
Pipelines			
Process Safety Management			
SEIM Templates			
REMARKS			REV
1.0 The design, fabrication and supply of materials listed in the Scope of Supply shall be in accordance with the data sheets, drawings, specifications, standards, technical notes and attachments listed above.			



DATA SHEET

AIR COOLED EXCHANGER

DOCUMENT NO. 1780-DS-AC6010

JOB NO. 1780 PAGE 1 OF 2

TAG NO. AC-6010 QTY. 1

ITEM PRODUCED GAS AERIAL COOLER

SPECIFICATION NO.

PREPARED BY DL DATE 2011-11-28

MANUFACTURER Air-X Ltd.

SERVICE PRODUCED GAS (SOUR)

CLIENT MURPHY OIL CORP.
PROJECT CADOTTE PILOT CSS
LOCATION 13-09-085-17 W5M

BAY SIZE 1219 mm x 2134 mm (4' x 7') TYPE DRAFT FORCED NO. OF BAYS One
SURFACE AREA (m²): * EXTENDED 123.65 (1331 ft²) BARE TUBE 7.8 (84 ft²)
HEAT EXCHANGED (kW) 212.7 (726,460 BTU/hr) EFFECTIVE MTD. (°C) *
TRANSFER RATE (W/m²-°C): FINNED * BARE TUBE, SERVICE * CLEAN *

PERFORMANCE DATA

TUBE SIDE

FLUID CIRCULATED		PRODUCED GAS		TEMPERATURE:	
TOTAL FLUID ENTERING (kg/hr)		678 (1495 lb./hr)		IN (°C) 149	
				OUT (°C) 60	
	INLET	OUTLET		INLET PRESSURE (kPag) 172	
VAPOR	kg/hr	678	355	FOULING FACTOR (FT2-of/BT 0.002 (note 12)	
LIQUID	kg/hr	-	323	LATENT HEAT (kJ/kg) 2280	
STEAM	kg/hr	-	-	PRESSURE DROP:	
NON-CONDENSABLES	kg/hr	-	-	ALLOWABLE (kPa) 70	
DENSITY-LIQUID/VAPOR	kg/m ³	- / 1.52	980.5 / 1.29	DESIGN (kPa) 19.3 (2.8 psi)	
MOLECULAR WEIGHT-LIQUID/VAPOR		- / 19.95	18.02 / 22.07	VELOCITY:	
VISCOSITY-LIQUID/VAPOR	cP	- / 0.012	0.4631 / 0.0127	IN (m/s) *	
SPECIFIC HEAT-LIQUID/VAPOR	kJ/kg-°C	- / 1.911	4.329 / 1.717	OUT (m/s) *	
CONDUCTIVITY-LIQUID/VAPOR	W/m-°C	- / 0.035	0.6535 / 0.0319		

AIR SIDE

AIR QUANTITY, TOTAL (kg/s) *	FACE VELOCITY(m/s) *	TEMPERATURE IN (°C) 30
AIR FLOW RATE (Am ³ /s) 7.64 (15,976 SCFM)	MASS VELOCITY (m/s) *	TEMPERATURE OUT (°C) 53 (127.4 F)
STATIC PRESSURE (kPa) *	MIN. DESIGN TEMP. (°C) -45	ALTITUDE (m) 677m ASL

DESIGN - MATERIALS - CONSTRUCTION

DESIGN PRESSURE 1380 kPag TEST PRESSURE 1794 kPag DESIGN TEMPERATURE 200 °C

TUBE BUNDLE		HEADER		TUBE															
SIZE (W x L) (mm) *		TYPE	BOX	MATERIAL	SA-179														
NO./BAYS one		MATERIAL	SA-516-70N	OUTSIDE DIAMETER (mm)	15.9 (5/8")														
NO. OF TUBE ROW 3		CORROSION ALLOW. (mm)	1.6	MIN. WALL THICKNESS (mm)	1.65 (0.065")														
BUNDLES IN PARALLEL 1		PASSES	4	NO./BUNDLE	89														
BUNDLES IN SERIES 1		TUBE/TUBESHEET JOINING	DBL Grooved	LENGTH (mm)	1829 (6ft)														
STRUCTURE MOUNTING GRADE		SLOPE	*	PITCH (mm)	*														
LADDERS YES		PLUG MATERIAL	SA-350 LF2	<table border="1"> <thead> <tr> <th colspan="2">FIN</th> </tr> </thead> <tbody> <tr> <td>TYPE</td> <td>HI-EFF</td> </tr> <tr> <td>MATERIAL</td> <td>Aluminum</td> </tr> <tr> <td>OUTSIDE DIA. (mm)</td> <td>*</td> </tr> <tr> <td>THICKNESS (mm)</td> <td>*</td> </tr> <tr> <td>NO./m</td> <td>*</td> </tr> <tr> <td>DESIGN TEMP. (°C)</td> <td>*</td> </tr> </tbody> </table>		FIN		TYPE	HI-EFF	MATERIAL	Aluminum	OUTSIDE DIA. (mm)	*	THICKNESS (mm)	*	NO./m	*	DESIGN TEMP. (°C)	*
FIN																			
TYPE	HI-EFF																		
MATERIAL	Aluminum																		
OUTSIDE DIA. (mm)	*																		
THICKNESS (mm)	*																		
NO./m	*																		
DESIGN TEMP. (°C)	*																		
WALKWAYS YES		GASKET MATERIAL	*																
PLATFORMS YES		INLET	150# RFWN																
STRUCTURAL SURFACE PREP Galvanized		OUTLET	150# RFWN																
BUGSCREENS NOTE 5		VENT	*																
HAIL GUARDS NOTE 5		DRAIN	*																
LOUVERS NOTE 6		TI	Note 2																
VIBRATION SWITCH Murphy VS2EX		PI	Note 2																
		CHEMICAL CLEANING	*																
		HEADER SURFACE PREP	*																

HEATING COIL	
HEATING FLUID	N/A
FLOW (kg/s)	N/A
TEMPERATURE: IN (°C)	N/A
OUT (°C)	N/A
INLET PRESSURE (kPag)	N/A
DESIGN PRES (kPag)	N/A
DESIGN TEMP. (°C)	N/A
NOZZLES: IN	N/A
OUT	N/A

WEIGHTS	
TOTAL SHIPPING WT (kg)	*
HYDROTEST WT (kg)	*
BUNDLE WT (kg)	*

REV	DESCRIPTION	DATE	BY	CHK'D	APP'D	REV	DESCRIPTION	DATE	BY	CHK'D	APP'D
A	Issued for Quotation	2011-09-13	DL	RR	BH						
0	Issued for Purchase	2011-11-24	DL	RR	BJ						



DATA SHEET

AIR COOLED EXCHANGER

DOCUMENT NO. 1780-DS-AC5010

JOB NO. 1780 PAGE 2 OF 2

TAG NO. AC-5010 QTY. 1

ITEM PRODUCED GAS AERIAL COOLER

SPECIFICATION NO. _____

PREPARED BY DL DATE 2011-11-28

MANUFACTURER Air-X Ltd.

SERVICE PRODUCED GAS (SOUR)

CLIENT MURPHY OIL CORP.
 PROJECT CADOTTE PILOT CSS
 LOCATION 13-09-085-17 W5M

MECHANICAL EQUIPMENT

FAN		DRIVER		SPEED REDUCER	
MFR. AND MODEL	<u>Multi-wing</u>	TYPE	<u>Variable speed</u>	TYPE	<u>N/A</u>
NO./BAY	<u>one</u>	MODEL & MFR	<u>*</u>	MFR./MODEL	<u>-</u>
NO. BLADES	<u>8</u>	NO./BAY	<u>one</u>	NO./BAY	<u>-</u>
ANGLE (°)	<u>37.5</u>	KW/DRIVER	<u>3.72 (5HP)</u>	SERVICE FACTOR	<u>-</u>
SPEED (RPM)	<u>870</u>	SPEED (RPM)	<u>900</u>	SPEED RATIO	<u>-</u>
DIAMETER (mm)	<u>1067 (42")</u>	ENCLOSURE	<u>TEFC</u>	AGMA HP RATING (kW)	<u>-</u>
PITCH ADJ.	<u>Manual</u>	VOLT <u>480</u> PHASE <u>3</u> CYCLE <u>60</u>			
MATERIAL (BLADE/HUB)	<u>PAG</u>	FAN NOISE LEVEL (dBA) <u>85 dBA @ 1 m away</u>			
FAN DRAW:					
@ DESIGN (kW)	<u>2.6 (3.5 HP)</u>				
@ MIN. AMBIENT (kW)	<u>*</u>				
MAX. TIP SPEED:					
ALLOWABLE (m/s)	<u>*</u>				
CALCULATED (m/s)	<u>48.6 (9566 fpm)</u>				

- NOTES:**
1. "*" indicates vendor to provide information.
 2. Thermowell and pressure gauge connection shall be supplied on each inlet and outlet nozzle according to API 661.
 3. Design, Inspection and Test shall meet ASME Section VIII Div 1, API 661 and NACE requirements.
 4. Air Cooled Exchanger shall be registered in Alberta, Saskatchewan and British Columbia.
 5. Provide bug screens and hall guards.
 6. Provide auto louvers with pneumatic actuators and I/P transducer capable of receiving 4-20 mA from the PLC.
 7. Maintain temperature > 7 C during winter with warm air recirculation with pneumatic actuators and temperature RTD/transmitter (RTD/transmitter) to maintain steady air supply temperature and prevent freezing.
 8. Design for Full Vacuum conditions
 9. Nozzle loads to be suitable for 3 times API 661 nozzle Loads
 10. Deleted
 11. Equipment to be rated for NACE sour service.
 12. Vendor to confirm fouling factor.
 13. Vendor to provide recirculation louvers to go with air inlet louver and air discharge louver to prevent freeze-up.
 14. Deleted
 15. Deleted
 16. Deleted

REV	DESCRIPTION	DATE	BY	CHK'D	APP'D	REV	DESCRIPTION	DATE	BY	CHK'D	APP'D
A	Issued for Quotation	2011-09-13	DL	RR	BH						
0	Issued for Purchase	2011-11-24	DL	AP	BJ						



DATA SHEET

AIR COOLED EXCHANGER

DOCUMENT NO. 1780-DS-AC5020

JOB NO. 1780 PAGE 1 OF 2

TAG NO. AC-5020 QTY. 1

ITEM

SPECIFICATION NO.

PREPARED BY DL DATE 2011-11-28

MANUFACTURER Air-X Ltd.

SERVICE BOILER FEED WATER

CLIENT MURPHY OIL CORP.
PROJECT CADOTTE PILOT CSS
LOCATION 13-09-085-17 W5M

BAY SIZE 2743 mm x 5182 mm (9' x 17') TYPE DRAFT FORCED NO. OF BAYS One
SURFACE AREA (m²): EXTENDED 807 (8687 ft²) BARE TUBE 50.7 (546 ft²)
HEAT EXCHANGED (kW) 793.9 (2,711,224 BTU/hr) EFFECTIVE MTD. (°C) *
TRANSFER RATE (W/m²·°C): FINNED * BARE TUBE, SERVICE * CLEAN *

PERFORMANCE DATA

TUBE SIDE

FLUID CIRCULATED		BOLER FEED WATER		TEMPERATURE:	
TOTAL FLUID ENTERING (kg/hr)		18860 (41580 lb/hr)		IN (°C)	75
				OUT (°C)	40
		INLET	OUTLET	INLET PRESSURE (kPag)	503
VAPOR	kg/hr	-	-	FOULING FACTOR (FT2-oF/BT	0.001 (note 11)
LIQUID	kg/hr	18860	18860	LATENT HEAT (kJ/kg)	2109
STEAM	kg/hr	-	-	PRESSURE DROP:	
NON-CONDENSABLES	kg/hr	-	-	ALLOWABLE (kPa)	70
DENSITY-LIQUID/VAPOR	kg/m ³	968.7 / -	996.1 / -	DESIGN (kPa)	57.9 (8.4 psi)
MOLECULAR WEIGHT-LIQUID/VAPOR		18.02 / -	18.02 / -	VELOCITY:	
VISCOSITY-LIQUID/VAPOR	cP	0.3743 / -	0.6514 / -	IN (m/s)	*
SPECIFIC HEAT-LIQUID/VAPOR	kJ/kg·°C	4.348 / -	4.315 / -	OUT (m/s)	*
CONDUCTIVITY-LIQUID/VAPOR	W/m·°C	0.6662 / -	0.6315 / -		

AIR SIDE

AIR QUANTITY, TOTAL (SCFM)	*	FACE VELOCITY(m/s)	*	TEMPERATURE IN (°C)	30 (86 F)
AIR FLOW RATE/FAN (Am ³ /48.8 (103,485 SCFM)		MASS VELOCITY (m/s)	*	TEMPERATURE OUT (°C)	43.1 (109.6 F)
STATIC PRESSURE (kPa)	*	MIN. DESIGN TEMP. (°C)	-45	ALTITUDE (m)	677 m ASL

DESIGN - MATERIALS - CONSTRUCTION

DESIGN PRESSURE 1770 kPag TEST PRESSURE 2301 kPag DESIGN TEMPERATURE 100 °C

TUBE BUNDLE

HEADER

TUBE

SIZE (W x L) (mm)	*	TYPE	BOX	MATERIAL	SA-179
NO./BAYS	1	MATERIAL	SA-516-70	OUTSIDE DIAMETER (in)	15.9 (5/8")
NO. OF TUBE ROW	3	CORROSION ALLOW. (mm)	1.6	MIN. WALL THICKNESS (mm)	1.65 (0.065")
BUNDLES IN PARALLEL	1	PASSES	6	NO./BUNDLE	212
BUNDLES IN SERIES	1	TUBE/TUBESHEET JOINING	DBL Grooved	LENGTH (mm)	4877 (16')
STRUCTURE MOUNTING	GRADE	SLOPE	*	PITCH (mm)	*
LADDERS	YES	PLUG MATERIAL	SA-350 LF2	FIN	
WALKWAYS	YES	GASKET MATERIAL	*	TYPE	HI-EFF
PLATFORMS	YES	INLET	150# RFWN	MATERIAL	Aluminum
STRUCTURAL SURFACE PREP	Galvanized	OUTLET	150# RFWN	OUTSIDE DIA. (mm)	*
BUGSCREENS	NOTE 5	VENT	*	THICKNESS (mm)	*
HAIL GUARDS	NOTE 5	DRAIN	*	NO./m	*
LOUVERS	NOTE 6	TI	Note 2	DESIGN TEMP. (°C)	*
VIBRATION SWITCH	Murphy VS2EX	PI	Note 2		
		CHEMICAL CLEANING	*		
		HEADER SURFACE PREP	*		

HEATING COIL

HEATING FLUID	N/A
FLOW (kg/s)	N/A
TEMPERATURE: IN (°C)	N/A
OUT (°C)	N/A
INLET PRESSURE (kPag)	N/A
DESIGN PRES (kPag)	N/A
DESIGN TEMP. (°C)	N/A
NOZZLES: IN	N/A
OUT	N/A

WEIGHTS

TOTAL SHIPPING WT (kg)	*
HYDROTEST WT (kg)	*
BUNDLE WT (kg)	*

REV	DESCRIPTION	DATE	BY	CHK'D	APP'D	REV	DESCRIPTION	DATE	BY	CHK'D	APP'D
A	Issued for Quotation	2011-09-13	DL	RR	BH						
B	Revised BFW flow rate	2011-09-30	DL	AP	BJ						
0	Issued for Purchase	2011-11-24	DL	AP	BJ						



DATA SHEET

AIR COOLED EXCHANGER

DOCUMENT NO. 1780-DS-AC5020

JOB NO. 1780 PAGE 2 OF 2

TAG NO. AC-5020 QTY. 1

ITEM _____

SPECIFICATION NO. _____

CLIENT MURPHY OIL CORP.

PREPARED BY DL DATE 2011-11-28

PROJECT CADOTTE PILOT CSS

MANUFACTURER Air-X Ltd.

LOCATION 13-09-085-17 W5M

SERVICE BOILER FEED WATER


MECHANICAL EQUIPMENT

FAN		DRIVER		SPEED REDUCER	
MFR. AND MODEL	<u>MOORE C/W VT TIP SEALS</u>	TYPE	<u>Variable speed</u>	TYPE	<u>V- Belt</u>
NO./BAY	<u>1</u>	MODEL & MFR	<u>*</u>	MFR./MODEL	<u>*</u>
NO. BLADES	<u>6</u>	NO./BAY	<u>1</u>	NO./BAY	<u>1</u>
ANGLE (°)	<u>18.9</u>	KW/DRIVER	<u>18.6 (25 HP)</u>	SERVICE FACTOR	<u>1.15</u>
SPEED (RPM)	<u>389</u>	SPEED (RPM)	<u>1800</u>	SPEED RATIO	<u>*</u>
DIAMETER (mm)	<u>2438 (96")</u>	ENCLOSURE	<u>TEFC</u>	AGMA HP RATING (kW)	<u>*</u>
PITCH ADJ.	<u>Manual</u>	VOLT <u>480</u> PHASE <u>3</u> CYCLE <u>60</u>			
MATERIAL (BLADE/HUB)	<u>Aluminum</u>	FAN NOISE LEVEL (dBA) <u>85 dBA @ 1 m away</u>			
FAN DRAW:					
@ DESIGN (kW)	<u>16.6 (22.3 HP)</u>				
@ MIN. AMBIENT (k)	<u>*</u>				
MAX. TIP SPEED:					
ALLOWABLE (m/s)	<u>*</u>				
CALCULATED (m/s)	<u>49.7 (9776 fpm)</u>				

- NOTES:**
1. "*" Indicates vendor to provide information.
 2. Thermowell and pressure gauge connection shall be supplied on each inlet and outlet nozzle according to API 661.
 3. Design, Inspection and Test shall meet ASME Section VIII Div 1 and API 661 requirements.
 4. Air Cooled Exchanger shall be registered in Alberta, Saskatchewan and British Columbia.
 5. Provide bug screens and hall guards.
 6. Provide auto louvers with pneumatic actuators and I/P transducer capable of receiving 4-20 mA from the PLC.
 7. Maintain temperature > 7 C during winter with warm air recirculation with pneumatic actuators and temperature RTD/transmitter (RTD/transmitter) to maintain steady air supply temperature and prevent freezing.
 - 8 Deleted
 - 9 Nozzle loads to be suitable for 3 times API 661 nozzle Loads
 - 10 Deleted
 - 11 Vendor to confirm fouling factor.
 - 12 Deleted
 - 13 Deleted
 - 14 Deleted
 - 15 Deleted

REV	DESCRIPTION	DATE	BY	CHK'D	APP'D	REV	DESCRIPTION	DATE	BY	CHK'D	APP'D
65	A	Issued for Quotation	2011-09-13	DL	RR BH						
66	B	Revised BFW flow rate	2011-09-30	DL	AP BJ						
67	0	Issued for Purchase	2011-11-24	DL	AP BJ						

Handwritten initials/signature

 DATA SHEET	DOCUMENT NO. <u>1780-DS-ACM5010</u> JOB NO. <u>1780</u> PAGE <u>1</u> OF <u>3</u> TAG NO. <u>ACM-5010</u> QTY. <u>1</u> ITEM <u>Produced Gas Aerial Cooler Fan Motor</u> SPECIFICATION NO. <u>N/A</u> PREPARED BY <u>BM</u> DATE <u>2011-09-07</u> MANUFACTURER <u>See Note 3 on Sheet 3</u> SERVICE <u>Produced Gas Aerial Cooler</u>
SMALL ELECTRIC MOTOR (≤ 150 kW)	
CLIENT <u>Murphy Oil Corporation</u> PROJECT <u>Cadotte CSS Pilot</u> LOCATION <u>LSD 13-09-85-17 W5M</u>	

NAME PLATE SIZE: <u>5</u> HP * POWER FACTOR _____ VOLTAGE <u>460</u> V, THREE-PHASE, 60Hz * FULL LOAD SPEED: <u>900</u> rpm SERVICE FACTOR <u>1.15</u> <input checked="" type="checkbox"/> INSULATION CLASS "F" (as per spec.) <input type="checkbox"/> OTHER: <input checked="" type="checkbox"/> TEMP. RISE (by RESISTANCE): <u>80</u> °C ABOVE <u>40</u> °C AMBIENT <input type="checkbox"/> OTHER (by RTD): _____ °C ABOVE _____ °C AMBIENT	SITE CONDITIONS ALTITUDE: <u>678</u> m (above sea level) AMBIENT TEMPERATURE: MAX <u>30</u> °C, MIN. <u>-40</u> °C <input checked="" type="checkbox"/> INDOOR <input type="checkbox"/> OUTDOOR <input type="checkbox"/> NON-HAZARDOUS <input checked="" type="checkbox"/> HAZARDOUS: CLASS <u>1</u> ZONE <u>2</u> GAS GROUP <u>IIA</u> INDOOR TEMPERATURE MAX _____ °C, MIN. _____ °C <input type="checkbox"/> UNUSUAL CONDITIONS: <input type="checkbox"/> CORROSIVE <input type="checkbox"/> DUST <input type="checkbox"/> GASES: <input checked="" type="checkbox"/> OTHER: <u>"Sour" Ambient Environment</u>
--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

MOTOR TYPE <input type="checkbox"/> HORIZONTAL <input checked="" type="checkbox"/> VERTICAL <input checked="" type="checkbox"/> SQUIRREL CAGE INDUCTION <input type="checkbox"/> SYNCHRONOUS FIELD CTRL. METHOD: _____ <input type="checkbox"/> OTHER: _____	POWER SYSTEM AND STARTING METHOD SYSTEM IMPEDANCE AT MOTOR TERMINALS: R% + jX% _____ ON 100 MVA BASE MAXIMUM LOCKED ROTOR CURRENT AT RATED VOLTS: <u>650% of FLA</u> A MAXIMUM VOLTAGE DROP AT MOTOR TERMINALS: <u>-20% of rated voltage</u> V STARTING METHOD: <u>Inverter Duty (Supplied by Owner)</u> * RECOMMENDED MAXIMUM POWER FACTOR CORRECTION CAPACITOR: _____ kVar
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ENCLOSURE <input type="checkbox"/> ODP <input checked="" type="checkbox"/> TEFC <input type="checkbox"/> WP/II <input type="checkbox"/> TEMP: ZONE <u>2</u> GAS GROUP <u>IIA</u> SURFACE TEMPERATURE CODE <u>T2B</u> <input type="checkbox"/> TEFV: AIR FLOW RATE _____ m³/h INLET PRESSURE _____ kPa <input type="checkbox"/> TEWAC: <input type="checkbox"/> SINGLE COOLER TUBES <input type="checkbox"/> DOUBLE COOLER TUBES COOLING WATER DATA: INLET TEMP. MAX _____ °C, MIN. _____ °C TEMP. RISE MAX _____ °C, MIN. _____ °C INLET PRESSURE MAX _____ kPa, MIN. _____ kPa MAX. AVAIL. FLOWRATE: _____ l/min <input type="checkbox"/> WATER ANALYSIS ENCLOSED CORROSION ALLOWANCE: _____ mm FOULING ALLOWANCE: _____ (Excess area) _____ <input type="checkbox"/> OTHER ENCLOSURE: _____ * FRAME NO.: _____ * MAX. KW IN QUOTED FRAME: _____ kW	IMPEDANCE AND FAULT PARAMETERS * REACTANCES: SUBTRANSIENT, X'd _____ % TRANSIENT, X'd _____ % SYNCHRONOUS, Xd _____ % * AC RESISTANCE OF STATOR: _____ Ω AT _____ °C * OPEN CIRCUIT AC TIME CONSTANT: _____ s * FORCE EXERTED AT STATOR FEET DURING THREE-TERMINAL FAULT: _____ N
-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

ADJUSTABLE FREQUENCY DRIVE <input checked="" type="checkbox"/> APPLICABLE: TYPE _____ LOAD CHARACTERISTIC _____ FREQUENCY RANGE: _____ TO _____ Hz, _____ TO _____ rpm DISPLACED NEUTRAL: _____ TORSIONAL STUDY: <input type="checkbox"/> PERFORM <input type="checkbox"/> SUPPLY DATA TO _____	REWINDING WINDING DATA _____ _____ _____ _____ _____ _____ _____ _____ _____ _____
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REV	DESCRIPTION	DATE	BY	CHK'D	APP'D	REV	DESCRIPTION	DATE	BY	CHK'D	APP'D
A	Issued for Quotation	2011-09-07	BM	SST	BH						
0	Issued for Purchase	2011-11-29	BM	SST	BJ						



DATA SHEET

SMALL ELECTRIC MOTOR (≤ 150 kW)

DOCUMENT NO. 1780-DS-ACM5010

JOB NO. 1780 PAGE 2 OF 3

TAG NO. ACM-5010 QTY. 1

ITEM Produced Gas Aerial Cooler Fan Motor

SPECIFICATION NO. N/A

PREPARED BY BM DATE 2011-09-07

MANUFACTURER See Note 3 on Sheet 3

SERVICE Produced Gas Aerial Cooler

CLIENT Murphy Oil Corporation

PROJECT Cadotte CSS Pilot

LOCATION LSD 13-09-85-17 W5M

PERFORMANCE

* STARTING
RATED VOLTAGE
REDUCED VOLTAGE
* LOCKED ROTOR VALUES AT RATED VOLTAGE
CURRENT
POWER FACTOR
SAFE STALL TIME: COLD s, HOT s
* GD² INERTIA:
ROTOR kg.m²
FLYWHEEL kg.m²
LOAD kg.m²
* ACCELERATION TIME (with load): s
* NUMBER OF STARTS PER HOUR:

TORQUE (% FLT) AT RATED VOLTAGE

INDUCTION MOTOR SYNCHRONOUS MOTOR
LOCKED ROTOR: STARTING:
PULL-UP: PULL-IN:
BREAKDOWN: PULL-OUT:

CURVES (at rated and reduced voltage)

SPEED Vs MOTOR TORQUE COMBINED SPEED/TORQUE
SPEED Vs LOAD TORQUE FOR PUMP
SPEED Vs CURRENT
SPEED Vs POWER FACTOR
"V" CURVES (synchronous)

RUNNING AT RATED VOLTAGE

* FULL LOAD CURRENT: A
* FULL LOAD TORQUE: N.m
* EFFICIENCY:
EFFICIENCY (%)
POWER FACTOR (%)
EFFICIENCY COST FACTOR: \$/kW
IEEE STD 12 TEST METHOD:
STRAY LOSS LOAD ALLOWANCE: %
SYNCHRONOUS MOTOR EXCITER:
BRUSHLESS EXCITER RATING kW
EXCITER FIELD CURRENT
RATED: A
MAX.: A
MIN.: A
EXCITER RATED VOLTAGE: V
EXCITER FIELD RESISTANCE: Ω AT °C

POWER TERMINAL BOX AND EQUIPMENT

LOCATION FROM ODE:
LHS RHS
DIRECTION OF CABLE ENTRANCE
LUGS REQUIRED:
LIGHTNING ARRESTER:
SURGE CAPACITOR:
DIFFERENTIAL CTs
SELF BALANCING (3 - CTs)
PERCENTAGE DIFFERENCE (6 - CTs)
RATIO:
ACCURACY:
SPACE FOR STRESS CONES
FILTERS
WEATHERPROOF JUNCTION BOXES
OTHER:

TEMPERATURE MEASURING EQUIPMENT

100 Ω PLATINUM TYPE RTD FOR:
WINDINGS:
NUMBER PER PHASE (min 1)
BEARINGS:
* SETPOINT DATA
WINDING (°C) ALARM SHUTDOWN
BEARING (°C)

MISCELLANEOUS

VIBRATION SENSORS OPTION
MANUFACTURER: Murphy VS2EX
LOCATION: Field Installation
SPACE HEATERS:
VOLTAGE V PHASE
QUANTITY X SIZE: X W
EXPLOSION PROOF:
ZONE GAS GROUP
* EXPECTED NO-LOAD SOUND LEVEL: dBA
* SPECIAL BEARING SEALS (list below)

Table with 6 columns: REV, DESCRIPTION, DATE, BY, CHK'D, APP'D. Contains revision history for the document.



DOCUMENT NO. 1780-DS-ACM5010

REV

JOB NO. 1780 PAGE 3 OF 3

TAG NO. ACM-5010 QTY. 1

ITEM Produced Gas Aerial Cooler Fan Motor

SPECIFICATION NO. N/A

PREPARED BY BM DATE 2011-09-07

MANUFACTURER See Note 3 on Sheet 3

SERVICE Produced Gas Aerial Cooler

DATA SHEET

SMALL ELECTRIC MOTOR (≤ 150 kW)

CLIENT Murphy Oil Corporation

PROJECT Cadotte CSS Pilot

LOCATION LSD 13-09-85-17 W5M

DRIVE SYSTEM

- * SHAFT
 - SINGLE DOUBLE
 - DIRE # _____
 - BELT DRIVE
 - ROTATION: CLOCKWISE COUNTER-CLOCKWISE
 - COUPLING: SUPPLIED BY _____
 - MOTOR COUPLING HALF MOUNTED BY: _____
 - DRIVEN EQUIP. MFR. MOTOR MFR. PURCHASER
 - COUPLING REFERENCE: _____

SHOP TESTS AND INSPECTIONS

	REQ'D	OBSERVE	WITNESS
ROUTINE	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
COMPLETE	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

WITNESS TESTING TO BE PRICED SEPARATELY IF AT ADDITIONAL COST

BEARINGS

- * TYPE: DE _____
- ODE _____
- * PART NUMBER: DE _____
- ODE _____
- INSULATED ODE BEARING
- BOTH BRGS INSUL W/ DE GRD STRAP
- * SHAFT END PLAY: _____ mm
- * ANTI-FRICTION BEARING RETAINER RING MATERIAL: _____

* WEIGHTS

ROTOR _____ kg	STATOR _____ kg
TOTAL _____ kg	SHIPPING _____ kg
MAX MAINTENANCE: _____ kg	

LUBRICATION

- GREASE OIL FORCE FEED OIL
- OIL MIST (see details under notes)
- MANUFACTURER: _____
- NAME: _____
- OIL FLOW RATE: _____ l/h AT _____ kPa

* OUTLINE DIMENSIONS

L _____ mm W _____ mm H _____ mm

PAINT

- MFR. STANDARD
- OTHER: _____

MISCELLANEOUS

- * FANS: UNI-DIRECTIONAL MFR. STANDARD NON-SPARKING
- * MOUNTING PLATES: SOLE BASE
- STATOR SHIFT
- AIR FILTERS: MFR. _____
- TYPE _____
- LATERAL CRITICAL SPEED DATA: _____
- TORSIONAL CRITICAL SPEED DATA: _____
- LATERAL CRITICAL SPEED COMPLIANCE REQUIRED

QUALITY CONTROL

- ISO 9001
- OTHER: _____

NOTES:

1. * Indicates Vendor to provide information.
2. Refer to Drawings and Data sheet.
3. Approved Motor Vendors- Toshiba, Reliance/Baldor, General Electric, TECO Westinghouse, Siemens, Hyundai, ABB, US Electric

REV	DESCRIPTION	DATE	BY	CHK'D	APP'D	REV	DESCRIPTION	DATE	BY	CHK'D	APP'D
A	Issued for Quotation	2011-09-07	BM	SST	BH						
0	Issued for Purchase	2011-11-29	BM	SST	BJ						
			BM	SST	BJ						



DATA SHEET

SMALL ELECTRIC MOTOR (≤ 150 kW)

CLIENT Murphy Oil Corporation
 PROJECT Cadotte CSS Pilot
 LOCATION LSD 13-09-85-17 W5M

DOCUMENT NO. 1780-DS-ACM5020
 JOB NO. 1780 PAGE 1 OF 3
 TAG NO. ACM-6020 QTY. 1
 ITEM Raw Water Aerial Cooler Fan Motor
 SPECIFICATION NO. N/A
 PREPARED BY BM DATE 2011-09-07
 MANUFACTURER See Note 3 on Sheet 3
 SERVICE Raw Water Aerial Cooler

REV

NAME PLATE

SIZE: 25 HP
 * POWER FACTOR _____
 VOLTAGE 460 V, THREE-PHASE, 60Hz
 * FULL LOAD SPEED: 1800 rpm
 SERVICE FACTOR 1.15
 INSULATION CLASS "F" (as per spec.) OTHER:
 TEMP. RISE (by RESISTANCE): 80 °C ABOVE 40 °C AMBIENT
 OTHER (by RTD): _____ °C ABOVE _____ °C AMBIENT

SITE CONDITIONS

ALTITUDE: 678 m (above sea level)
 AMBIENT TEMPERATURE: MAX 30 °C, MIN. -40 °C
 INDOOR
 OUTDOOR
 NON-HAZARDOUS
 HAZARDOUS:
 CLASS I ZONE 2 GAS GROUP IIA
 INDOOR TEMPERATURE MAX _____ °C, MIN. _____ °C
 UNUSUAL CONDITIONS:
 CORROSIVE
 DUST
 GASES:
 OTHER: "Sour" Ambient Environment

MOTOR TYPE

HORIZONTAL VERTICAL
 SQUIRREL CAGE INDUCTION
 SYNCHRONOUS
 FIELD CTRL. METHOD: _____
 OTHER: _____

POWER SYSTEM AND STARTING METHOD

SYSTEM IMPEDANCE AT MOTOR TERMINALS:
 R% + jX% _____ ON 100 MVA BASE
 MAXIMUM LOCKED ROTOR CURRENT AT RATED VOLTS:
650% of FLA A
 MAXIMUM VOLTAGE DROP AT MOTOR TERMINALS:
-20% of rated voltage V
 STARTING METHOD: Inverter Duty (Supplied by Owner)
 * RECOMMENDED MAXIMUM POWER FACTOR CORRECTION
 CAPACITOR: _____ kVAR

ENCLOSURE

ODP TEFC WP/II
 TEXP: ZONE 2 GAS GROUP IIA
 SURFACE TEMPERATURE CODE T2B
 TEFV:
 AIR FLOW RATE _____ m³/h
 INLET PRESSURE _____ kPa
 TEWAC:
 SINGLE COOLER TUBES DOUBLE COOLER TUBES
 COOLING WATER DATA:
 INLET TEMP. MAX _____ °C, MIN. _____ °C
 TEMP. RISE MAX _____ °C, MIN. _____ °C
 INLET PRESSURE MAX _____ kPa, MIN. _____ kPa
 MAX. AVAIL. FLOWRATE: _____ l/min
 WATER ANALYSIS ENCLOSED
 CORROSION ALLOWANCE: _____ mm
 FOULING ALLOWANCE: _____
 (Excess area) _____
 OTHER ENCLOSURE: _____
 * FRAME NO.: _____
 * MAX. kW IN QUOTED FRAME: _____ kW

IMPEDANCE AND FAULT PARAMETERS

* REACTANCES:
 SUBTRANSIENT, X'd _____ %
 TRANSIENT, X'd _____ %
 SYNCHRONOUS, Xd _____ %
 * AC RESISTANCE OF STATOR: _____ Ω AT _____ °C
 * OPEN CIRCUIT AC TIME CONSTANT: _____ s
 * FORCE EXERTED AT STATOR FEET DURING THREE-TERMINAL
 FAULT: _____ N

ADJUSTABLE FREQUENCY DRIVE

APPLICABLE:
 TYPE _____
 LOAD CHARACTERISTIC _____
 FREQUENCY RANGE:
 _____ TO _____ Hz, _____ TO _____ rpm
 DISPLACED NEUTRAL: _____
 TORSIONAL STUDY:
 PERFORM
 SUPPLY DATA TO _____

REWINDING

WINDING DATA _____

REV	DESCRIPTION	DATE	BY	CHK'D	APP'D	REV	DESCRIPTION	DATE	BY	CHK'D	APP'D
A	Issued for Quotation	2011-09-07	BM	SST	BH						
0	Issued for Purchase	2011-11-29	BM	SST	BJ						



DATA SHEET

SMALL ELECTRIC MOTOR (≤ 150 kW)

CLIENT: Murphy Oil Corporation
PROJECT: Cadotte CSS Pilot
LOCATION: LSD 13-09-85-17 W5M

DOCUMENT NO. 1780-DS-ACM5020
JOB NO. 1780 PAGE 2 OF 3
TAG NO. ACM-5020 QTY. 1
ITEM Raw Water Aerial Cooler Fan Motor
SPECIFICATION NO. N/A
PREPARED BY BM DATE 2011-09-07
MANUFACTURER See Note 3 on Sheet 3
SERVICE Raw Water Aerial Cooler

REV

PERFORMANCE

* STARTING
RATED VOLTAGE RED 480 %
* LOCKED ROTOR VALUES AT RATED VOLTAGE
CURRENT % FULL LOAD
POWER FACTOR
SAFE STALL TIME: COLD s, HOT s
* GD² INERTIA:
ROTOR kg.m²
FLYWHEEL kg.m²
LOAD kg.m²
* ACCELERATION TIME (with load): s
* NUMBER OF STARTS PER HOUR:

POWER TERMINAL BOX AND EQUIPMENT

LOCATION FROM ODE:
LHS RHS
DIRECTION OF CABLE ENTRANCE
LUGS REQUIRED:
LIGHTNING ARRESTER:
SURGE CAPACITOR:
DIFFERENTIAL CTs
SELF BALANCING (3 - CTs)
PERCENTAGE DIFFERENCE (6 - CTs)
RATIO:
ACCURACY:
SPACE FOR STRESS CONES
FILTERS
WEATHERPROOF JUNCTION BOXES
OTHER:

TORQUE (% FLT) AT RATED VOLTAGE

INDUCTION MOTOR SYNCHRONOUS MOTOR
LOCKED ROTOR: STARTING:
PULL-UP: PULL-IN:
BREAKDOWN: PULL-OUT:

TEMPERATURE MEASURING EQUIPMENT

100 Ω PLATINUM TYPE RTD FOR:
WINDINGS:
NUMBER PER PHASE (min 1)
BEARINGS:
* SETPOINT DATA
WINDING (°C) ALARM SHUTDOWN
BEARING (°C)
ROTOR PROTECTION:

CURVES (at rated and reduced voltage)

SPEED Vs MOTOR TORQUE COMBINED SPEED/TORQUE
SPEED Vs LOAD TORQUE FOR PUMP
SPEED Vs CURRENT
SPEED Vs POWER FACTOR
"V" CURVES (synchronous)


RUNNING AT RATED VOLTAGE

* FULL LOAD CURRENT: A
* FULL LOAD TORQUE: N.m
* EFFICIENCY:
EFFICIENCY (%) POWER FACTOR (%)
EFFICIENCY COST FACTOR: \$/kW
IEEE STD 12 TEST METHOD:
STRAY LOSS LOAD ALLOWANCE: %
SYNCHRONOUS MOTOR EXCITER
BRUSHLESS EXCITER RATING kW
EXCITER FIELD CURRENT
RATED: A
MAX.: A
MIN.: A
EXCITER RATED VOLTAGE: V
EXCITER FIELD RESISTANCE: Ω AT °C

MISCELLANEOUS

VIBRATION SENSORS OPTION
MANUFACTURER: Murphy VS2EX
LOCATION: Field Installation
SPACE HEATERS:
VOLTAGE V PHASE
QUANTITY X SIZE: X W
EXPLOSION PROOF:
ZONE GAS GROUP
EXPECTED NO-LOAD SOUND LEVEL: dBA
SPECIAL BEARING SEALS (list below)

Table with 6 columns: REV, DESCRIPTION, DATE, BY, CHK'D, APP'D. Contains revision history for the document.

 DATA SHEET	DOCUMENT NO. <u>1780-DS-ACM5020</u> JOB NO. <u>1780</u> PAGE <u>3</u> OF <u>3</u> TAG NO. <u>ACM-5020</u> QTY. <u>1</u> ITEM <u>Raw Water Aerial Cooler Fan Motor</u> SPECIFICATION NO. <u>N/A</u> PREPARED BY <u>BM</u> DATE <u>2011-09-07</u> MANUFACTURER <u>See Note 3 on Sheet 3</u> SERVICE <u>Raw Water Aerial Cooler</u>
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<p>SMALL ELECTRIC MOTOR (≤ 150 kW)</p> <p>CLIENT <u>Murphy Oil Corporation</u> PROJECT <u>Cadotte CSS Pilot</u> LOCATION <u>LSD 13-09-85-17 W6M</u></p> <p style="text-align: center;">DRIVE SYSTEM</p> <p>* SHAFT <input type="checkbox"/> SINGLE <input type="checkbox"/> DOUBLE <input type="checkbox"/> DIRE # <input type="checkbox"/> BELT DRIVE ROTATION: <input checked="" type="checkbox"/> CLOCKWISE <input checked="" type="checkbox"/> COUNTER-CLOCKWISE <input type="checkbox"/> COUPLING: SUPPLIED BY _____ MOTOR COUPLING HALF MOUNTED BY: <input type="checkbox"/> DRIVEN EQUIP. MFR. <input type="checkbox"/> MOTOR MFR. <input type="checkbox"/> PURCHASER <input type="checkbox"/> COUPLING REFERENCE: _____</p> <p style="text-align: center;">BEARINGS</p> <p>* TYPE: DE _____ ODE _____ * PART NUMBER: DE _____ ODE _____ <input type="checkbox"/> INSULATED ODE BEARING <input type="checkbox"/> BOTH BRGS INSUL /W DE GRD STRAP * SHAFT END PLAY: _____ mm * ANTI-FRICTION BEARING RETAINER RING MATERIAL: _____</p> <p style="text-align: center;">LUBRICATION</p> <p><input checked="" type="checkbox"/> GREASE <input type="checkbox"/> OIL <input type="checkbox"/> FORCE FEED OIL <input type="checkbox"/> OIL MIST (see details under notes) <input type="checkbox"/> MANUFACTURER: _____ <input type="checkbox"/> NAME: _____ <input type="checkbox"/> OIL FLOW RATE: _____ l/h AT _____ kPa</p> <p style="text-align: center;">MISCELLANEOUS</p> <p>* FANS: <input type="checkbox"/> UNI-DIRECTIONAL <input type="checkbox"/> MFR. STANDARD <input type="checkbox"/> NON-SPARKING * MOUNTING PLATES: <input type="checkbox"/> SOLE <input type="checkbox"/> BASE <input type="checkbox"/> STATOR SHIFT <input type="checkbox"/> AIR FILTERS: MFR. _____ TYPE _____ <input type="checkbox"/> LATERAL CRITICAL SPEED DATA: _____ <input type="checkbox"/> TORSIONAL CRITICAL SPEED DATA: _____ <input type="checkbox"/> LATERAL CRITICAL SPEED COMPLIANCE REQUIRED</p>	<p style="text-align: center;">SHOP TESTS AND INSPECTIONS</p> <table style="width:100%; border-collapse: collapse;"> <tr> <td></td> <td style="text-align: center;">REQ'D</td> <td style="text-align: center;">OBSERVE</td> <td style="text-align: center;">WITNESS</td> </tr> <tr> <td>ROUTINE</td> <td style="text-align: center;"><input type="checkbox"/></td> <td style="text-align: center;"><input type="checkbox"/></td> <td style="text-align: center;"><input type="checkbox"/></td> </tr> <tr> <td>COMPLETE</td> <td style="text-align: center;"><input checked="" type="checkbox"/></td> <td style="text-align: center;"><input type="checkbox"/></td> <td style="text-align: center;"><input type="checkbox"/></td> </tr> <tr> <td>_____</td> <td style="text-align: center;"><input type="checkbox"/></td> <td style="text-align: center;"><input type="checkbox"/></td> <td style="text-align: center;"><input type="checkbox"/></td> </tr> <tr> <td>_____</td> <td style="text-align: center;"><input type="checkbox"/></td> <td style="text-align: center;"><input type="checkbox"/></td> <td style="text-align: center;"><input type="checkbox"/></td> </tr> <tr> <td>_____</td> <td style="text-align: center;"><input type="checkbox"/></td> <td style="text-align: center;"><input type="checkbox"/></td> <td style="text-align: center;"><input type="checkbox"/></td> </tr> </table> <p><input type="checkbox"/> WITNESS TESTING TO BE PRICED SEPARATELY IF AT ADDITIONAL COST</p> <p style="text-align: center;">* WEIGHTS</p> <table style="width:100%; border-collapse: collapse;"> <tr> <td>ROTOR _____ kg</td> <td>STATOR _____ kg</td> </tr> <tr> <td>TOTAL _____ kg</td> <td>SHIPPING _____ kg</td> </tr> <tr> <td colspan="2">MAX MAINTENANCE: _____ kg</td> </tr> </table> <p style="text-align: center;">* OUTLINE DIMENSIONS</p> <p>L _____ mm W _____ mm H _____ mm</p> <p style="text-align: center;">PAINT</p> <p><input checked="" type="checkbox"/> MFR. STANDARD <input type="checkbox"/> OTHER: _____</p> <p style="text-align: center;">QUALITY CONTROL</p> <p><input checked="" type="checkbox"/> ISO 9001 <input type="checkbox"/> OTHER: _____</p>		REQ'D	OBSERVE	WITNESS	ROUTINE	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	COMPLETE	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	ROTOR _____ kg	STATOR _____ kg	TOTAL _____ kg	SHIPPING _____ kg	MAX MAINTENANCE: _____ kg	
	REQ'D	OBSERVE	WITNESS																												
ROUTINE	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>																												
COMPLETE	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>																												
_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>																												
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ROTOR _____ kg	STATOR _____ kg																														
TOTAL _____ kg	SHIPPING _____ kg																														
MAX MAINTENANCE: _____ kg																															

NOTES:

1. * Indicates Vendor to provide information.
2. Refer to Drawings and Data sheet.
3. Approved Motor Vendors- Toshiba, Reliance/Baldor, General Electric, TECO Westinghouse, Siemens, Hyundai, ABB, US Electric

REV	DESCRIPTION	DATE	BY	CHK'D	APP'D	REV	DESCRIPTION	DATE	BY	CHK'D	APP'D
A	Issued for Quotation	2011-09-07	BM	SST	BH						
0	Issued for Purchase	2011-11-29	BM	SST	BJ						
			BM	SST	BJ						

SCOPE OF SUPPLY

MURPHY OIL CORPORATION
 CADOTTE CSS PILOT
 PROJECT NO. 1780



REQUISITION NO.: 1780-RFQ-009
 AERIAL COOLERS
 TAG NO. AC-5010, AC-5020

REV	DATE	DESCRIPTION	BY
A	2011-09-13	Issued for Quotation	DL
0	2011-11-28	Issued for Purchase	DL

ITEM	TAG NO.	DESCRIPTION	QTY	UOM	DELIVERY DATE	UNIT COST	TOTAL COST	REV
1	AC-5010	Produced Gas Aerial Cooler	1					
2	AC-5020	Boiler Feed Water Aerial Cooler	1					

TOTAL AMOUNT (LESS GST):

REMARKS	REV

DOCUMENT REQUIREMENTS

MURPHY OIL CORPORATION
CADOTTE CSS PILOT
PROJECT NO. 1780



REQUISITION NO.: 1780-RFQ-009
AERIAL COOLERS
TAG NO. AC-5010, AC-5020

REV	DATE	DESCRIPTION	BY
A	2011-09-13	Issued for Quotation	DL
0	2011-11-28	Issued for Purchase	DL

DOCUMENT DESCRIPTION ⁽¹⁾	SDR CODE	QUANTITY & FORMAT ⁽²⁾				WKS ⁽³⁾	DATE ⁽³⁾
		Q	A	C	R		
DRAWINGS							
General Drawings and Diagrams							
Outline Drawings/Schematics	DG02		E	E, D			
Electrical Drawings							
Motor Drawings/Diagrams	DE07			E, D	E		
DATA							
Engineering Calculations							
Nozzle Load Calculations	CE06			E, D	E		
General and Miscellaneous Data							
Data Sheets	GD01		E	E, D			
Nameplates - Rubbing/Photo	GD07			E, D			
Operation and Maintenance Information							
Operating Instructions	OM01			E, D			
Maintenance & Lubrication Recommendations	OM02			E, D			
Priced Recommended Spare Parts for Start-up	OM03			E, D			
Priced, Recommended Spare Parts for 2 Years	OM04			E, D			
Procedures							
Quality Control Procedures	RP01			E, D	E		
Hydrostatic or Pneumatic Test Procedure	RP02			E, D	E		
Non-Destructive Test Procedures	RP03			E, D	E		
Welding Procedures for Shop, Field and Repair Welds	RP04			E, D	E		
Shipping, Handling & Storage Procedures	RP09			E, D			
Installation/Erection Procedure	RP10			E, D			
Inspection Test Plan (ITP) Procedure	RP13			E, D	E		
Mechanical Reports & Certificates - Fabricated Equipment							
U1-A Form	RF01			E, D			
CRN	RF04			E, D			
NDE Maps	RF06			E, D			
Non-Destructive Examination (NDE) Reports	RF07			E, D			
WPS Log	RF09			E, D			
Welders Log and Qualifications	RF10			E, D			
Weld Map	RF11			E, D			
Material Test Reports (MTR's)	RF12			E, D			
Hydrostatic Test Gauge Certificate	RF13			E, D			
Hydrostatic Test Report	RF14			E, D			
PWHT Report and Charts	RF15			E, D			
Mechanical Reports & Certificates - Miscellaneous							
Dimensional Check Report	RM04			E, D			
Electrical Reports & Certificates							
Function Test/Run Test Records	RE03			E, D			
CSA Certification	RE05			E, D			
Instrumentation Reports & Certificates							
CSA Approval	RI01			E, D			
DATA BOOKS ⁽⁴⁾	DB01		1H/1E	2H/1E			
QC DATA BOOK ⁽⁵⁾	DB02		1H				
REMARKS							
1.0 Refer to the Supplier Document Requirements (SDR) Code List for further document description. 2.0 Vendor to provide quantity of drawings/documents in the format listed. 3.0 Vendor to provide/confirm weeks and committed date for complete first submission with quotation. Timely subsequent issues are required thereafter. 4.0 A total of three hard copies of the Data Books are required. The first hard copy (1H) and a CD shall be submitted for review. The remaining two hard copies (2H) and a CD copy shall be submitted after all comments and omissions have been incorporated. Refer to the attached Documentation Submittal Requirements for Vendors.							

DOCUMENT REQUIREMENTS

MURPHY OIL CORPORATION
 CADOTTE CSS PILOT
 PROJECT NO. 1780



REQUISITION NO.: 1780-RFQ-009
 AERIAL COOLERS
 TAG NO. AC-5010, AC-5020

REV	DATE	DESCRIPTION	BY
A	2011-09-13	Issued for Quotation	DL
0	2011-11-28	Issued for Purchase	DL

DOCUMENT DESCRIPTION ⁽¹⁾	SDR CODE	QUANTITY & FORMAT ⁽²⁾				WKS ⁽³⁾	DATE ⁽³⁾
		Q	A	C	R		
5.0 The QC Data Book shipped with the equipment is in addition to the 3 Data Book copies. The supplier must complete the requested preliminary QC turnover documentation as listed above and have it accepted by Vista Projects Limited or assigned third party inspector before project is considered complete. Sub-vendor documentation shall meet the same requirements as prime supplier, and included in the QC Data Book. All units must have preliminary QC Data Book binders placed in the unit before it is released for shipment and noted on the packing slip. Non-skidded equipment must have preliminary QC Data Book binders shipped with each item. Any items not included in the preliminary QC Data Book binders must be noted as a deficiency and approved before shipment.							
6.0 All Drawings and Data listed above which are to be included in the Data Book, shall have Codes A or D only. Code A - Reviewed without exception. Proceed with fabrication. Issue final drawings. Code D - Not required for review. Received for information.							
LEGEND							ACCEPTANCE
TYPE OF SUBMISSION	FORMAT FOR SUBMISSION		REQUIRED WEEKS FOR SUBMISSION		Vendor acceptance of above document requirements.		
Q With Quotation	H	Hardcopy	ARO	After Receipt of Order	Initials		
A For Review	E	Electronic Copy	AS	After Shipment			
C Certified/Final/As-built	D	Copy in Data Book	BS	Before Shipment			
R For Record Only	Q	Copy in QC Data Book	WS	With Shipment			

SUPPLIER DOCUMENT REQUIREMENTS (SDR) CODE LIST

**MURPHY OIL CORPORATION
CADOTTE CSS PILOT
PROJECT NO. 1780**

LINE	SDR CODE	DATA BOOK SECTION	CATEGORY & DESCRIPTION	ADDITIONAL DESCRIPTION
1	DB##		DATA BOOKS	
2	DB01	n/a	Data Books	
3	DB02	n/a	QC Data Books	Manufacturer's Record Books (MRB)
4	DX##		DRAWINGS & DIAGRAMS	
5	DG##		General Drawings & Diagrams	
7	DG02	3	Outline Drawings/Schematics	Plan/Elevation drawings with overall dimensions, connection dimensions and ratings, and required clearances for assembly, operation, and maintenance access.
21	DE##		Electrical Drawings	
28	DE07	3	Motor Drawings/Diagrams	Includes Motor Outline Drawings, Motor Terminal Box Layouts and Motor Wiring Diagrams. Includes Engineering Stamped issued for construction drawings.
60	CE##		ENGINEERING CALCULATIONS	
66	CE08	5	Nozzle Load Calculations	
70	GD##		GENERAL & MISCELLANEOUS DATA	
71	GD01	2	Data Sheets	Mechanical (Equipment and Specialty Items), Instrumentation, and Electrical
77	GD07	5	Nameplates - Rubbing/Photo	Rubbing/photo for equipment, instruments, electrical, etc. Nameplates to include manufacturer, tag no., CRN, model no. serial no. and area classification (as applicable).
82	OM##		OPERATION & MAINTENANCE INFORMATION	
83	OM01	4	Operating Instructions	Instructions for pre-commissioning, start-up, normal operation, off-design operation, emergency operation, and shutdown including but not limited to equipment, piping components, valves, instrumentation, electrical equipment and devices.
84	OM02	4	Maintenance & Lubrication Recommendations	Recommended maintenance procedures and intervals with lubricant descriptions, grades and alternate Vendor designations.
85	OM03	4	Priced Recommended Spare Parts for Start-up	Commissioning spares and special maintenance handling tools for but not limited to equipment, piping components, valves, instrumentation, electrical equipment and devices. Include wearing parts such as bushings, seals, gaskets which need replacement after start-up, testing and shutdowns prior to production start.
86	OM04	4	Priced, Recommended Spare Parts for 2 Years	Priced recommended spare parts for two years for but not limited to equipment, piping components, valves, instrumentation, electrical equipment and devices.
91	RX##		REPORTS & CERTIFICATES	
92	RP##		Procedures	
93	RP01	5	Quality Control Procedures	
94	RP02	5	Hydrostatic or Pneumatic Test Procedure	
95	RP03	5	Non-Destructive Test Procedures	Provide procedures as applicable for radiographic, dye penetrant, magnetic particle and ultrasonic testing for Equipment, Piping and Instrumentation, etc.
96	RP04	5	Welding Procedures for Shop, Field and Repair Welds	
101	RP09	5	Shipping, Handling & Storage Procedures	
102	RP10	5	Installation/Erection Procedure	
105	RP13	5	Inspection Test Plan (ITP) Procedure	
108	RF##		Mechanical Reports & Certificates - Fabricated Equipment	
109	RF01	5	U1-A Form	Provide for equipment fabricated in/outside of Alberta; provide "A" number certification.
112	RF04	5	CRN	Provide CRN in some form of official documentation (i.e. CRN could be provided within other documents such as U1-A form for vessels or on equipment drawings)
114	RF06	5	NDE Maps	UT, RT, MT, PT, hardness, PMI, etc - Fabricated Equipment
115	RF07	5	Non-Destructive Examination (NDE) Reports	UT, RT, MT, PT, hardness, PMI, etc - Fabricated Equipment including Operator Certificate
117	RF09	5	WPS Log	For fabricated equipment
118	RF10	5	Welders Log and Qualifications	For fabricated equipment
119	RF11	5	Weld Map	Including Weld Stamp, MTR mapping, NDE, etc for fabricated equipment.
120	RF12	5	Material Test Reports (MTR's)	Fabricated Equipment
121	RF13	5	Hydrostatic Test Gauge Certificate	Fabricated Equipment
122	RF14	5	Hydrostatic Test Report	Fabricated Equipment
123	RF15	5	PWHT Report and Charts	Fabricated Equipment
202	RM##		Mechanical Reports & Certificates - Miscellaneous	
206	RM04	5	Dimensional Check Report	Miscellaneous
235	RE##		Electrical Reports & Certificates	
238	RE03	5	Function Test/Run Test Records	Includes Motor Test, Heat Run Test and Voltage Test Records - Electrical
240	RE05	5	CSA Certification	CSA Certification, CEC requirements - Electrical
254	RI##		Instrumentation Reports & Certificates	
255	RI01	5	CSA Approval	Instrumentation
DATA BOOK SECTIONS				
1	PO			
2	Datasheets			
3	Drawings			
4	Operation and Maintenance Manuals/Catalog Information			

SUPPLIER DOCUMENT REQUIREMENTS (SDR) CODE LIST

MURPHY OIL CORPORATION
CADOTTE CSS PILOT
PROJECT NO. 1780

LINE	SDR CODE	DATA BOOK SECTION	CATEGORY & DESCRIPTION	ADDITIONAL DESCRIPTION
5			QA/QC certification	

LEVEL OF INSPECTION

MURPHY OIL CORPORATION
CADOTTE CSS PILOT
PROJECT NO. 1780



REQUISITION NO.: 1780-RFQ-009
AERIAL COOLERS
TAG NO. AC-5010, AC-5020

REV	DATE	DESCRIPTION	BY
A	2011-09-13	Issued for Quotation	DL
0	2011-11-28	Issued for Purchase	DL

LEVEL	MECHANICAL	EIC	PAINTING/ COATING	DISCIPLINE	LEVEL OF INSPECTION	REV
				MECHANICAL ELECTRICAL, INSTRUMENTATION AND CONTROL PAINTING AND COATING	3 2 n/a	
DESCRIPTION						
0				NO QUALITY SURVEILLANCE IS REQUIRED		
1				RELEASE FOR SHIPMENT SURVEILLANCE IS REQUIRED		
	n/a	n/a	n/a	This level requires final surveillance inspection only to ensure the complete equipment and/or material is: <ul style="list-style-type: none"> In compliance with the purchase order; Is properly identified; Coating Inspection shall be performed by periodically auditing equipment and/or material for surface preparation, final coating inspection, and verification of repairs and complete cure of the lining; The inspector will audit at one of the three "hold points" as outlined in the ITP; Is adequately prepared for shipment; and The documentation requirements have been fulfilled. 		
2		x		LIMITED SCOPE SURVEILLANCE IS REQUIRED		
	n/a	n/a	n/a	This level requires in addition to the activities outlined under Level 1: <ul style="list-style-type: none"> A prefabrication meeting to review the quality requirements established by the Purchase Order and Owner's Specifications; Sign off of hold / witness / verify points as outlined in the Inspection Test Plan; Random visits as required; Coating inspection shall be performed on a "hold point" basis for surface preparation, final coating inspection, and verification of repairs and complete cure of the lining; The inspector will audit at the three "hold points" as outlined in the ITP; and Inspection company to prepare ITP for inspection milestones, capturing requirements of PO and Vendors ITP's. 		
3	x			FULL SCOPE SURVEILLANCE IS REQUIRED		
	n/a	n/a	n/a	This level requires in addition to the activities outlined under Level 2: <ul style="list-style-type: none"> Random visits during fabrication with the purpose of monitoring and verifying the Supplier's compliance with the Quality Control Program and Purchase Order; Coating inspection shall be performed on a "hold point" basis. Surface preparation and coating inspection will be performed on all hold points, beginning with "pre-blast" inspection, and continues until the completion of the coating cure; Verification of compliance to the coating specifications at each "hold point"; The inspector will perform surface preparation and coating inspections at each "hold point" as outlined in the ITP; and Frequency of visits is based on the complexity of the equipment, equipment reliability requirements and the Supplier's Quality Control performance. 		
4				RESIDENCY SURVEILLANCE IS REQUIRED		
				This level requires in addition to the activities outlined under Level 3: <ul style="list-style-type: none"> Daily visits or full residency as directed by the project; Monitoring Supplier's Quality Control Program on an ongoing basis; and Witnessing of all specified tests. 		
REMARKS						
1.0 The level of surveillance is based upon complexity, sensitivity, safety, codes and the project specifications. 2.0 Owner or Vista Projects representative may change the specified surveillance level at any time based on the Vendor's capability and/or performance. The Owner and/or Vista Projects will not accept any Vendor's cost associated with such change. 3.0 Level of inspection is applicable to the Vendor and all Sub-Vendors.						

MECHANICAL INSPECTION REQUIREMENTS

MURPHY OIL CORPORATION
 CADOTTE CSS PILOT
 PROJECT NO. 1780



REQUISITION NO.: 1780-RFQ-009
 AERIAL COOLERS
 TAG NO. AC-5010, AC-5020

REV	DATE	DESCRIPTION	BY
A	2011-09-13	Issued for Quotation	DL
0	2011-11-28	Issued for Purchase	DL

ITEM	REQUIREMENT	PRESSURE VESSELS			TANKS			PIPING SYSTEMS			PACKAGED EQUIP.			ROTATING EQUIP.			STRUCTURAL STEEL			REV
		H	W	V	H	W	V	H	W	V	H	W	V	H	W	V	H	W	V	
SPECIAL REQUIREMENTS																				
1	Vendor ITP prepared for Prefabrication Meeting											X								
2	Vendor Drawings, P&ID's & Calculation are IFC for Prefabrication Meeting											X								
3	Prefabrication Meeting											X								
PRE-FABRICATION INSPECTION REQUIREMENTS																				
1	Vendor's QC Manual Valid and Current											X								
2	WPS Registered and Accepted by Owner Representative											X								
3	Welder Qualifications Valid and Current											X								
4	Material Correct and Traceable to MTR's (size, thickness, grade, sour service requirements)											X								
5	Bill of Materials compliant with Approved Manufacturers List											X								
6	Approved for Fabrication/Construction Drawings											X								
7	Supplier's ITP and Shop Travel Sheet											X								
8	Welding per WPS and Owner Specifications, including welding parameters, fill-up, etc											X								
NDE INSPECTION REQUIREMENTS (Witness NDE when possible and review film/reports)																				
1	Radiographic Test (RT)/Ultrasonic Test (UT)											X								
2	Magnetic Particle Test (MT)/Dye Penetrant Test (PT)											X								
3	Visual Test (VT)											X								
4	Hardness Test											X								
5	Impact Test											X								
6	Vacuum Test											X								
7	Post Weld Heat Treatment (PWHT) Completion and Chart Review											X								
8	Hydrostatic/Pneumatic Test											X								
9	Performance/Run Test																			
10	NPSH Test																			
11	Dismantle and Inspect After Test																			
12	Other:																			
PAINTING/COATING INSPECTION REQUIREMENTS																				
1	Refer to Painting/Coating Inspection Requirements Sheet.																			
STRUCTURAL INSPECTION REQUIREMENTS																				
1	Refer to Structural Steel Inspection Requirements on this Sheet.																			
INSPECTION REQUIREMENTS																				
1	Mapping including NDE, Weld ID, and MTR's.											X								
2	Dimensional Inspection and check for Plumb, Level and Square.											X								
3	Final Visual/P&ID Check											X								
4	Bolt Torque Requirements											X								
5	Non-Conformance Resolution											X								
6	Deficiency Punch List											X								
7	Preliminary QC Package Review											X								
8	QC Document Package Completion											X								
9	Package and Shipping Inspection											X								
REMARKS																				
LEGEND																				
H Hold - Approval required, manufacturing cannot proceed until approved.																				
W Witness - Vendor to provide a minimum of 3 days notification of witness points. Manufacturing can proceed.																				
V Verify/Approve - Manufacturing to proceed in accordance to schedule. Assigned inspector to review and approve.																				

ELECTRICAL INSPECTION REQUIREMENTS

MURPHY OIL CORPORATION
 CADOTTE CSS PILOT
 PROJECT NO. 1780



REQUISITION NO.: 1780-RFQ-009
 AERIAL COOLERS
 TAG NO. AC-5010, AC-5020

REV	DATE	DESCRIPTION	BY
A	2011-09-13	Issued for Quotation	DL
0	2011-11-28	Issued for Purchase	DL

ITEM	REQUIREMENT	H	W	V	REV
SPECIAL REQUIREMENTS					
1	Vendor ITP prepared for Prefabrication Meeting				
2	Vendor Drawings, P&ID's and Calculation are IFC and ready for Prefabrication Meeting				
3	Prefabrication Meeting				
PRE-FABRICATION INSPECTION REQUIREMENTS					
1	Vendor's QC Manual Valid and Current			X	
2	Approved for Fabrication Drawings			X	
3	Review vendor ITP and Hold Points.				
INSPECTION & TESTING REQUIREMENTS					
4	Final Visual and Dimensional Inspection			X	
5	Final P&ID check (tagging)			X	
6	CSA Compliance			X	
7	Installed material checked against PO and Approved Manufacturers List.			X	
8	Terminations marked as per Drawings, Engineering Specifications and instructions.			X	
9	Wiring checked against Wiring Diagrams			X	
10	Electrical tagging as per P&ID (HP, Voltage, etc.)			X	
11	Building Nameplate (zoning)				
12	Function Testing as specified (loop check, meggar, continuity, load, run, etc.)			X	
13	Devices set for use				
14	Non-Conformance Resolution				
15	Deficiency Punch List				
16	Preliminary QC Package Review			X	
17	QC Document Package Completion			X	
18	Package and Shipping Inspection			X	
19	Control Panel/Junction Box Fabrication Inspection (point-to-point verification).			X	
20	Control Panel/Junction Box Fabrication Inspection				
REMARKS					REV
LEGEND					
H	Hold - Approval required, manufacturing cannot proceed until approved.				
W	Witness - Vendor to provide a minimum of 3 days notification of witness points. Manufacturing can proceed.				
V	Verify/Approve - Manufacturing to proceed in accordance to schedule. Assigned inspector to review and approve.				

INSTRUMENTATION INSPECTION REQUIREMENTS

MURPHY OIL CORPORATION
 CADOTTE CSS PILOT
 PROJECT NO. 1780



REQUISITION NO.: 1780-RFQ-009
 AERIAL COOLERS
 TAG NO. AC-5010, AC-5020

REV	DATE	DESCRIPTION	BY
A	2011-09-13	Issued for Quotation	DL
0	2011-11-28	Issued for Purchase	DL

ITEM	REQUIREMENT	H	W	V	REV
SPECIAL REQUIREMENTS					
1	Vendor ITP prepared for Prefabrication Meeting				
2	Vendor Drawings, P&ID's and Calculation are IFC and ready for Prefabrication Meeting				
3	Prefabrication Meeting				
PRE-FABRICATION INSPECTION REQUIREMENTS					
1	Vendor's QC Manual Valid and Current				
2	Approved for Fabrication Drawings				
3	Review vendor ITP and Hold Points.				
INSPECTION & TESTING REQUIREMENTS					
1	Control Valve Operation				
2	Material of Construction				
3	Instruments have CRN's and are tagged correctly.				
4	Instrument tubing in accordance with drawings and Installation details.				
5	Instrument Calibration Results				
6	Bill of Materials compliant with Approved Manufacturers List				
7	PSV's installed in correct location and rated correctly.				
8	Instrument Air Pressure Tests				
9	Process Instrument Venting				
10	Double block and bleed at sample points				
11	Devices set for use			X	
12	Functional Tests.				
13	Final Visual Inspection				
14	Final P&ID Check (valve, PSV, regulator tagging)				
15	Non-Conformance Resolution				
16	Deficiency Punch List				
17	Preliminary QC Package Review				
18	QC Document Package Completion				
19	Package and Shipping Inspection				
REMARKS					REV
LEGEND					
H Hold - Approval required, manufacturing cannot proceed until approved.					
W Witness - Vendor to provide a minimum of 3 days notification of witness points. Manufacturing can proceed.					
V Verify/Approve - Manufacturing to proceed in accordance to schedule. Assigned inspector to review and approve.					

WELD PROCEDURE SUMMARY (WPS)



MURPHY OIL CORPORATION
 CADOTTE CSS PILOT
 PROJECT NO. 1780

REQUISITION NO.: 1780-RFQ-009
 AERIAL COOLERS
 TAG NO. AC-5010, AC-5020

REV	DATE	DESCRIPTION	BY
A	2011-09-13	Issued for Quotation	DL
0	2011-11-28	Issued for Purchase	DL

QSC COORDINATOR CMT CONTACT SUPPLIER NAME & CONTACT SUPPLIER REGISTERED QC PROGRAM NO. SUPPLIER WPS REGISTRATION NO.	INSPECTOR ACCEPTANCE OF WPS
	Signature

PIPE GRADE/ PIPE DIAMETER/ JOINT TYPE	"t" RANGE(S) TO BE WELDED	CODE B31.3, Z662, ASME SEC VIII, STRUCTURAL STEEL	WPS # PQR #	QUALIFIED "t" RANGE	VENDOR COMMENTS (ITEM DESCRIPTION)	EP QC COORDINATOR & INSPECTOR COMMENTS	REV

REMARKS 1.0 Supplier is to complete at the RFQ Stage and return to the EP QC Coordinator. 2.0 No welding may proceed until the third party inspector has approved the Weld Procedure Summary. 3.0 By signing the WPS, the Inspector and Shop QC Personal understand which WPS is to be used for fabrication and will monitor that the fabricator's welders are using the correct WPS.	REV
------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	-----

As Built Data Sheets

- Specifications Sheet



AXH air-coolers
air-x-limited

401 E. Lowry Road Phone (918) 283-9200
Claremore, OK 74017 Fax (918) 283-9229
info@axh.com www.axh.com

Proposal / Job No. 118455
Date 10/14/2011
Page 1 OF 1

1	Purchaser	VISTA PROJECTS / MURPHY OIL CORP.	Ultimate User	MURPHY OIL CORP.
2	Inquiry / PO#	PO: 1780-009 (VISTA) / 54115097-207 (MURPHY)	Destination	CADOTTE PILOT CSS
3	# Units	1	Reference	BOILER FEED WATER COOLER
4	Assembly	PACKAGED	Draft	FORCED
			Overall Size, Ft	9'W x 17'L
			Est Wt	8,800 LBS

THERMAL & MECHANICAL DESIGN

5	Service	BOILER FEED WATER
6	Flow	41580#/HR
7	Fluid	WATER
8	Temp. In / Out, °F	167.0 / 104.0
9	Pressure, PSI	73PSIG
10	Pressure Drop, PSI	8.4
11	Heat Load, BTU/HR	2711224
12	True LMTD	30.5
13	Overall Rate, U	162.7
14	Fouling Factor	.0010
15	Surface, Tube / Total, Sq Ft	546 / 8687
16	Sections, #	(1)
17	Design Temp, °F Max / Min	212 / -49
18	MWP / Test Press, PSIG	256 / 333
19	Pass Arrangement	CROSSFLOW
20	# Tube Rows	3
21	# Tube Passes	6
22	Tubes, OD x BWG	5/8X16
23	Material	SA179 STEEL
24	# Per Section / Length, Ft	212 / 16
25	Turbulators	
26	Accelerators	
27	Fins, Type	HI-EFF
28	Material	AL
29	Nozzles, Rating / Type	150RF
30	Material	SA350LF2
31	#-Inlets / Size In	(1) 3
32	#-Outlets / Size In	(1) 3
33	Headers, Type	BOX
34	Material	SA516-70
35	Corrosion Allow, In	.0625
36	Grooved Tubesheet	DBL
37	Plugs, Type	SHOULDER
38	Plugs Material	SA350LF2
39	PWHT	YES
40	ASME Code & Nat'l Board	YES
41	CRN	AB / BC / SK
42	Add'l Specs & Options	
43	API	661*
44	Louvers / Hail Screen	AUTO / INT

45 **Inspection / NDT**
FX= 100% X-Ray of all header seam, attachment & nozzle butt welds. **SX=** Spot X-Ray of 1 long seam & 1 end closure, per header
BX= 100% X-Ray of all nozzle butt welds. **UT =** 100% UT of all header seam, attachment & nozzle butt welds. **H =** Hardness testing.

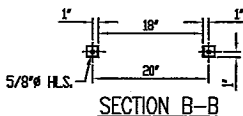
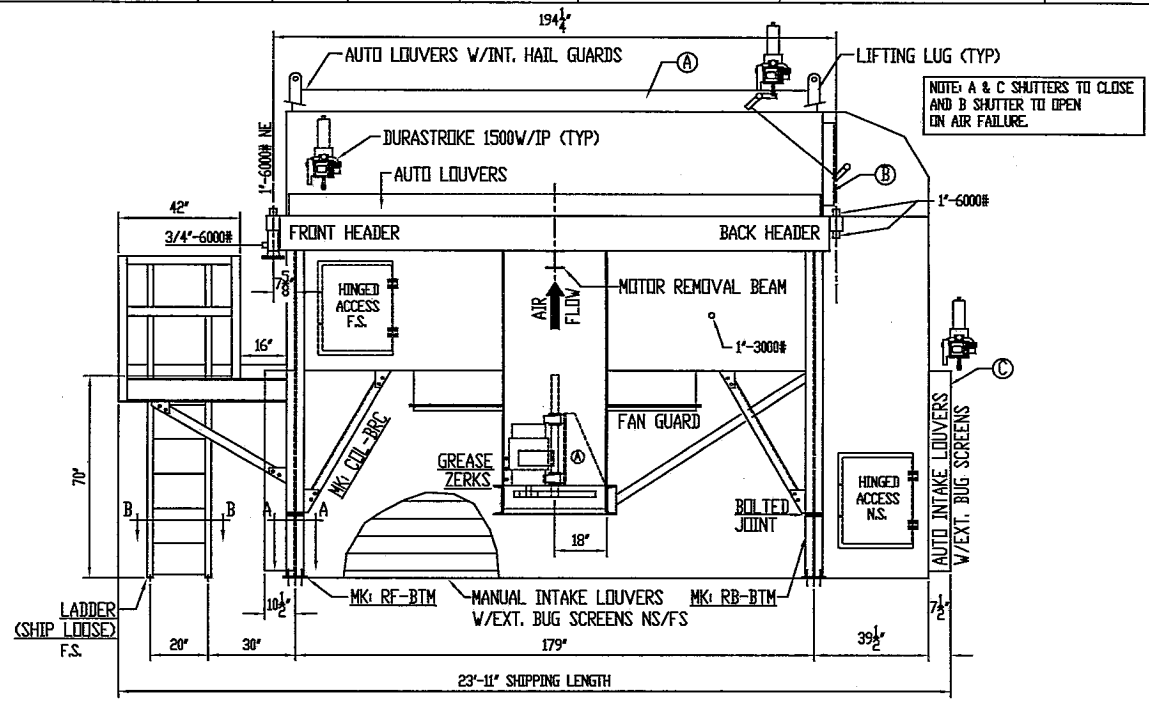
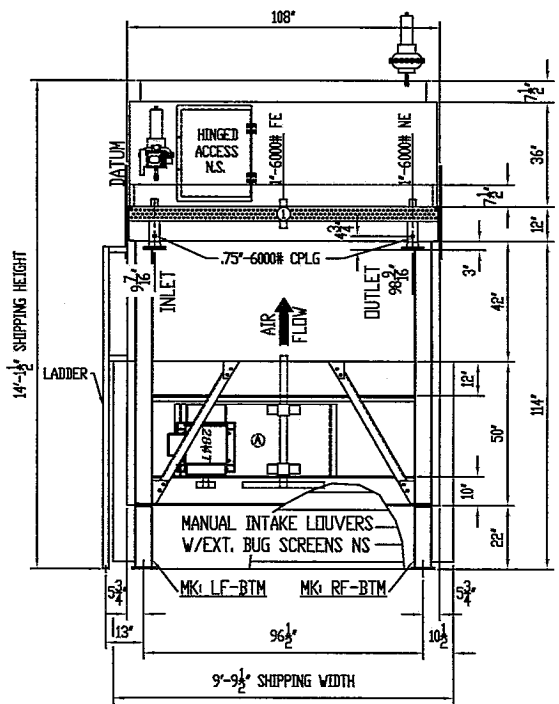
AIR-SIDE PERFORMANCE		FAN DATA		DRIVER DATA		STRUCTURAL	
46	Ambient Air Temp, In °F	86	Fan(s) 1) MOORE-10KVT-S42	Type		Guards	FAN / DRIVE
47	Elevation, Ft	2221	Blade Material ALUMINUM	V-BELT DRIVE BY (1) 25HP,			SOFT BUGSCREENS
48	Air Flow, SCFM	103,485	HP / Fan	22.3	1800RPM, 460/60/3, TEFC,		INTEGRAL HAIL GUARD
49	Outlet Air Temp, °F	109.6	Dia, In / # Blades	96 / 6	VFD COMP. MOTOR (CSA)		WARM AIR RECIRC SYSTEM
50	Min Air Temp, °F	-20	RPM	389	WITH 1.15 SERVICE FACTOR		LADDER & PLATFORM
51			Tipspeed, FPM	9776	MURPHY VS2EX VIB. SWITCH		
52	Est. Noise Data:	85 dBA @ 1m, 65 dBA @ 15m	Pitch, Deg	18.9			

53 **Additional Info.**
54 * - API 661 WITH STANDARD EXCEPTIONS & CLARIFICATIONS
55
56
57
58

As-Built Drawings and Calculations

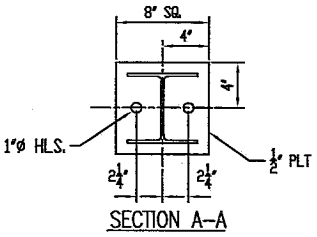
- Certified Drawing
- As-Built Cooler Drawing
- Shaft Detail Drawing
 - CRN Drawing
- ASME Pressure Vessel Code Calculations

ITEM	SERVICE	MAWP	CODE	NOZZLES		COUPLING V/D/P/I/TI	REF. DIMENSION		LOUVERS	BUG SCREEN	DRIVE	FAN	FINISH
				INLET	OUTLET		B	C					
1	BOILER FEED WATER (5.8 CUFT VOL.)	256 PSI @ 212/-49°F 1765 kPa @ 100/-45°C	ASME	3-150 RFWN	3-150 RFWN	(A) 1-6000 (2) .75-6000	-	-	AUTO	YES (SOFT)	ELECTRIC MOTOR DRIVE SHEAVES, BELTS, AND GUARDS BY AXH 25 HP(19 KW), 1800 RPM, 3P, 60 HZ, 460V, TEFC VFD ELECTRIC MOTOR W/ 1.15 SF, CSA, CL. 1, ZN. 2, GROUP IIA A) VIB. SWITCH MURPHY VS 2EX XP	96"Ø MOORE 10K, 42 VT HD 6-BLADE 18.9 PA, LH ROTATION 389 RPM @ 22.3 HP REQ'D (17 KW) Ø2.4375" BORE WITH .625 x .3125 KWY.	STRUCTURE SIDE FRAMES GALVANIZED HEADERS METALIZED



NOTE: ALL DIMENSIONS ARE IN INCHES.

RELEASED
FABRICATION OF THIS
ORDER HAS BEGUN



REV	REVISION DESCRIPTION	BY	CK	APP	DATE	DR:	DATE:	DATE:
5	CHG'D MOTOR DESC.	MIKE	L.W.		02/27/12	USER:	MURPHY OIL COMPANY Ltd.	
4	ADDED TO MOTOR DESC.	MIKE	L.W.		02/13/12	JOB SITE:	CADOTTE PILOT CSS	
3	ADDED CPLG IN PLENUM, LABELED CPLGS & CORRECTED kPa	MIKE	L.W.		02/08/12	JOB NO.:	118455	
2	ADDED MOTOR REMOVAL BEAM	MIKE	L.W.		01/24/12	WORK ORDER NO.:	-	
1	ADDED CUSTOMER COMMENTS & RELEASED	MIKE	L.W.		01/18/12	DR:	J.J.	DATE: 12/19/11
						CK:	J.S.	DATE: 12/29/11

FOR: MURPHY OIL CANADA ESTIMATED DRY WEIGHT 13,100# (SHIPPING)

P.O. NO: 1780-009 (Vista)
54119097-207 (Murphy)

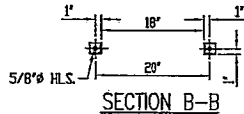
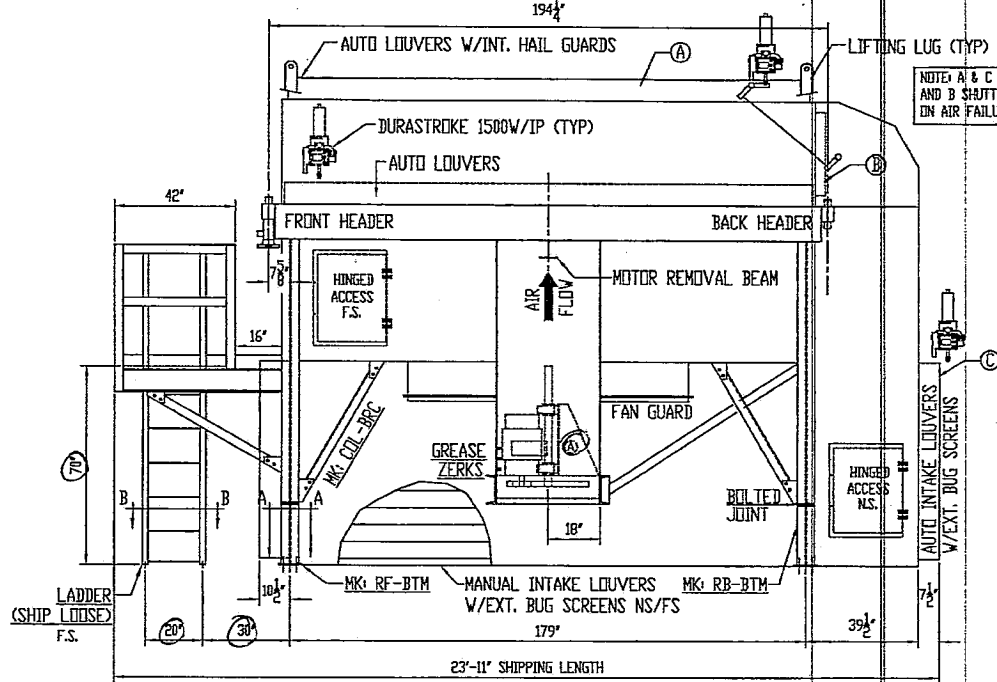
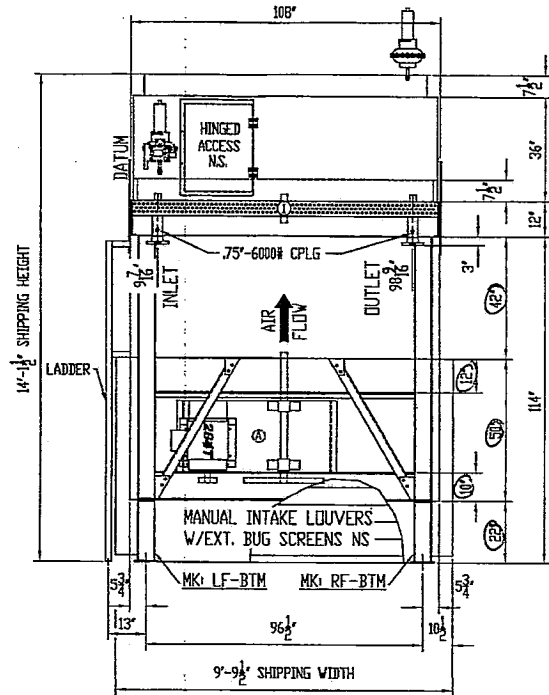
CUST. TAG NUM: AC-5020



CERTIFIED DRAWING FOR:
MODEL 96BZF-R QUANTITY: 1

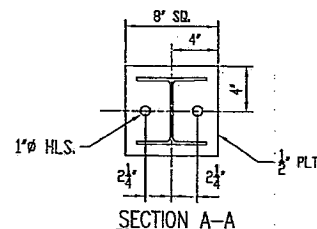
DWG. NO. 118455-CRT
SCALE: FULL DATE: 12/19/2011 REV 5

ITEM	SERVICE	MAWP	CODE	NOZZLES		COUPLING V/D/P/I/TI	REF. DIMENSION		LOUVERS	BUG SCREEN	DRIVE	FAN	FINISH
				INLET	OUTLET		B	C					
1	BOILER FEED WATER (5.8 CUFT VOL.)	256 PSI @ 212/-49°F 12.26 kPa @ 100/-45°C	ASME	3-150 RFWN	3-150 RFWN	(4) 1-6000 (2) .75-6000	-	-	AUTO	YES (SOFT)	ELECTRIC MOTOR DRIVE SHEAVES, BELTS, AND GUARDS BY AXH 25 HP (19 KW), 1800 RPM, 3P, 60 HZ, 460V, TEFC VFD ELECTRIC MOTOR (CSA) W/ 1.15 SF ⓐ VIB. SWITCH MURPHY VS 2EX XP	96" Ø MOORE 10K, 42 VT HD 6-BLADE 18.9 PA, LH ROTATION 389 RPM @ 22.3 HP REQ'D (17 KW) Ø2.4375" BORE WITH .625" x .3125 KWY.	STRUCTURE SIDE FRAMES GALVANIZED HEADERS METALIZED



NOTE: ALL DIMENSIONS ARE IN INCHES.

RELEASED
FABRICATION OF THIS
ORDER HAS BEGUN



						FOR: MURPHY OIL CANADA ESTIMATED DRY WEIGHT 13,100# (SHIPPING)					
						P.O. NO: 1780-009 (VFD) 54118027-207 (Murphy)					
						CUST. TAG NUM: AC-5020					
						USER: MURPHY OIL COMPANY Ltd.					
						JOBSITE: CADOTTE PILOT CSS					
						JOB NO: 118455					
						WORK ORDER NO: -					
						DR: J.J. DATE: 12/19/11					
						DATE: 12/29/11					
						SCALE: FULL					
						DATE: 12/19/2011					
						REV 2					

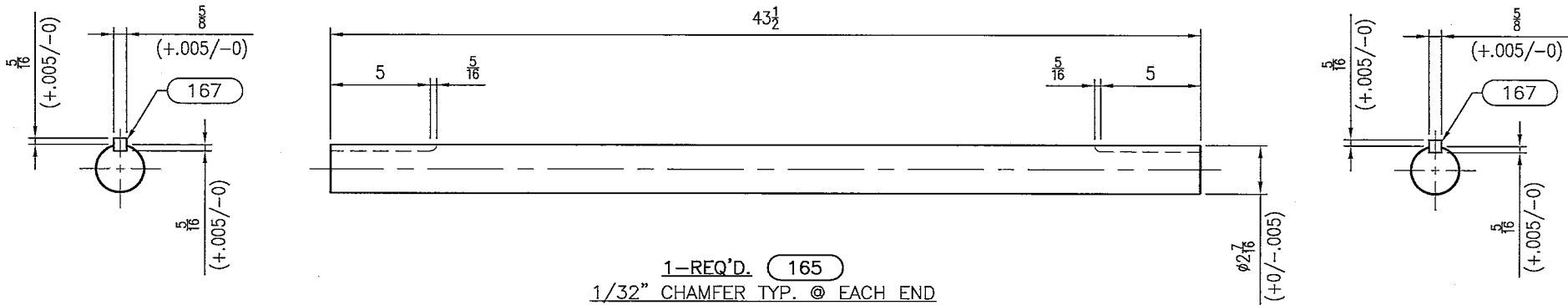


CERTIFIED DRAWING FOR:
MODEL 96BZF-R QUANTITY: 1
DWG. NO. 118455-CRT

KP 322-R

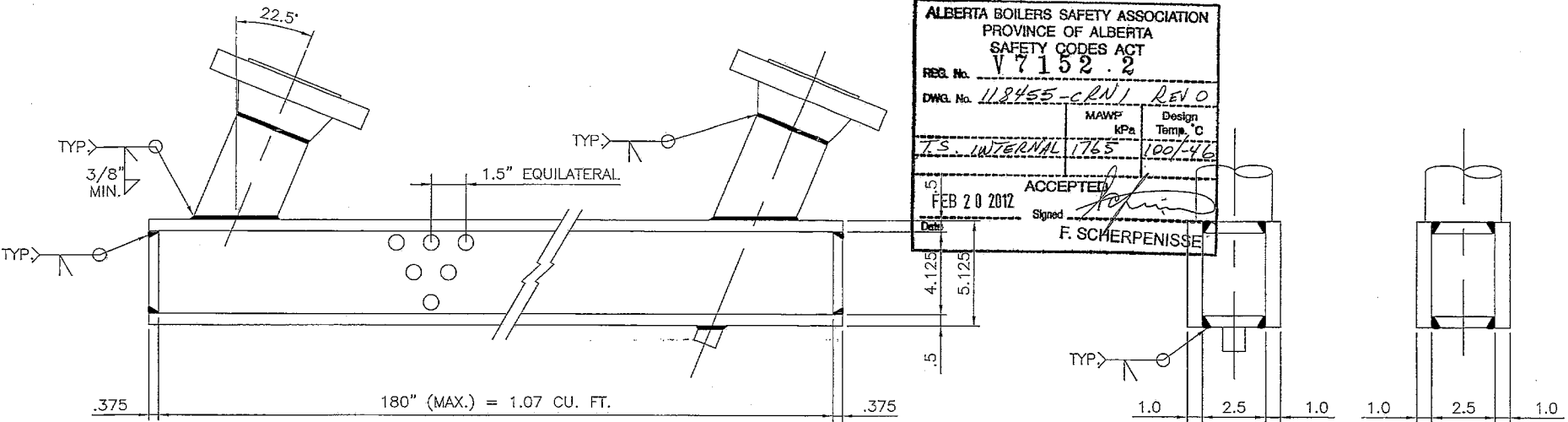
WISCO
W O R
Initials: [Signature]
Date: 3/20/12
117

BILL OF MATERIAL					
MARK	QTY	DESCRIPTION	WIDTH	LENGTH	WEIGHT
165	1	2.4375" DIA. (C1045 MATERIAL)		3'-7 1/2"	58
167	2	KEYSTOCK - 5/8" SQUARE		4 1/2"	1
TOTAL WEIGHT					59



CUSTOMER:	DRAWN BY: <i>GB</i>	CHECKED BY: <i>JB</i>
P.O. NO.:	SCALE: 1=5	
PROJECT: 118455 (1-UNIT)	DATE: 01/27/2012	
DESCRIPTION: 2-7/16" SHAFT DETAIL 96BZF-R	JOB NUMBER: 118455	SHEET: SHD
LOCATION:		REV. NO.: 0

REV	DESCRIPTION	BY	CK'D	DATE

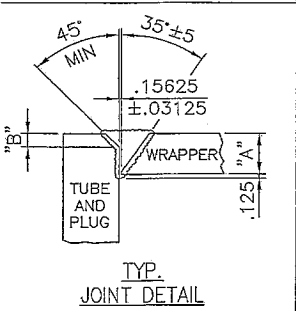


ALBERTA BOILERS SAFETY ASSOCIATION
 PROVINCE OF ALBERTA
 SAFETY CODES ACT
 REG. No. V7152.2
 DWG. No. 118455-CRN1 REV 0
 MAFP kPa Design Temp. C
 7.5 INTERNAL 1765 100/46
 ACCEPTED
 FEB 20 2012
 Signed: F. SCHERPENISSE
 Date: 4.125 5.125 .5

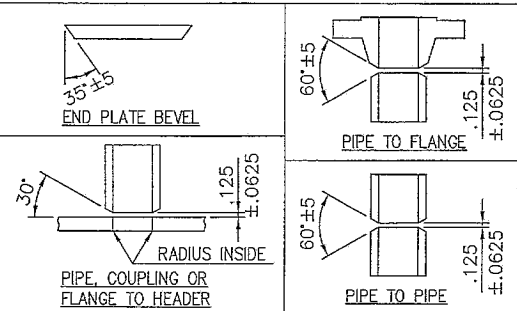
NOTE: DIMENSION "B" IS ACTUAL WELD BEVEL PREPARATION FOR FABRICATION. DIMENSION "a2" REPRESENTS THE REQUIRED AMOUNT OF FUSION PER APPENDIX 28.

CROSS SECTION - SIDE VIEW

CROSS SECTION - END VIEW



"A"	"B"
.375	NONE
.5	NONE
.625	NONE
.75	.125
.875	.125
1.0	.125
1.125	.1875
1.25	.1875
1.375	.25
1.5	.25
1.625	.375
1.75	.375
2.0	.5
2.25	.5
2.5	.625
2.75	.625
3.0	.6875



WELD PROCEDURES (LOW TEMP.)		≤ 1/2" P1-P1-11	≤ 1/2" P1-P1-11	≤ 1/2" P1-P1-10	S.S. P1-P8-03	≤ 1/2" P1-P1-11	≤ 2" NPS P1-P1-14
		≥ 5/8" P1-P1-08	≥ 5/8" P1-P1-08	≥ 5/8" P1-P1-07	C.S. P1-P1-11	≥ 5/8" P1-P1-08	≥ 1/2" P1-P1-11
END PL.	WR. PL.	END PL.	TS/PS	WR. PL.	TS/PS	WR. PL.	TS/PS
30°	30°	35° ± 5	1/4"	1/8"	1/4"	1/8"	1/8"
1/8"	1/8"	1/8"	1/4"	1/8"	1/4"	1/8"	1/8"
NOTE: VESSELS CONSTRUCTED UNDER THIS REGISTRATION SHALL BE ASME CODE STAMPED "U" & REGISTERED WITH THE NATIONAL BOARD							
REV	DESCRIPTION	BY	CHKD	DATE			

MATERIALS		DESIGN INFORMATION	
PLATE	SA 516-70N	DESIGN PRESSURE	256 P.S.I.
FLANGES	3"-150# RFWN SCH 160 (SA-350-LF2 CLASS-1)	DESIGN TEMPERATURE	212/-50F
PIPE	3" SCH 160 (SA-333 GR.6)	HYDROSTATIC TEST	333 P.S.I.
TUBES	.625" Ø x .060" MIN. WALL (SA214 STEEL)	CORROSION ALLOWANCE	0.0625
PLUGS	.75" x 16 UNF3A x .75" LG. SHDR (SA-350-LF2 CLASS-1)	DESIGN CODE	2010 ASME SECTION VIII, DIV. 1, APPX. 13 & 28, NO AD.
COUPLING	1"-6000# (SA-350-LF2 CLASS-1)		
MACHINING		IMPACT EXEMPT	UCS-66(a) CURVE D, UCS-66(g) & UCS-68(c)
TUBE HOLES - DRILLED AND REAMED TO 0.633" ± .002"	P.W.H.T.	400F HEATING, .5 HR HOLD @ 1150F, 500F COOLING	
TUBE HOLES - GROOVED PER TEMA-C 7.44	PREHEAT	NONE	NDT TEST DYE PENETRANT PER UG-93d3
PLUG HOLES - TAPPED FOR 0.75"-16 UNF-1B.	CHARPY IMPACT TEST	NONE	

air-coolers
 CLAREMORE, OKLAHOMA

CAN' REG' DWG. FOR: BOILER FEED WATER

CUSTOMER MURPHY OIL

DRAWN: JJ CHECKED: JS

SCALE: NONE

DATE: 02/15/2012

JOB NUMBER 118455 SHEET CRN1 REV. 0

AXH air-coolers
 401 EAST LOWRY ROAD, CLAREMORE, OK 74017
 OF: 918-283-9200 / FX: 918-283-9229

ASME PRESSURE VESSEL CODE SECTION VIII-DIVISION 1 (2010 EDITION, NO ADDENDA)
 STRESS CALCULATIONS FOR NON-REINFORCED RECTANGULAR CROSS SECTION HEADERS
 WRAPPER AS SHORT-SIDE PLATE / TUBE AND PLUG SHEET AS LONG-SIDE PLATE

1	REFERENCE NAME DATE REF. NO.	VISTA PROJECTS / MURPHY OIL CORP.				02/15/12	118455	
2	SERVICE NO.	1	2	3	4	5		
3	SERVICE LABEL	BF WATER						
4	SERVICE TAG NO.	118455.1						
5	SECTION DESIGN PRESSURE, ACTUAL MAX	PSIG	P	256	256			
6	SECTION HYDRO TEST, MULTIPLIER PSIG @ 100°F			1.3	333			
7	DESIGN TEMP, MAX MIN	F		212	-50.0			
8	CORROSION ALLOWANCE	IN	CA		0.0625			
9	TUBE O.D.	IN			0.6250			
10	TUBE GAUGE	BWG			16			
11	TUBE MIN WALL THICKNESS	IN			0.0600			
12	TUBE MATERIAL	SA214 STEEL						
13	TUBE PITCH	IN	pt		1.5000			
14	TUBE VERTICAL SPACING	IN			1.299038			
15	SHLDR PLUG PITCH DIA.	IN	DE		0.7192			
16	TUBE ROWS	3						
17	FLANGE DIA	IN			3			
18	FLANGE CLASS	150RF						
20	NOZZLE TO HEADER CONNECTION TYPE	SET-ON PIPE						
19	NOZZLE CONNECTION SCH	S160						
20	NOZZLE CONNECTION, OD AVG ID	IN		3.5000	2.6240			
21	WRAPPER SPAN	IN	H		2.5000			
22	TUBE/PLUG SPAN	IN	h		4.1250			
23	WRAPPER THICKNESS	IN	t1		0.5000			
24	TUBE/PLUG THICKNESS	IN	t2		1.0000			
25	END PLATE THICK, ACTUAL MINIMUM	IN	ts	0.3750	0.3750			
26	OUTSIDE DIMENSIONS, WRAPPER TUBE/PLUG	IN		4.5000	5.1250			
27	HEADER MATERIAL	SA516-70N						
28	FLANGE MATERIAL	SA350-LF2						
29	NOZZLE CONN. MATERIAL	SA333GR6						
30	END PLATE FACTOR/JOINT EFFICIENCY		C/E		0.2			
31	STRESS ALLOWABLE, HEADER MATERIAL	PSI	(S)h		20000			
32	STRESS ALLOWABLE, NOZZLE CONN.	PSI	(S)h		17100			
33	STRESS ALLOWABLE, TUBES	PSI	(S)t		13400			
34	PRESSURE MAX, HEADER BOX	PSIG			739			
35	PRESSURE MAX, FLANGE	PSIG			256			
36	PRESSURE MAX, NOZZLE CONN.	PSIG			3382			
37	PRESSURE MAX, TUBE	PSIG			3040			
38	ASME CALCULATIONS PER APPENDIX 13, FIG.13-2(a), SKETCH (1) AND CALCULATIONS PER APPENDIX 13 SECTION 13-7							
39	$(t1-CA)^{3/12}$		I1		0.0070			
40	$(t2-CA)^{3/12}$		I2		0.0687			
41	$(I2/I1)^a$		K		6.0774			
42	$3.4-2.4*((H+CA^2)/(h+CA^2))$ OR 2.5 MAX.		Z		1.9176			
43	$(H+CA^2)/(h+CA^2)$		a		0.6176			
44	$(t1-CA)/2$		c1		0.2188			
45	$(t2-CA)/2$		c2		0.4688			
46	$(pt-DE)/pt$		em,eb		0.5205			
47	STRESS TYPE AT ASME SECTION		STRESS PSI / % OF MAXIMUM STRESS (NOTE B)					
48	MEMBRANE STRESS - SHORT-SIDE (WRAPPER) / LONG-SIDE (TUBE/PLUG)			SHORT				
49	(1) $(P*(h+CA^2))/(2*(t1-CA))$	(Sm)N		1243	6%			
50	(2) $(P*(H+CA^2))/(2*em*(t2-CA))$	(Sm)M		689	3%			
51	BENDING STRESS - SHORT-SIDE (WRAPPER)							
52	(3) $((P*c1)/(12*I1))*(-1.5*(H+CA^2)^2+(h+CA^2)^2*(1+a^2*K))/(1+K)$	(Sb)N		1248	4%			
53	(4) $((P*(h+CA^2)^2*c1)/(12*I1))*((1+a^2*K)/(1+K))$	(Sb)Q		5664	19%			
54	BENDING STRESS - LONG-SIDE (TUBE/PLUG)							
55	(5) $((P*(h+CA^2)^2*c2)/(12*eb*I2))*(-1.5+(1+a^2*K)/(1+K))$	(Sb)M		5211	17%			
56	(6) $((P*(h+CA^2)^2*c2)/(12*I2))*((1+a^2*K)/(1+K))$	(Sb)Q		1233	4%			
57	TOTAL STRESS - SHORT-SIDE (WRAPPER)							
58	(7) EQ(1)+EQ(3)	(ST)N		2491	8%			
59	(8) EQ(1)+EQ(4)	(ST)Q		6907	23%			
60	TOTAL STRESS - LONG-SIDE (TUBE/PLUG)							
61	(9) EQ(2)+EQ(5)	(ST)M		5900	20%			
62	(10) EQ(2)+EQ(6)	(ST)Q		1922	6%			
63	STRESS - END PLATES PER UG-34(3)							
64	$P*Z*(C/E)*((H+CA^2)/(ts-CA))^2$	(S)EP		6928	35%			

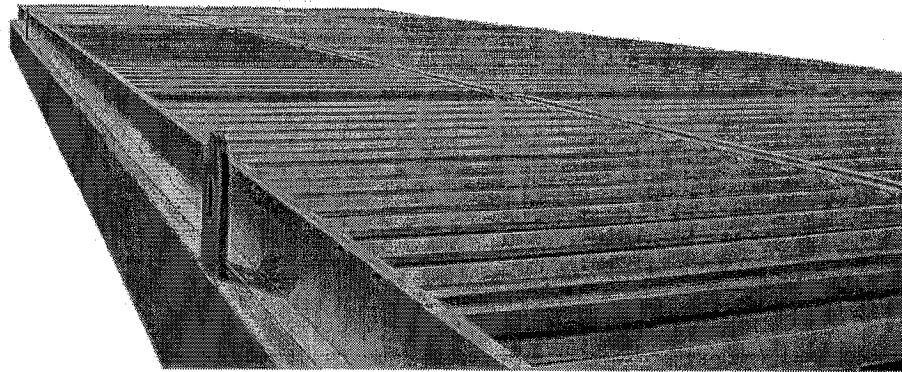
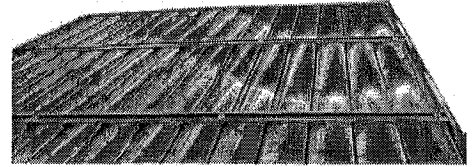
(A) ALL DIMENSIONS ARE LISTED AS UNCORRODED. ALL STRESS CALCULATIONS ARE BASIS FULLY CORRODED DIMENSIONS.
 (B) MAXIMUM STRESS IS ALLOWABLE HEADER STRESS (S)h FOR MEMBRANE AND END PLATES, 1.5 X (S)h FOR BENDING AND TOTAL STRESSES.

Catalogue data and Installation, Operating and Maintenance Manuals

- Airtech Products, Inc. – Duraflow Industrial Louvers
 - Moore Fans LLC – Class 10000 VT Series 42
 - Dodge - TAF Bearing 2-7/16 Pillow Block
- Airtech Products, Inc. – Durastroke Pneumatic Actuators – Series 1500
 - Teco Westinghouse Motor – Catalog Number EP0254
- Murphy Shock/Vibration Control Switches – Model VS-2EX-XP
 - Gates – Super HC Powerband Belts – 5VX1120
- Air-x-limited Polyester Vinyl Bug Screen Panels – Series 1.2-0704
 - Spare Parts List
 - AXH Installation and Operation Manual
 - AXH Brochure

Duraflow Industrial Louvers

- Aluminum or Galvanized Steel Construction
- Built to Heavy Duty Airtech Standards
- Optional API 661 Compliance
- Bolted or Welded Construction
- Internal Mechanism / Actuation



- Bug Screens & Hail Guards
 - Wire Cloth
 - Expanded Metal
 - Vinyl
- Fan Guards
- Recirc Doors with Frames



- Short Lead Times
- Built to Customer Specifications
- Competitive Pricing
- Domestic or Export Crating

AIRTECH Products, Inc.
P.O. Box 790
Sand Springs, OK 74063
Phone: 918-241-0264
Fax: 918-241-0270
Email: info@airtechinc.biz

Technical Information / Standard Configurations

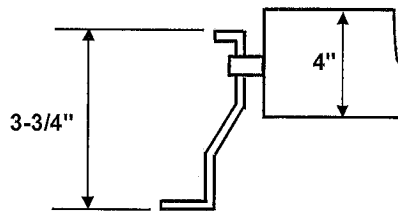
Aluminum Frame (extrusion):	6063-T5
Aluminum Frame (folded sheet):	3003-H14
Galvanized Steel Frame:	A653-G90 Carbon Steel (Mechanical Galvanized Finish)
Blades:	6063-T6 Aluminum
Blade Pins:	
Aluminum:	6061-T6 Aluminum
Stainless Steel:	303 Stainless Steel
Torque Tube:	6063-T6 Aluminum
Actuator Rod:	6063-T6 Aluminum
Actuator Lever Arm:	6061-T6 Aluminum
Clevis:	1018 Carbon Steel
Clevis to Arm Connecting Link:	6061-T6 Aluminum

Assembly Hardware:

Cap Screws:	ANSI/ASME 18.2.1 Grade 5, Zinc Plate
Nuts:	Locking nut, Performance Spec IFI/100, MIL/N/25027, Light Hex, Standard Height, Zinc Plate
Bearings:	Glass Filled Nylatron, (Per API Specification 661)

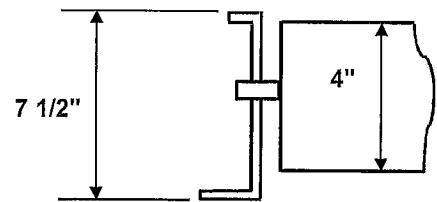
Series 300

- 3 3/4" Frame
- 4" Blade



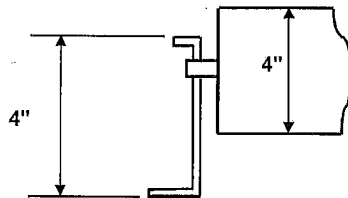
Series 740

- 7 1/2" Frame
- 4" Blade



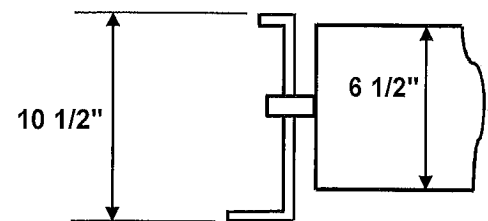
Series 400

- 4" Frame
- 4" Blade



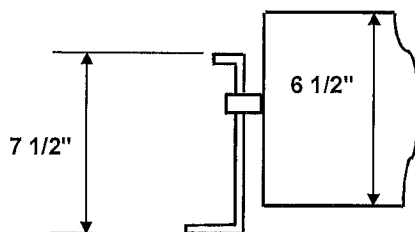
Series 1000

- 10 1/2" Frame
- 6 1/2" Blade



Series 700

- 7 1/2" Frame
- 6 1/2" Blade



Airtech Products, Inc., P.O. Box 790, Sand Springs, OK 74063
 Phone: 918-241-0264, Fax: 918-241-0270
 Email: info@airtechinc.biz

AIRTECH PRODUCTS, INC.

P.O. Box 790
8101 West 16th Street
Sand Springs, OK 74063
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918-241-0264 (Phone)
918-241-0270 (Fax)

Duraflow Industrial Louvers

Installation and Maintenance Instructions

PRE-INSTALLATION ACTIVITIES:

1. With the louver crate resting firmly on either saw horses or a smooth and level area at grade, remove packing crate top and sides.
2. Make a visual inspection of the louver frame, blades and all linkages/drive mechanisms to ensure there was no shipping damage.
3. Various small parts needed to connect the drive linkages are shipped in a separate and smaller cardboard box. Keep this box at hand but out of the way and in a safe place.
4. Inspect the mounting surface of the cooler giving particular attention to ensure it provides uniform support of the louver perimeter and that it is structurally adequate to support all static and dynamic loadings.
 - a. If the louver is to be mounted in a horizontal configuration, it is **CRITICALLY IMPORTANT** to ensure the mounting surface is uniform and level to +/- .25" over 20'. Airtech louvers are manufactured to precise tolerances and bolting to an off-level surface will cause binding in the moving parts. This will result in inconsistent operation, shorten product life and can cause permanent damage that voids the manufacturers warranty.
 - b. If the louver is to be mounted in a vertical configuration, the installer must confirm there will be uniform support / attachment to the mounting surface at spacing not greater than 18" centers on the louver perimeter flange. Failure to do so may result in bending of the louver frame and inconsistent operation, a shortened product life and can cause damage that voids the manufacturers warranty.
5. Take a moment to visualize the installation and plan the placement of individual louver sub-assemblies. Although all louver installations involve essentially the same procedure, any given application will have some unique characteristics. Some projects will require louver sections to link together at the side via torque tube connectors while others may link together at the ends via end links on the actuator rod. Small projects may require neither type of connection while large projects will require both.
6. Open the cardboard box of small parts and confirm all the necessary pieces are at hand. Depending on the application, this could be torque tube couplings, actuator rod end links, grade level operator components, clevises, etc. Please note, unless the louvers are to be attached via angle clips, the actual attachment hardware won't be included in the louver shipment.
7. Most of the time, louver installation is easiest done using self-drilling speed screws, 1/4" x 1 1/4" long, fine thread. Ensure a screw is in place on all corners and not greater than 18" centers around the louver perimeter. Simply drill through the louver flange into the host structure making sure the screw is completely pulled down tight. If retaining clips is your preferred method of attachment, please review to "Reference A" for instructions on use and installation.

MOUNTING & ATTACHMENT

1. Hoist the louver (or first louver sub-section) into place making sure the lift is well supported around the perimeter. DO NOT ALLOW THE LOUVER TO RACK or excessively bend during the lifting process.
 - a. **For horizontal applications**, set the louver onto the mounting surface and visually confirm 100% of the perimeter is supported and resting flat upon the top of the cooler. Make sure the operating mechanism travels freely through the entire range of motion and there is no interference from complete shut to complete open. If the louver is supplied in multiple sections, install the section with the operator first and perform the motion/operation test noted above. Square the louver to the cooler as best you can but above all, be sure the louver remains square – do not force to the louver out of square to accommodate the cooler. THE LOUVER MUST BE SQUARE to operate properly. After confirming the louver is properly placed relative to the mounting surface (and to other subsequent sections, if applicable), install a self-drilling screw at each corner and at no greater than 18” centers along all flanges. If applicable, hoist subsequent sections into place and following the above instructions, attach each to the host structure. DO NOT STEP ON LOUVER BLADES AT ANY TIME. If you must step out onto the louver, use dimension lumber or plywood as a walking surface.
 - b. **For vertical applications**, hoist the louver (or first louver section) into place and after checking for clearance on moving parts, attach to the cooler with a self drilling screw at each corner and at no greater than 18” spaces along all flanges. Install all attachment screws before releasing hoist cables or hoisting device to ensure the louver is fully attached and there is no deflection in the louver frame. If applicable, hoist subsequent sections into place and following the above instructions, attach each to the host structure.
2. If the louver is supplied in multiple sections, remove the connecting links / couplers from the shipping box and install them as required at the ends of actuator rods and torque tubes. End link installation instructions are detailed as attached “Reference B” and Torque Tube coupling installation instructions are detailed as attached “Reference C”.
3. When all sections are installed and connected, test the drive mechanism to ensure it moves freely, without binding or interference. On very large louvers with multiple sections, this may require use of a lever. Small to average size louvers should easily operate by hand strength on the torque tube.
4. Complete the installation by attaching any remaining components such as pneumatic actuator or grade level operators. Detailed installation instructions for actuator can be found in its shipping carton. For instructions on grade level operators, see attached “Reference D”.
5. After installing any remaining operators, complete the installation process by cycling the louver several times to ensure it moves freely, without interference and isn’t binding at any location. Some adjustment of end links may be required to ensure all louver blades open and shut consistently down the entire length of the louver.
6. Check all attachment fasteners to ensure all are properly tightened and completely engaged to the louver flange.
7. If applicable, check all end link connections and torque tube couplers to ensure they are properly tightened and fasteners are completely engaged.

MAINTENANCE INSTRUCTIONS (Annual)

1. Visually inspect all blade pins to ensure the pin bearings are in place and do not have unacceptable wear.
2. Visually inspect all connections between blade horns and actuator rod to confirm all connecting bearing, bolts and nuts are in place and not showing unacceptable wear.
3. Visually inspect all attachment screws to ensure none have backed off or are missing.
4. If dirt or grease buildup is excessive, clean louver blades and operating mechanisms with high pressure clear water wash.
5. Operate any manual levers or grade level operators to confirm all are in good working order and move freely without binding or interference.
6. If actuators are installed, visually inspect the mounting bolts to ensure all are tight and in place. Visually inspect the condition of all connecting links, the clevis and clevis pin.
7. Visually inspect all actuator rod end links and torque tube connectors to confirm all are in place and properly engaged.
8. Remove any leaves or other debris that may have collected in corners or between the louver blades and integral hailguards.

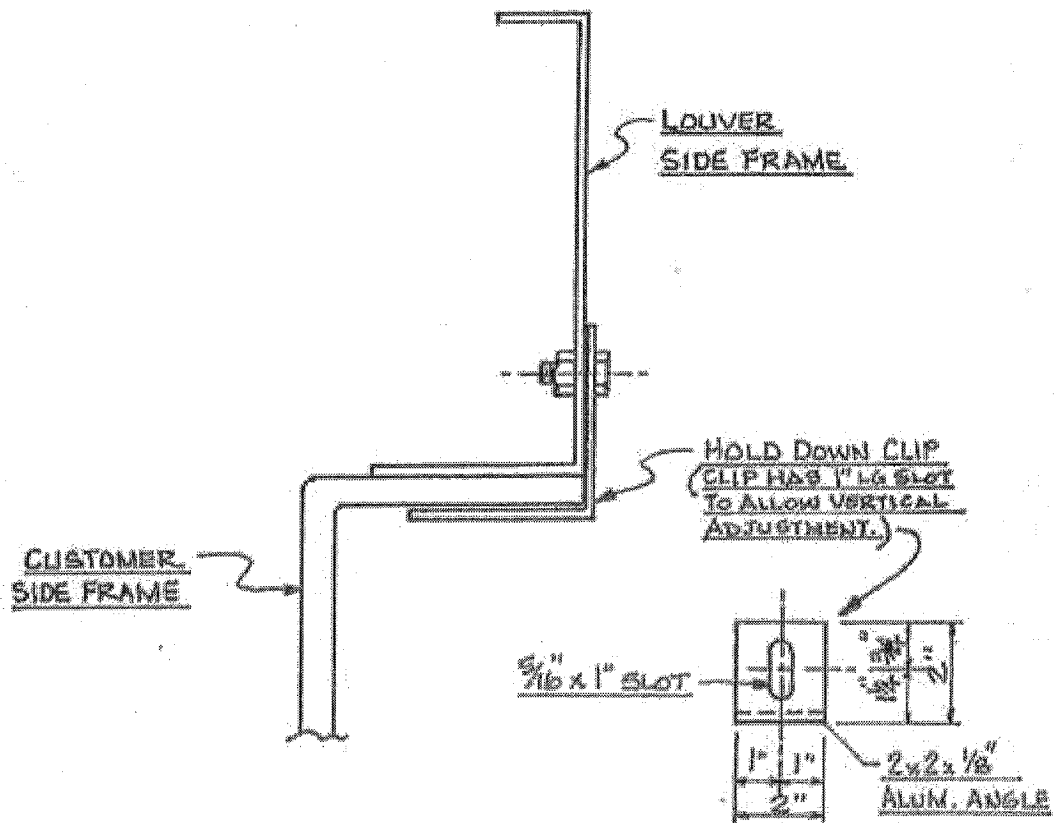
RECOMMENDED SPARE PARTS LIST

Item Description	Suggested Quantity
1. Blade horn bearing, bolt and nut kit	1 per 5 Ft ² louver area
2. Actuator rod end link kit	1 per 2 connections
3. Torque Tube couplings	1 per 2 torque tube connections
4. Blade Pin and Pin Bearing kits	5 per 10 Ft ² louver area
5. Manual handle kits	1

AIRTECH Products Inc.

Reference A

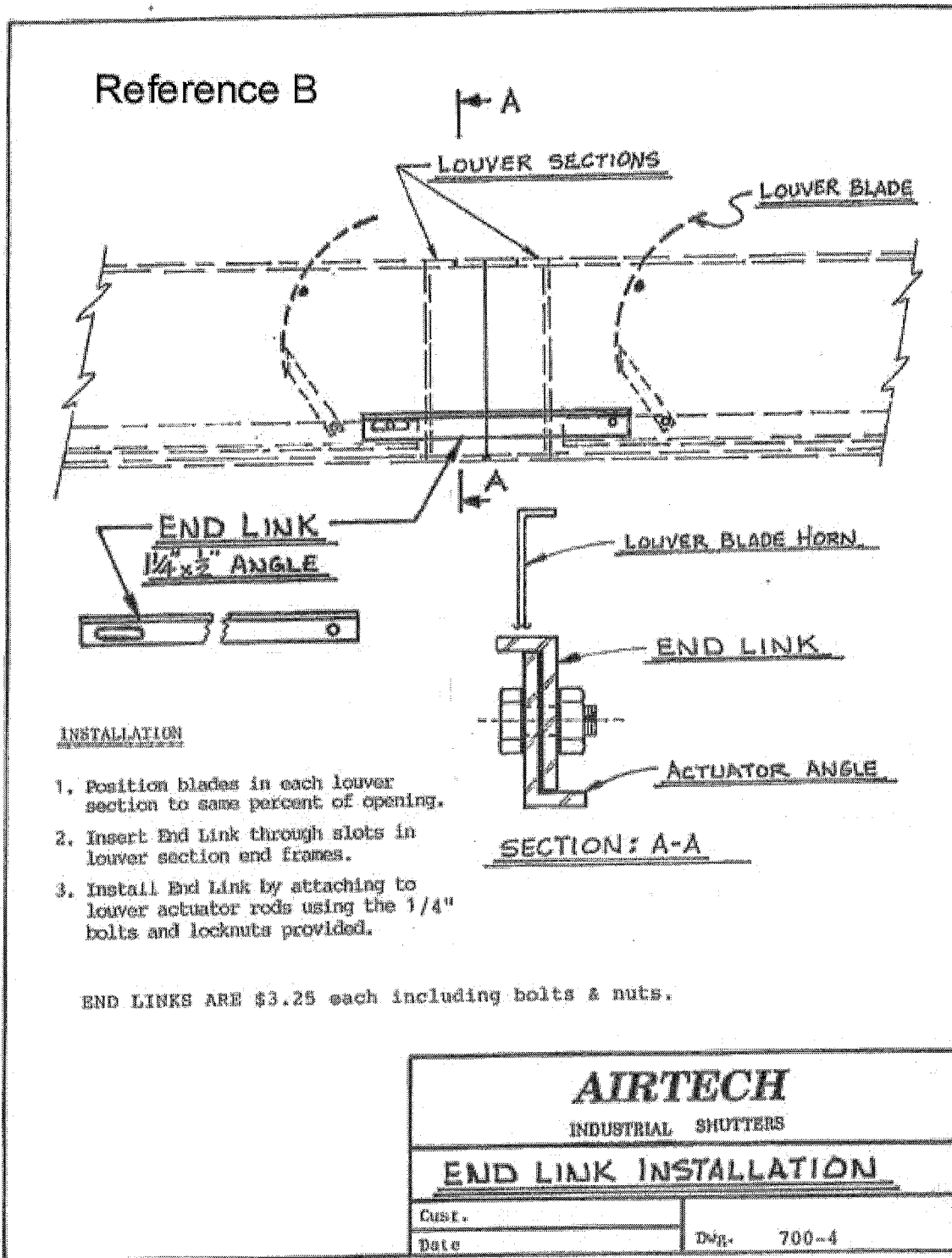
MOUNTING CLIP DETAIL



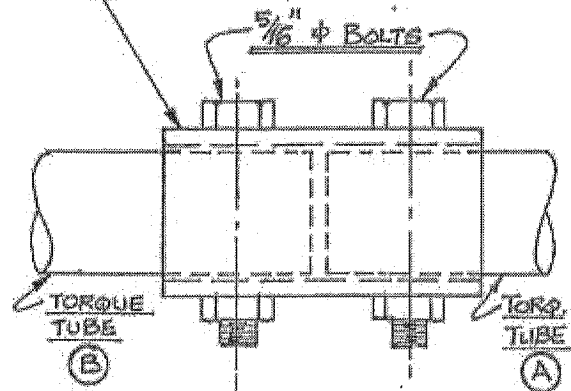
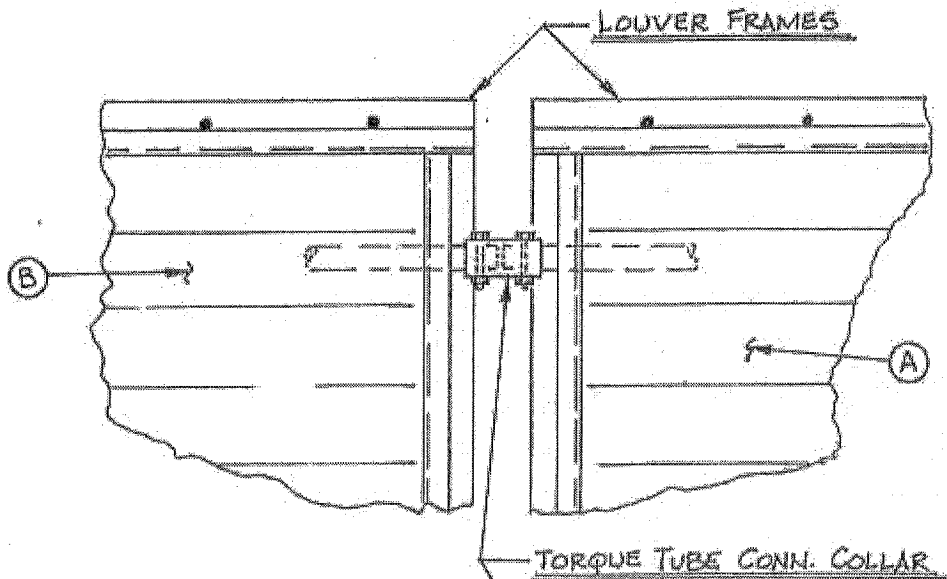
P.O. BOX 790

SAND SPRINGS, OK 74063

(918) 241-0264



Reference C



INSTALLATION

1. Attach louver section "A" to structure.
2. Remove 5/16" bolt and nut from end of Conn. Collar where section "B" torque tube will attach.
3. Slide section "B" torque tube into Conn. Collar as section "B" is placed into position on structure.
4. Attach section "B" to structure.
5. Holes in Conn. Collar and torque tube are pre-drilled at factory to assure proper opening and closing of louver blades. Be sure all louver blades are in same percent of opening before replacing 5/16" bolt and nut to Conn. Collar and section "B" torque tube.

AIRTECH

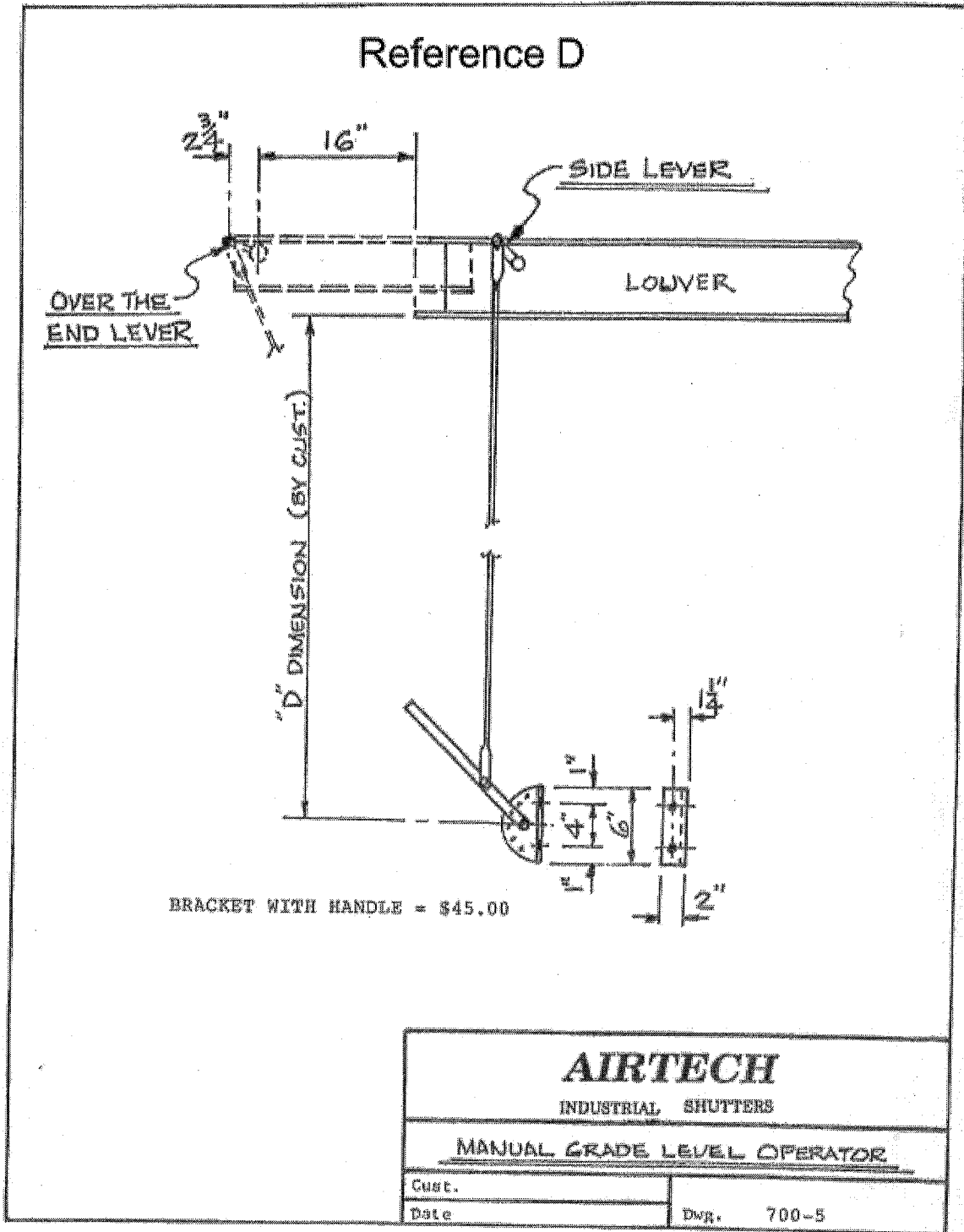
INDUSTRIAL SHUTTERS

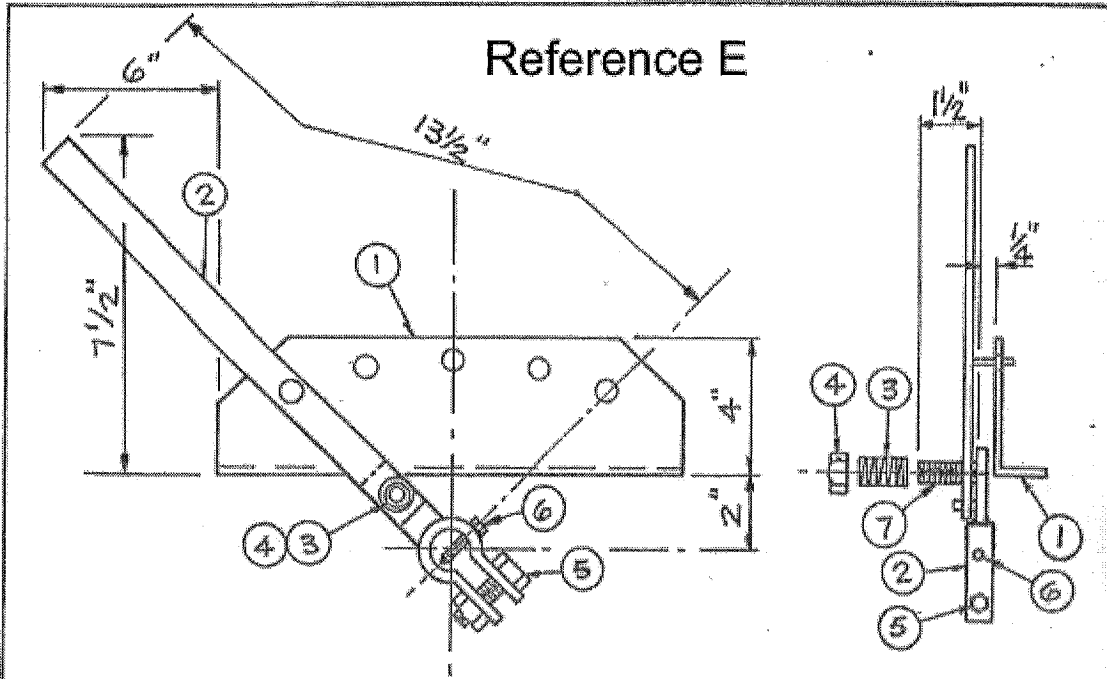
Connecting Collar Installation

Cust.

Date

Fig. 700-4





Reference E

MANUAL OPERATOR DETAIL

- (1) = Manual Operator Bracket.
- (2) = Manual Operator Handle.
- (3) = Manual Operator Handle Spring.
- (4) = Manual Handle Nut.
- (5) = Manual Handle Clamp Bolt & Nut.
- (6) = Set Screw
- (7) = 3/8" dia. all-thread.

AIRTECH	
INDUSTRIAL SHUTTERS	
MANUAL OPERATOR PARTS	
Cust.	
Date	Dwg. 700 - 3

Reference F

AIRTECH PRODUCTS, INC.

P.O. Box 790
8101 West 16th Street
Sand Springs, OK 74063

918-241-0264 (Phone)
918-241-0270 (Fax)

Louver Materials of Construction

Aluminum Frame (extrusion):	6063 T6
Aluminum Frame (folded sheet):	3003 H14
Galvanized Steel Frame:	A653-G90 10 Ga. Carbon Steel (Mechanical Galvanized Finish)
Blades:	6063-T6 Aluminum
Blade Pins:	
Aluminum:	6061-T6 Aluminum
Stainless Steel:	303 Stainless Steel
Torque Tube:	6063-T6 Aluminum
Actuator Rod:	6063-T6 Aluminum
Actuator Lever Arm:	6061-T6 Aluminum
Clevis:	1018 Carbon Steel
Clevis to Arm Connecting Link:	6061-T6 Aluminum
Assembly Hardware:	
Cap Screws:	ANSI/ASME 18.2.1 1/4-20, Grade 5, Zinc Plate
Nuts:	Nylon Insert lock nut, Performance Spec IFI/100, MIL/N/25027, Light Hex, Standard Height, Zinc Plate
Bearings:	Glass Filled Nylatron, (Per API Specification 661)

Airtech Products, Inc.

Reference G

P.O. Box 790

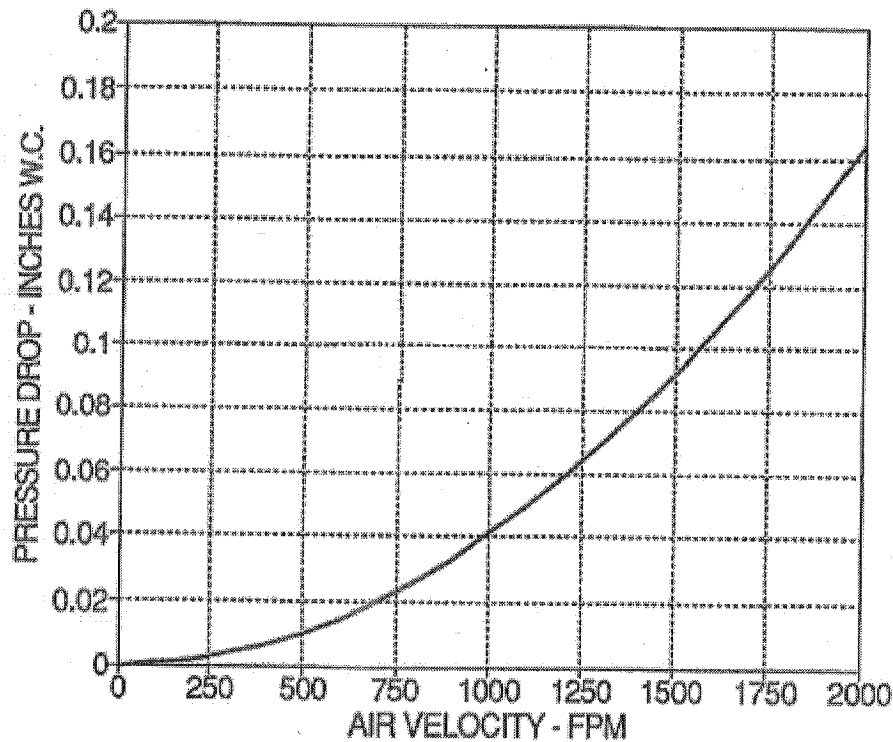
8101 West 16th Street

Sand Springs, OK 74063

918-241-0264 Phone

918-241-0270 Fax

LOUVER PRESSURE DROP CURVE

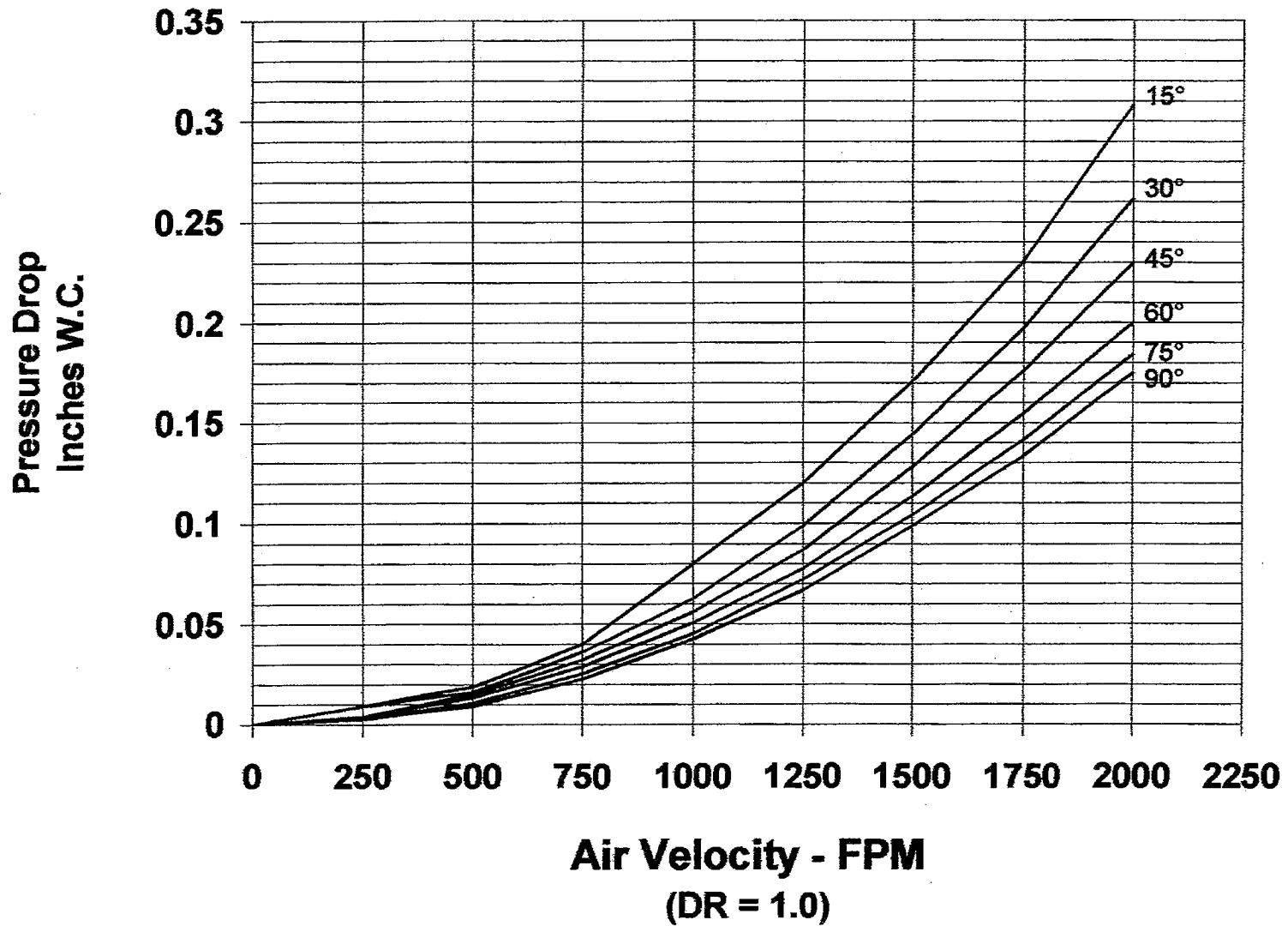


DENSITY RATIO = 1.0

Corrected Pressure Drop Across The Louvers As A
Function of Air Speed Within The Wind Tunnel.

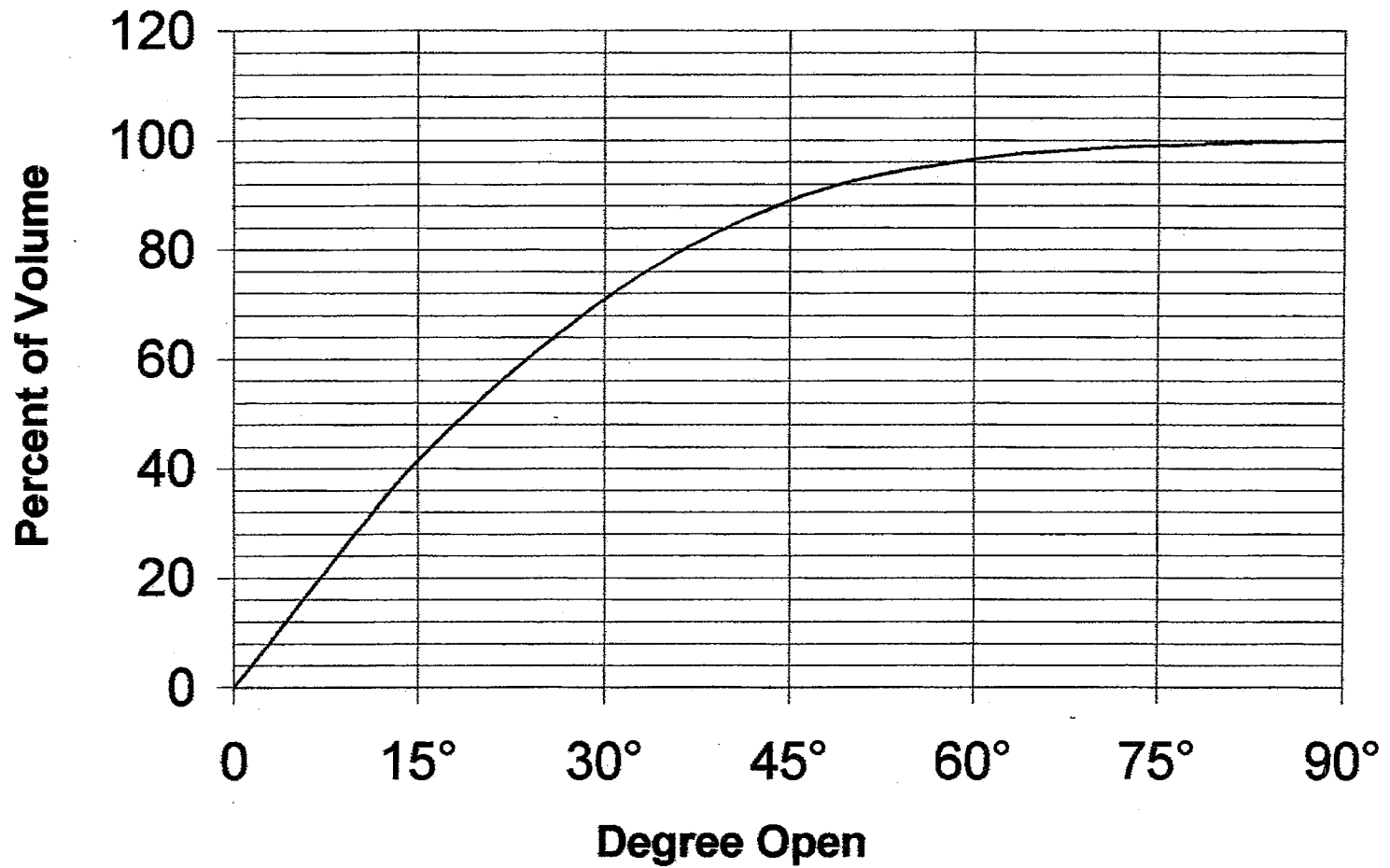


Pressure Drop vs Degree of Opening





Percent of Volume Per Degree Open





CLASS 10000 FANS OWNER'S MANUAL

CONTENTS

- 1.0 CLASS 10000 FANS OWNER'S MANUAL
 - 1.2 INSPECTION
- 2.0 INSTALLATION
 - 2.2 INSTALL MANUAL HUB AND AIR SEAL
 - 2.3 AUTOMATIC HUB AND AIR SEAL
 - 2.4 INSTALL PNEUMATIC TUBING
 - 2.5 INSTALL AND ADJUST BLADES
 - 2.6 START-UP PROCEDURES
- 3.0 MAINTENANCE
 - 3.1 PERIODIC INSPECTION
 - 3.2 ANNUAL INSPECTION
 - 3.3 VIBRATION AND UNBALANCE
 - 3.3.5 THROAT FLUTTER
 - 3.4 WARRANTY
 - 3.3.6 FIELD BALANCING
 - 3.5 MANUAL FAN PARTS LIST
 - 3.6 AUTOMATIC FANS PARTS LIST
- 4.0 OPERATION
 - 4.2 BLADE OVERLOAD
 - 4.3 CAUSES OF IMPROPER BLADE LOADING
 - 4.4 CHECKING BLADE LOAD
 - 4.4.1 SAMPLE GRAPH OF BLADE ANGLE IN DEGREES
 - 4.5 DAMAGING OPERATING CONDITIONS
 - 4.5.3 OBSTRUCTIONS

1.0 CLASS 10000 FANS OWNER'S MANUAL

1.1 ABOUT THIS MANUAL

Moore is as interested, as are its customers, that Moore fans operate at top efficiency for many, many years. This manual has been written to achieve that result and is based on more than fifty years of experience as a manufacturer of axial flow fans.

Moore fans represent the highest degree of axial fan development and are in all respects, regardless of price, the finest obtainable for their intended purpose. As for any fine equipment, certain precautions are necessary and certain abuses must be avoided in order to insure the best performance over the longest period of time. If you have any questions regarding the installation or operation of your Moore fan(s), please contact the Company for assistance.

1.2 INSPECTION

All Moore units are carefully balanced, inspected

and packed at the factory. If any damage is evident before or after unpacking, the delivering carrier should be promptly notified so that an inspection may be made by the claims adjustor. It is the responsibility of the consignee to file damage claims with the carrier. Although Moore will not be responsible for shipping damage, it is requested that any damage, even of a minor nature, be reported to the factory at once.

1.3 IDENTIFY YOUR FAN'S FEATURES

The installation instructions which follow will include some steps for installing fans with features not provided on your unit(s). Section 2 Getting Started should be read carefully before installation begins. Moore fans have several unique features. Those unfamiliar with these units should read the short summary of these important features on the last page of this manual.

2.0 INSTALLATION

2.1 GETTING STARTED

2.1.1 FAN IDENTIFICATION

Every fan, or group of identical fans, is assigned a Job Number. This number will be found on the Order Information Sheet showing fan specifications. A copy is attached to this manual. If non-identical fans are shipped together, a Job Number is assigned to each fan or group and a set of Information Sheets will be included for each Job Number.

The Job Number is written in semi-permanent ink on each blade, hub and air seal. All fan parts bearing the same Job Number are entirely interchangeable. (Blades of the same Series and Diameter are also interchangeable between Job Numbers.)

Fan components covered by more than one Job Number may be crated together. The Job Number that is written on each part, however, will make sorting simple.

Each individual fan produced by Moore is assigned a Serial Number. This Serial Number is embossed on a permanent metal tag and attached to each fan hub. The Fan Information Sheet provided for each Job Number lists all of the individual Serial Numbers of the identical fans covered by that Job Number so that, in future years, reference to the fan specifications provided will identify the characteristics of each individual fan.

Moore keeps records indexed by serial and job

numbers of all fans produced for at least forty years in order to provide proper maintenance advice and information on spare parts and replacements.

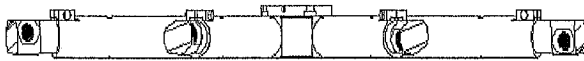
2.1.2 PLANNING THE INSTALLATION

The sequence given for the installation may be changed if the conditions warrant. For example, the air seal may be installed on the hub before the hub is installed on the drive shaft. (In fact, for inverted fans, it is necessary to install the air seal first.) The installation should be planned before beginning so that the steps required are taken in the most convenient order. If you need information not found here, please contact Moore.

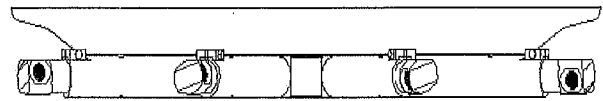
Class 10000 fans are suitable for horizontal or vertical mounting, for electric motor or engine drive and may be designed for clockwise (right hand) or counterclockwise (left hand) rotation. **Note: Automatic fans can only be installed for horizontal applications. (Vertical shaft)**

Some drawings illustrating the installation assume vertical mounting and need to be mentally rotated for horizontal mounting. Be sure to refer to the dimensional drawing(s) provided. These will illustrate the proper orientation of the fan and the rotation direction.

2.2 INSTALL MANUAL HUB AND AIR SEAL



Hub Only Without Air Seal



Air Seal Installed on Hub

Hub installation instructions

Moore Class 10000 hubs are shipped with Moore Hi-Torque (HT) Aluminum Bushings. The following paragraph details the installation procedure for these hubs.

Lubrication:

If the bushing was pre-installed in the hub at the factory, no further lubrication is required prior to installation.

If the bushing was not installed in the hub at the factory, it is imperative to apply high quality grease to the following surfaces:

1. The cap screw threads
2. The underside of the cap screw heads
3. The bushing taper / hub bore

DO NOT apply lubricant between the bushing bore and the shaft.

Installation:

Install the bushing in the hub by aligning the threaded holes on the I.D. of the hub with the slots on the OD of the bushing with the cap screws captured between the bushing and the hub. Insert the bushing in the hub. Using a hex key wrench, sequentially tighten the socket head cap screws until the bushing is almost fully engaged in the hub. Leave slight play between the bushing and hub to facilitate installation on the shaft. Place the hub/bushing on the shaft. (Preferably cap screw heads will be towards free end of shaft.) Insert the key, and tighten the setscrew to secure the hub and key to the shaft. Now begin sequentially tightening the socket head cap screws (approximately 2-3 turns per cap screw initially) to firmly engage the bushing in the hub and seat the bushing on the shaft. Once the bushing/hub is firmly seated on the shaft, continue tightening the cap screws sequentially until the specified torque, shown in the following table, is reached. **DO NOT** over-tighten cap screws as this could cause damage to the hub.

Bushing TYPE	Bushing OD	Allen Head Bolt	Hex Key Size	Required Torque
T	3"	12 mm	10 mm	50 ft-lb (6.9m-kg)
U	4"	12 mm	10 mm	50 ft-lb (6.9m-kg)
W	5.5"	16 mm	14 mm	90 ft-lb (12.5m-kg)
X	5.5" Long	16 mm	14 mm	135 ft-lb (18.7m-kg)
Z	7"	16 mm	14 mm	135 ft-lb (18.7m-kg)

Caution:

If bushing is expected to see frequent oscillating loads (Greater than 50% of nominal expected Static Torque), Fan should be operated for approximately 15 minutes and then re-torque bushing cap screws.

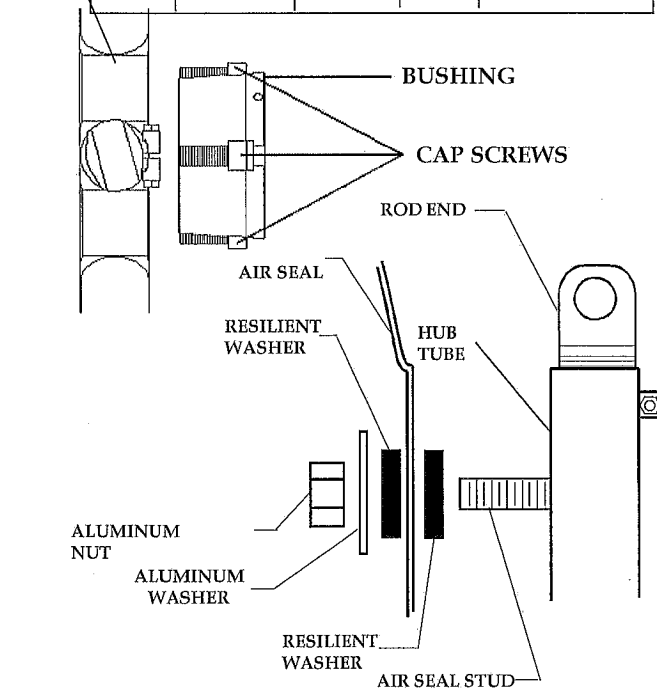
To install the airseal:

If the airseal is to be installed on the shaft side of the fan, cut out the center to provide clearance for the bushing.

Locate the air seal installation hardware in the plastic bag taped to one of the hub tubes. Install the air seal studs on the appropriate side of the hub tube. Finger tighten.

Place one resilient washer on each stud as shown in the drawings at left. Place the air seal onto the studs and install the remaining hardware, following the sequence shown in the drawings. Do not lubricate this end of the studs.

Note that the diameter of the resilient washers, before they are compressed, is slightly less than the diameter of the aluminum washer. Tighten each nut until the resilient washer's diameter is the same as the aluminum washer. Do not overtighten. Overtightness exists when the resilient washer has expanded in diameter larger than the diameter of the aluminum washer.

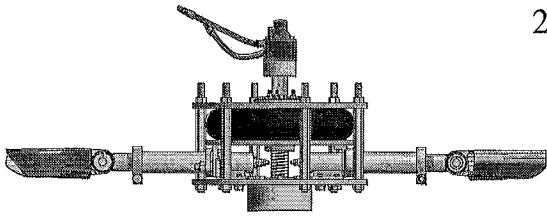


AIR SEAL INSTALLATION ON HUB

Note: Some air seals are provided with more mounting holes than may be required. This is done intentionally to make the air seals more interchangeable between units. For example, an air seal with 8 mounting holes can be used with either a 4-blade or an 8-blade unit.

2.3 AUTOMATIC HUB AND AIR SEAL

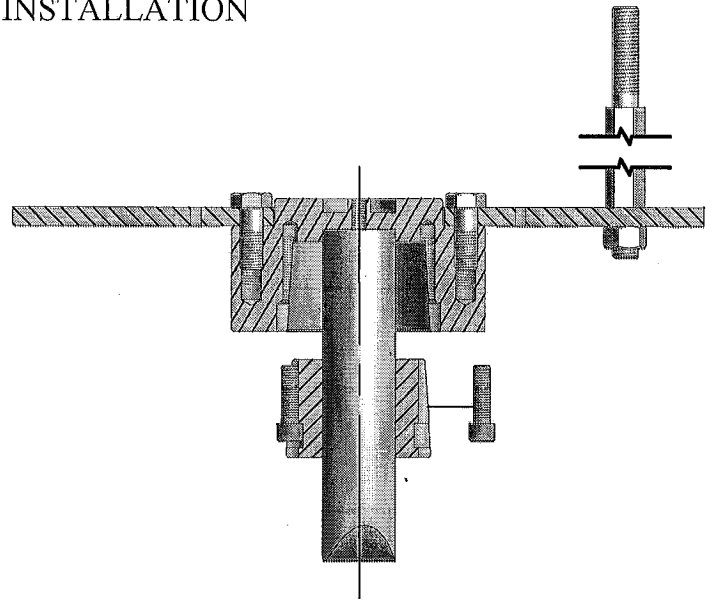
2.3.1 HUB INSTALLATION



AUTOMATIC HUB ONLY WITHOUT AIR SEAL

IF BUSHING IS NOT PRE-INSTALLED INTO HUB

Install the bushing in the hub by aligning the threaded holes on the I.D. of the hub with the slots on the OD of the bushing with the cap screws captured between the bushing and the hub. Insert the bushing in the hub. Using a hex key wrench, sequentially tighten the socket head cap screws until the bushing is almost fully engaged in the hub. Leave slight play between the bushing and hub to facilitate installation on the shaft.

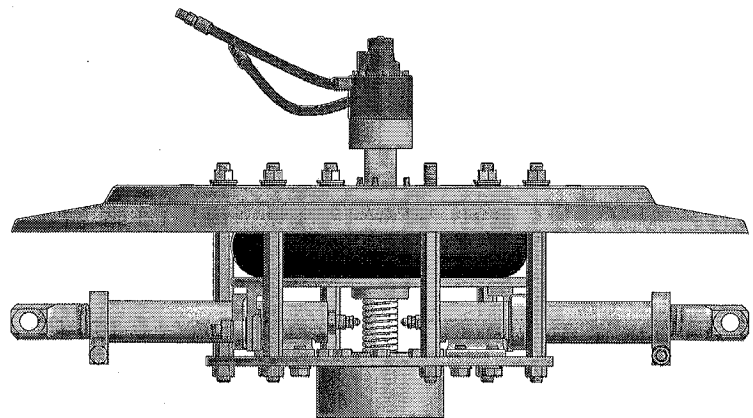


IF BUSHING IS PRE-INSTALLED INTO HUB

Place the hub/bushing on the shaft. Insert the key, and tighten the setscrew to secure the hub and key to the shaft. Now begin sequentially tightening the socket head cap screws (approximately 2-3 turns per cap screw initially) to firmly engage the bushing in the hub and seat the bushing on the shaft. Once the bushing/hub is firmly seated on the shaft, continue tightening the cap screws sequentially until the specified torque, shown in the following table, is reached. DO NOT over-tighten cap screws as this could cause damage to the hub.

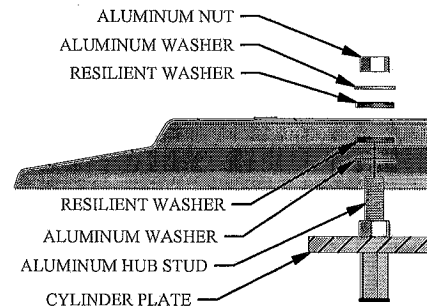
FAN SERIES	BUSHING TYPE	BUSHING OD	ALLEN HEAD BOLT	HEX KEY SIZE	REQ'D TORQUE
24	T	3"	12mm	10mm	50 ft-lb (6.9 m-kg)
30-72	U	4"	12mm	10mm	50 ft-lb (6.9 m-kg)
30-72	W	5.5"	16mm	14mm	90 ft-lb (12.5 m-kg)

To install **air seal** locate the air seal installation hardware in the plastic bag taped to one of the hub tubes. Remove the protective plastic caps from the bolts or studs. Place one aluminum washer and one resilient washer on each bolt or stud as shown in the drawings. Lower the air seal onto the bolts or studs and install the remaining hardware, follow the sequence shown in the drawings. Do not lubricate the end of the bolts or studs.



AIR SEAL INSTALLED ON AUTOMATIC HUB WITH POSITIONER

Note that the diameter of the resilient washers before they are compressed, is slightly less than the diameter of the aluminum washers. Tighten each nut until the resilient washer's diameter is the same as the aluminum washer. Do not overtighten. The nut is overtightened when the resilient washer has expanded in diameter larger than the diameter of the aluminum washer.



AIR SEAL INSTALLATION ON AUTOMATIC HUB

2.4 INSTALL PNEUMATIC TUBING

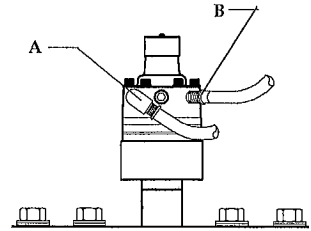
2.4.1 AUTOMATIC HUB WITH STANDARD POSITIONER

Connect the special flexible hoses provided to the instrument port "A" and the supply port "B" shown in the drawing. Use the elbow provided on one hose so that the hoses will be parallel. Support the positioner while tightening all fittings to prevent rotary union damage.

The flexible hoses supplied must be used and a slight amount of slack should be left when connecting to rigid piping to relieve any abnormal loading of the rotary union internal bearings and seal.

The ends of the hoses must be capped if not coupled to the system piping immediately. The flexible hoses provided terminate in 1/4" N.P.T. male fittings.

Flexible Hoses
Connected to Supply
and Instrument Ports
on Positioner



Pressure Requirements		
	P.S.I.	Kg/Cm ²
Control	3 to 15 (Std)	0.21 to 1.05 (Std)
Supply	55	3.9

MAXIMUM SUPPLY PRESSURE:
60 P.S.I. (4.2 Kg/Cm²)

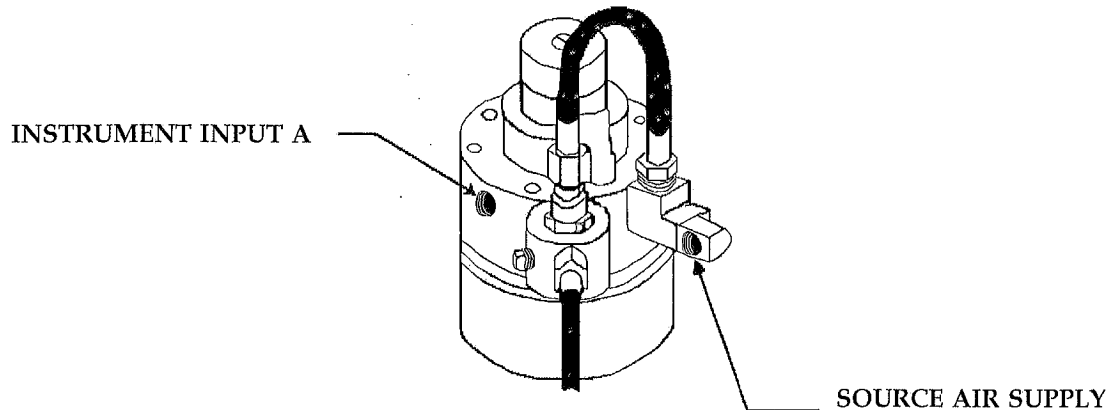
2.4.2 FOR POSITIONER WITH FAIL LOCKED IN LAST POSITION

When a fan is specified to fail locked in last position, pressure is retained in the actuator chamber if the system pressure falls abruptly. This retained pressure prevents the blade angle from changing when a failure occurs in the system supply pressure.

Connect hoses "A" to the instrument port as described in 2.4.1. Hose "B", which is normally connected to the supply port is to be connected to the fitting labeled

"source air supply". The flexible hoses provided must be used and a little slack must be left in them to prevent damage to the bearing or seal in the rotary union.

When the system is charged, normal pressure at the valve keeps it in the open position and flow occurs in either direction between the positioner and the supply actuator. If the system pressure fails, the valve automatically closes, retaining pressure in the actuator.

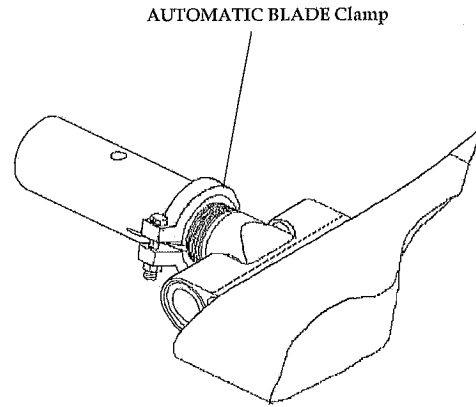
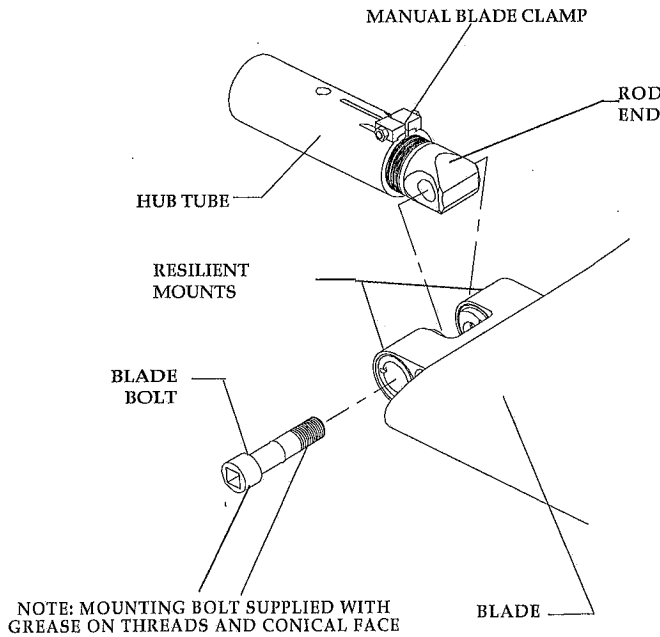


Note:

After installing hub onto bushing: Check the hub and positioner for run out.
Maximum run out of positioner in the horizontal direction is $\pm 1/8$ " (3mm)
If outside the tolerance adjust the bushing nuts slightly to level the fan hub.

2.5 INSTALL AND ADJUST BLADES

2.5.1 INSTALL BLADES



NOTE: AUTOMATIC Blade clamp's require higher torque setting see section 2.5.2

BEFORE INSTALLING BLADES. . .

Check to see that the hub is level. If the drive shaft is not truly horizontal (or vertical), causing the hub to be cocked, it will be difficult to adjust blade angles accurately. Eccentric rotation of the fan can also cause serious vibration problems.

If misalignment, vibration or unbalance in the system is present, it will be more easily identified and corrected at this time.

Moore fan blades are carefully balanced to the same moment at the factory. Any Class 10000 blade of the same series and diameter may be installed on any hub furnished on the job. They are completely interchangeable.

Moore Class 10000 Heavy Duty Fans are designed for engine drive and other applications with the more severe requirements of this service. Proper installation, with particular attention to tightening nuts to the specified torque, is essential to maintain the design integrity of these units.

Install one blade: Clean any dirt or grease from the rod end and the surfaces of the resilient mounts. Align the rod end hole with the holes in the resilient mounts and insert the blade mounting bolt first through the resilient mount with the recess to accept the bolt head, then through the rod end hole and screw the bolt into the second resilient mount

lightly. A 3/4" drive torque wrench with a short extension may be used. The blade mounting bolt is supplied from the factory with grease on the threads and conical face. **Do NOT clean the grease from the bolt.**

Complete the installation of one blade by holding the blade so that the blade extends straight out from the hub tube. Holding the blade in this position, **tighten the bolt using a torque wrench set to 200 ft-lb (28 m-kg) making sure the rod end and the resilient mounts seat.**

After installing the first blade, manually rotate the fan while moving the blade tip in and out to be sure the blade clears the ring or throat at all points. When the blade is held in alignment with the blade tube (that is, straight outward from the hub), it should clear the fan ring by a distance adequate to provide for any relative motion between the fan wheel and the ring. Excess clearance between the blade tips and the ring, however, should be avoided to prevent backflow which seriously reduces fan efficiency. If clearance is excessive, the diameter may be adjusted at this time. See Section 2.5.2.

Install the rest of the blades so that they are identical with the first blade. **Torque all bolts to 200 ft-lbs (28 m-kg).** If blades are installed properly, they will return to their undisturbed position if the tips are pressed in the axial direction with moderate force (10 to 20 lb).

2.5.2 ADJUST BLADE ANGLE

Hubs are shipped from the factory with the rod end set for the blade angle indicated by the design performance. A change in blade angle is sometimes necessary, however, to adjust to actual site conditions. Failure to adjust the blade

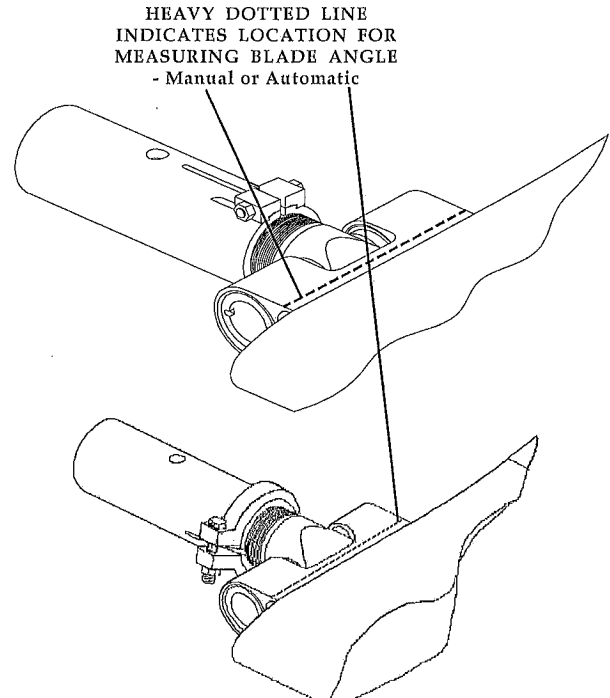
angle when required may result in blade overload. The causes of improper blade loading are explained in Section 4.3 of this manual. Section 4.4 "Checking Blade Load" provides a simple method of determining the maximum

blade angle allowable in terms of static pressure vs blade angle. Please refer to these sections before increasing blade angle.

To adjust, loosen the Clamp Nut just enough to allow the blade to be turned. Place a inclinometer on the flat surface of the mounts end as shown in the illustration at right. Turn the blade until the desired angle is achieved.. Make a permanent record of the final angle selected and take care that all blades on the fan are set at the same angle. A typical adjustment may be +/- 3°. The maximum recommended blade angle is 30°.

Retighten the Clamp Nut to **18 ft-lbs (2.5 m-kg)** for **Manual** and **50 ft-lb (7 m-kg)** for the **Automatic** while holding the blade in this position. Recheck each blade angle before tightening.

WARNING: The fan is designed to consume the horsepower stated on the Fan Specification Sheet. The engine drive typically produces far more power than the fan can absorb. Too great an increase in blade angle can cause serious blade overload which will stall the blades. In this condition, the fan will actually deliver less air and blade life may be shortened. Blade load considerations are discussed in Section 4.0 Operation in this manual.



CLASS 10000 AUTOMATIC HUB DETAIL
NOTE: CLAMP DIFFERENCES

2.5.3 ADJUST DIAMETER IF REQUIRED

At times it may be necessary to adjust the fan diameter to suit a particular ring. To do so, loosen the clamp nut so that the rod end can be rotated in the hub tube. One complete revolution will increase or decrease the radius of the fan by .059" (1.5 mm) for manual and .087" (2.2 mm) for automatics. Take care that the clevis is returned to exactly the factory-set angle unless it is intended that the blade loading be

changed as discussed in the previous section. A match mark may be made at a point on the threads and the tube before turning to assure that exactly one revolution is made. Tighten the clamp nut to 18 ft-lbs (2.5m-kg) for manual and 50 ft-lbs (6.9m-kg) for the automatic.

Maximum adjustment possible is about +/- 0.75" (19 mm). At least 1.0" (25 mm) of rod end threads must remain in the tube.

2.6 START-UP PROCEDURES

Before starting the fan, manually check all bolts or nuts to see if they are tightened. Take care not to exceed the stated torque limits.

Manually rotate the fan while checking each blade for proper clearance.

Start the fan and watch it in operation. All blades should move to the same operating position, indicating that the blade angles are properly set and that all blades are equally loaded. If vibration or unbalance is evident, see Section 3.3.

After the fan has been operating for several minutes,

stop the fan and observe the blades as the fan comes to rest. All of the blades should return to their original position at the same rate.

Inspect the inner surface of the fan ring and the blade tips for any indication of scoring.

The horsepower given on the Fan Specifications is the calculated horsepower (at the fan shaft) that is required for the specified performance. Consult the factory or the fan curve before increasing the blade angle for the fan to consume more than the specified horsepower.

3.0 MAINTENANCE

3.1 PERIODIC INSPECTION

3.1.1 PURPOSE

Fan failure is most likely the result of destructive repetitive stress acting over a period of time. These stresses may be caused by mechanical abuse, e.g. rough gears or drive shaft imbalance, or by aerodynamic abuse such as blade overload or abnormal flow conditions. Fortunately, these stresses manifest themselves in typical ways that may easily be detected on inspection if one knows what to look for. The purpose of this section of this manual is to describe the symptoms of potentially damaging mechanical problems and how they can be corrected. Aerodynamic abuses are covered in Section 4.0 Operation.

3.1.2 FREQUENCY OF INSPECTION

The frequency of inspection varies widely in accordance with the severity of service and a suitable inspection schedule should be developed with experience over time. During the first week of operation, at least one inspection should be made. At these initial inspections, in addition to the items listed below, check all nuts for tightness to make certain that all were tightened properly at installation. Take care not to exceed the stated torque limits. Following the first week, it is probable that inspections of the fan need be made no more frequently than inspection of the drive.

3.1.3 BLADE ANGLE AND RUNNING POSITION

Turn off the unit and watch the blade tips. A looseness in the clamp bolt will permit a blade to flatten in angle. This usually can be detected by looking at the tips of the blades while the fan is slowing down. At the same time, before the unit comes to a complete stop, watch the track of the blade tips to see that all blades move to the same operating position. If one or more blades is at a substantially different position than the other blades, or if all of the blades are at a different position than at the last inspection, investigate further. This condition may be caused by a damaged resilient mount, requiring blade replacement.

3.1.4 CRACKS, DENTS AND CORROSION

Skin cracking may be caused by the tips dragging on the fan ring, or it may be the result of long-term fatigue due to continued operation under conditions of vibration or unbalance as discussed in Section 3.3 which follows. Skin cracking can also be caused by continued operation under overload conditions as discussed in Section 4.3 Causes of Blade Overload.

Cracking in air seals can occur if the airseal has been improperly installed. See Section 2.2. Check to be sure the resilient washers are present and the nuts properly tightened.

The fatigue strength of materials, whether metal or plastic, may be lowered by long-term exposure to water.

Dents in blades are caused by objects falling into the fan or the fan striking some obstacle. Minor dents may sometimes be repaired by drilling a small hole in the center of the dent and pulling outward on the blade skin. Blades may be ordered from the factory for replacement. If there is any evidence of this type of damage, the hub should be carefully inspected as discussed in Section 3.1.6 which follows.

The Type 5052 aluminum, a marine alloy, used as the blade material on Moore fans works well with either fresh or sea water. Waters that are acid, alkaline, or contain copper salts, however, should be avoided for all aluminum alloys. If you have questions regarding the suitability of the fan materials under certain water conditions, please contact the factory.

3.1.5 HUB INSPECTION

If damage to the fan has occurred, the hub should be carefully inspected since subtle damage may have been caused that is not readily apparent. Check the hub for any sign of bending or twisting of the hub tubes. Hub tubes cannot be replaced in the field on manual fans and a new hub should be ordered.

Bushings are frequently cracked during a fan wreck and should be carefully inspected. Damage may occur to the studs that attach the hub to the bushing. It is a good idea to replace the studs when replacing a damaged fan blade.

As with any industrial equipment, before entry into fan chamber, strict adherence to ALL Lock-out / Tag-out procedures is well advised!



3.2 ANNUAL INSPECTION

3.2.1 CLEAN BLADES IF INDICATED

A smooth blade surface is essential for efficient fan performance. If an incrustation forms on the blades it should be removed. Use steel wool as an abrasive along with a mild detergent or a very mild form of solvent. Lye must not be used because it attacks aluminum readily.

3.2.2 CHECK SYSTEM PRESSURE

Radiator sections may be effected by the accumulation of dust and dirt in some atmospheres. (Cottonwood seeds are particularly troubling.) These accumulations may significantly increase the static pressure. Adjust the blade angle if necessary as described in Section 4.4 Checking Blade Load.

3.2.3 CLOSE INSPECTION

The yearly inspection should be a very thorough one. All nuts and bolts should be checked and careful scrutiny given to all highly stressed areas.

Inspect the resilient mounts as follows: With the fan turned off, grasp each blade and feel for looseness at the mount. If in doubt, the blade should be removed and the mount assembly visually inspected. Wear is indicated by a fretting effect and the resilient mount material will show signs of extruding from the cavity. If these indications are not apparent, replace the blade and continue normal operations.

Inspect the blade tips for any signs of cracking and the fan ring for any scoring that might indicate that the blades have been striking or rubbing against the fan ring.

3.3 VIBRATION AND UNBALANCE

3.3.1 GENERAL

No piece of rotating equipment is perfectly balanced. It is always possible that the minute unbalances of the various components may combine to provide a noticeable lack of balance. This rarely occurs, since it is unlikely that all unbalanced components will become assembled with their heavy sides in the same direction. Nevertheless, if unbalance is noted, the various components should be rotated into different positions to see if this might cure the unbalanced condition.

If vibration or unbalance occur, either at the time of installation or later during the operation of the unit, its cause may be determined by following the directions below.

3.3.2 FAN UNBALANCE

Vibration is most likely to be caused by the fan if the blades are not set at the same angle. If the blades are properly set, the fan is the least likely cause of vibration. All fan components are balanced to within ± 0.2 ft-lbs.

If the fan is in an unbalanced condition, the frequency of vibration of the structure will be that of the RPM of the fan and is quite low. In the case of large fans, the frequency is often low enough to be mentally counted along with the rotation of the fan. A vibration of 500 RPM or less will be felt as a weave in the structure rather than a vibration. Below 400 RPM, the vibration may be mentally counted and above that point may be read with a frequency meter.

Before assuming fan unbalance, check for loose bearing seats or bearings journaling the shaft on which the fan is mounted. This condition will cause the shaft to rotate eccentrically, throwing the weight of the fan off-center, resulting in unbalance of the frequency of the fan RPM.

After all checks have been made and the fan is still determined to be unbalanced, field balancing may be accomplished as described below in Section 3.3.6.

It should be noted that the loads imposed on the drive shaft and its supporting bearings by fan unbalance

are negligible. A rotating centrifugal load of 100 pounds, due to unbalance, would be extremely objectionable and possibly even damage the structure on which the drive was mounted. By contrast, it would be unlikely that the drive shaft of a fan, of perhaps 25 HP, would be supported on bearings rated less than 2000 or 3000 pounds radial load. For higher horsepower, the bearing capacity would be correspondingly increased. From this it is evident that speed reducer or drive shaft bearing failure could never be caused by moderate or even objectionable fan unbalance.

3.3.3 BELT DRIVE UNITS

The more common causes of vibration in belt drive units are not the drives themselves but the result of shafts that are too flexible or non-rigid supporting members. Vibration can be caused by misalignment of the sheaves or poorly adjusted belt tension. Consult the manufacturer of the drives for information. The quickest way to identify the cause of vibration in belt drive units is to operate the fan with the blades removed.

3.3.4 ROUGH GEARS

Continued operation on rough gears and bearings is almost certain to develop cracks in the blade skins. Rough gears may be of two types:

1. Rough or failed bearings in the drives or gears will result in a high frequency vibration being transmitted into the fan where some areas of the skin will respond to the frequencies applied. Cracks will appear in the blade skin and eventually, in some areas, the skin may actually fall away.

2. The other type of rough gear occurs when the output shaft accelerates and decelerates with each pinion tooth engagement. With a six tooth pinion and a motor speed of 1800 RPM, or 30 cycles per second, this gear misalignment impresses upon the fan a vibrating frequency of $30 \times 6 = 180$ cycles per second. If the engagement of teeth is also included, the frequency is 360 cycles per second. This type of high frequency vibration is at least as serious as that caused by bad bearings.

MAINTENANCE

3.3.5 THROAT FLUTTER

Any fan that is effectively moving air at the tips of the blades will develop a reduced pressure area (or suction) on the fan throat or ring at the tip of the blade. This suction tends to draw the throat toward the tip of each blade, which means that a four blade fan would tend to draw the throat into something approaching a square while a six blade fan would draw it into something resembling a hexagon, etc. Since the fan is rotating, the effect on the throat is that of continually drawing it into a rotating polygon. The resulting throat flutter is frequently mistaken for fan unbalance.

A substantial throat or ring will be sufficiently rigid that flutter will not exist. A weak or flexible throat, particularly when used with a fan of a low number of blades, will be greatly affected by this type of vibration. Throat flutter is easily detected due to the fact that it is invariably of a frequency of the fan RPM times the number of blades on the fan.

Throat flutter will cause no damage to the fan so long as the throat does not disintegrate and fall into the fan blades. It may be eliminated by stiffening or bracing the throat.

If in doubt that throat flutter is the cause of

vibration, reduce the angle of the blades until the fan is doing little or no work. If the vibration ceases under this condition, it is certain that throat flutter is present when the blades are loaded.

3.3.6 FIELD BALANCING

Unbalance in older fans may develop because of some structural change or by installing one new blade on an old fan where the existing blades had changed in weight in the course of operation.

Use wire to attach a small weight in succession to each of the air seal studs until the best location for the weight is found. The weight should then be increased or decreased until the best balance is achieved. The permanent weight may then be secured to the stud or hub tube, whichever is the most convenient for the type and shape of weight to be used. One or more pieces of metal shaped like a washer could be placed over the stud, on the hub tube, behind the stud, or over the threaded portion of the rod end. Aluminum or stainless weights should be used and weights should not be attached to the blade skin.

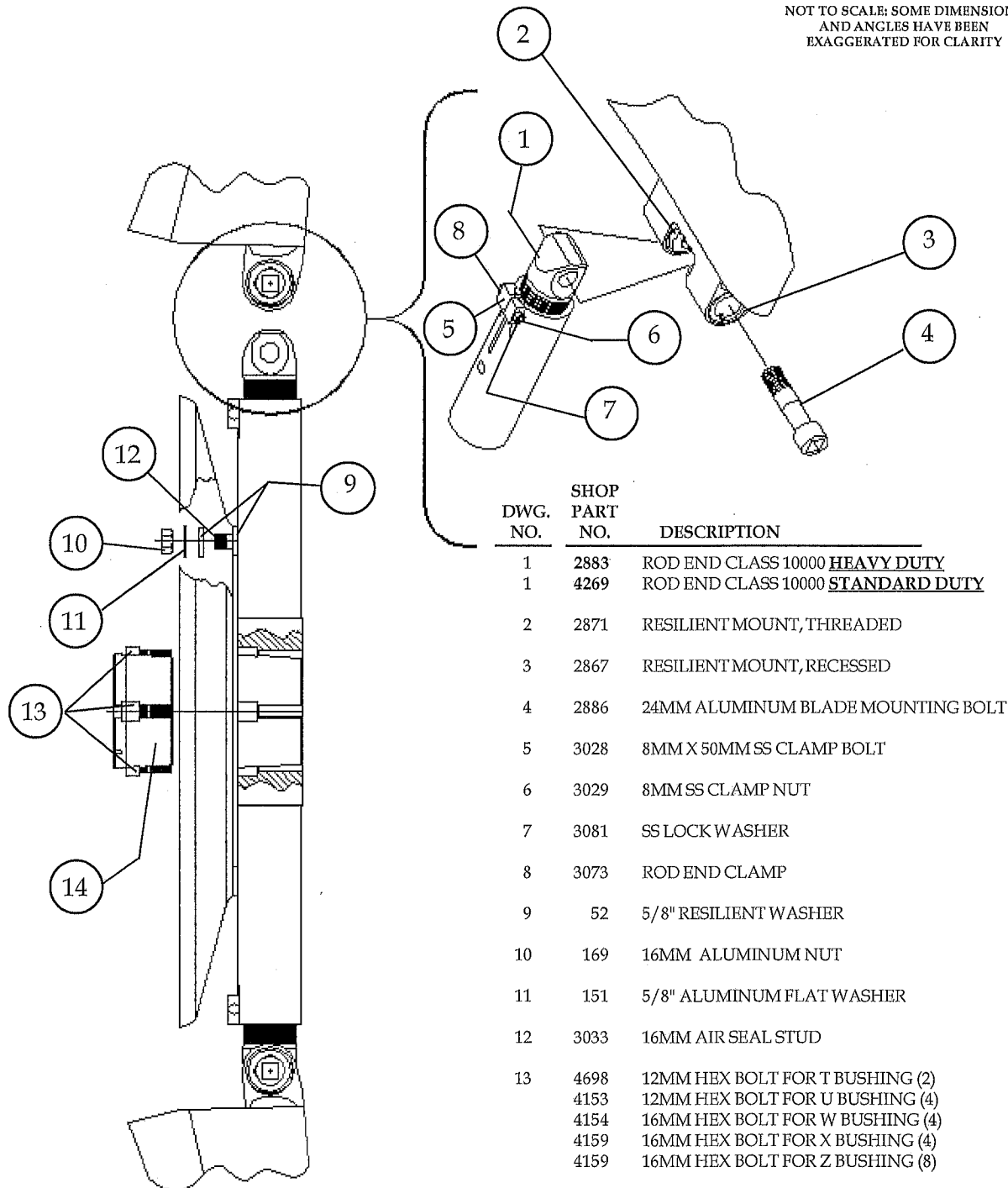
3.4 WARRANTY

MOORE FANS LLC (the Seller) warrants only to Buyer, as its purchaser for resale, that the fans manufactured and sold by Seller to Buyer under this Agreement will be free from all defects in material and workmanship under ordinary use for a period of two (2) years from the date of shipment or one (1) year from the date the fan is installed on a customer's premises, whichever occurs first. This warranty period shall apply only if Seller receives written notice of any defect within the warranty period. Upon receipt of such notice, Seller, at its option, may require Buyer to return the fan at Buyer's cost to Seller for inspection by Seller. If the fan is found to be defective on inspection by Seller, as a sole and exclusive remedy, Seller will, at its option, either repair or replace the fan. This warranty shall not

apply to damage on account of misuse, neglect or accident or shipping damage, or if repairs or part replacements have been made or attempted without Seller's prior written authorization. SELLER SHALL NOT BE LIABLE IN ANY EVENT FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES FOR BREACH OF THIS OR ANY WARRANTY. THIS WARRANTY IS IN LIEU OF ALL OTHER GUARANTEES OR EXPRESSED WARRANTIES AND ALL IMPLIED WARRANTIES, INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY AND OF FITNESS FOR A PARTICULAR PURPOSE. DUE TO THE VARIETY OF CONDITIONS UNDER WHICH THE FANS MAY BE USED, RISKS OF RESULTS OBTAINED FROM USE OF THE FANS, WHETHER USED ALONE OR IN COMBINATION WITH OTHER PRODUCTS, IS ENTIRELY BUYER'S. THE ABOVE LIMITATIONS ON DAMAGE AND EXCLUSION OR LIMITATION OF IMPLIED WARRANTIES ARE NOT APPLICABLE TO THE EXTENT PROHIBITED BY STATE LAW.

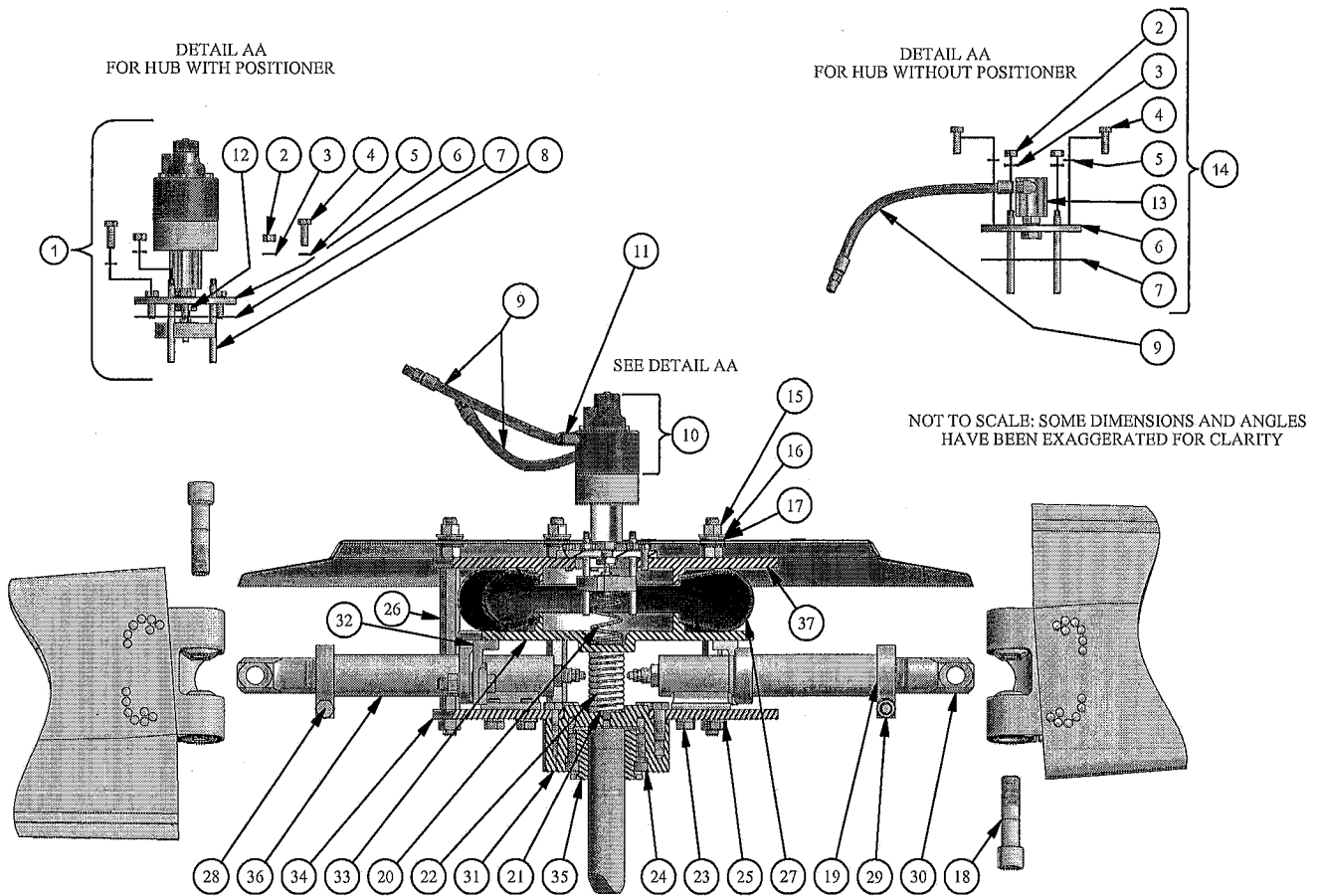
3.5 MANUAL FAN PARTS LIST

NOT TO SCALE: SOME DIMENSIONS
AND ANGLES HAVE BEEN
EXAGGERATED FOR CLARITY



DWG. NO.	SHOP PART NO.	DESCRIPTION
1	2883	ROD END CLASS 10000 <u>HEAVY DUTY</u>
1	4269	ROD END CLASS 10000 <u>STANDARD DUTY</u>
2	2871	RESILIENT MOUNT, THREADED
3	2867	RESILIENT MOUNT, RECESSED
4	2886	24MM ALUMINUM BLADE MOUNTING BOLT
5	3028	8MM X 50MM SS CLAMP BOLT
6	3029	8MM SS CLAMP NUT
7	3081	SS LOCK WASHER
8	3073	ROD END CLAMP
9	52	5/8" RESILIENT WASHER
10	169	16MM ALUMINUM NUT
11	151	5/8" ALUMINUM FLAT WASHER
12	3033	16MM AIR SEAL STUD
13	4698	12MM HEX BOLT FOR T BUSHING (2)
	4153	12MM HEX BOLT FOR U BUSHING (4)
	4154	16MM HEX BOLT FOR W BUSHING (4)
	4159	16MM HEX BOLT FOR X BUSHING (4)
	4159	16MM HEX BOLT FOR Z BUSHING (8)
14		T BUSHING (3") U BUSHING (4") W BUSHING (5.5") X BUSHING LONG (5.5") Z BUSHING (7")

3.6 AUTOMATIC FANS PARTS LIST AFTER 2009



ITEM	PART #	DESCRIPTION	ITEM	PART #	DESCRIPTION
1	2624	CSP UNION ASSEMBLY (WITH POSITIONER)	22		RETURN SPRING
2	1625	10mm STAINLESS STEEL NUT (3)	23	4515	16mm x 32mm ALUMINUM ANCHOR TEE BOLT (4 per BLADE)
3	733	3/8" SEALED WASHER (3)	24		12mm HEX BOLT FOR T BUSHING (2)
4	771	10mm x 30mm STAINLESS STEEL BOLT (6)			12mm HEX BOLT FOR U BUSHING (4)
5	179	3/8" FIBER WASHER (6)			16mm HEX BOLT FOR W BUSHING (4)
6	162	UNION PLATE			16mm HEX BOLT FOR X BUSHING (4)
7	163	UNION PLATE GASKET	25	152	5/8" ALUMINUM LOCK WASHER (4 per BLADE)
8	159	STAINLESS STEEL STOP STUD (3)	26	1530	18mm x 302mm ALUMINUM HUB STUD
9	257	12" STANDARD NEOPRENE AIR HOSE ASSEMBLY WITH 1/4" NPT EXTERNAL THREADS BOTH ENDS	27	16	DIAPHRAGM ACTUATOR
10	21	POSITIONER	28	167	16mm x 70mm ALUMINUM BOLT
11	210	1/4" BRASS STREET ELL	29	169	16mm ALUMINUM NUT
12	344	5/8-18 LH LOCKNUT	30	4269	ROD END
13	264	CS ROTARY UNION	31		AUTOMATIC FAN BUSHING ADAPTER
14	186	CS UNION ASSEMBLY WITH HARDWARE	32		PISTON STRUT ASSEMBLY WITH HARDWARE
15	1532	18mm ALUMINUM NUT	33		PISTON PLATE
16	164	3/4" ALUMINUM FLAT WASHER	34		AUTOMATIC HUB PLATE
17	52	5/8" RESILIENT WASHER	35		T BUSHING (3")
18	2886	24MM ALUMINUM BLADE MOUNTING BOLT			U BUSHING (4")
19	644	SMALL CLEVIS CLAMP			W BUSHING (5.5")
20		RANGE SPRING			X BUSHING LONG (5.5")
21		RETURN SPRING SHIM	36		HUB TUBE ASSEMBLY WITH HARDWARE
			37		CYLINDER PLATE

4.0 OPERATION

4.1 AERODYNAMIC ABUSE

4.1.1 ABOUT THIS SECTION

It is widely acknowledged that the kinds of mechanical abuse described on the preceding pages are destructive for all types of operating equipment. It is less well recognized that — for fans — aerodynamic stresses are an even more serious hazard. This section deals with the causes of destructive aerodynamic stresses and how they can be avoided.

Although this information is given primarily for the benefit of operators of Moore equipment, it may be applied to fans of any manufacture.

Unlike smaller fans, which are typically furnished complete with their surroundings, the large fan wheel is supplied as an unprotected component of the system and is installed in innumerable types of surroundings. Not only do the types and conditions of the drives for these fan wheels vary widely, but the entrance and exit conditions and the enclosure for the wheel assume a myriad of possible combinations. In designing his product, the manufacturer of fan wheels must anticipate the operating conditions based upon his knowledge of what is reasonable and customary for the industry. He may over-design for abnormal stresses only until the practical limit is reached to avoid excessive weight, cost and inefficiency.

4.1.2 NORMAL OPERATING CONDITIONS

The fan manufacturer assumes a fairly reasonable atmosphere for the operation of his product, including the following:

- The fan selection will be reasonably in line with the performance the unit is expected to maintain, with an adequate blade area for the pressure required at the given RPM. Blades will not be loaded beyond their capacity to maintain air flow.
- A fan ring will be provided that is round, rigid and of a depth at least sufficient to cover the tips of the blades. Tip clearances will be uniform and controlled.
- The approach air will represent a relatively uniform and axial flow with, of course, some unavoidable turbulence expected. Adequate open area will be provided at the inlet of the fan.
- Major obstructions will not be present at either the inlet or discharge of the fan.
- The RPM of the fan will be within the design limits.
- The relative direction and velocity of approaching air to the blades will be fairly constant and protection will be provided from extreme wind conditions.

Under such conditions, the unit stresses in the blades would not be expected to vary more than plus or minus 50%. Fan design based on such assumptions is entirely reasonable and, with proper drives and installation conditions, has proven highly successful.

4.1.3 ABNORMAL CONDITIONS

Abnormal operating conditions result in destructive repetitive stresses that can seriously shorten fan life. The aerodynamic abuses discussed in this section can cause repeated flexing of the fan blades and hub. Violent displacement of the resiliently mounted Moore fan blades may occur — a greater displacement than would occur in rigidly mounted blades. The resilient mounting, of course, minimizes the structural unit stresses which would be transmitted to the root of the blade and into the hub and drive. Although Moore units may be expected to resist greater stress than units of conventional design, such repetitive stresses may exceed the capability of the resilient mounts to absorb them. If so, fatigue of the mounts and metal may develop, adjusting linkages may wear, and ultimate failure becomes a possibility.

Some of the abuses set out in the following text are far less important than others. All of them may occur in varying degrees.

Specifically, abuse due to serious repetitive stresses can lead to mount failure and, if carried to extremes, can require blade replacement. In units of other manufacture with rigidly mounted blades, repetitive stresses of this type may lead to blade breakage, probably near the root or at the point of attachment to the hub where stresses are highest, or may lead to failure of the hub itself. The resilient mount design, unique with Moore fans, dampens these vibrational forces and results in a fan that is far less vulnerable to failure from these conditions than other units with rigidly mounted blades. Even so, extreme conditions can cause damage.

A well-designed fan can be expected to operate for many years without trouble under normal operation as described above. The extreme repetitive stresses described below, however, will certainly reduce the life of the fan, causing failure many years sooner than would occur if the fan were operated as intended. Fortunately, these destructive conditions are readily observable to someone who is knowledgeable about them, and they can be corrected with reasonable effort and expense once they are observed.

4.2 BLADE OVERLOAD

Of all the aerodynamic abuses to be avoided in the operation of a fan, the most important is that of overloading the fan blades. Blade overload occurs because of insufficient blade area: In other words, when there is an inadequacy in the number of blades on the fan selected.

The Moore system of rating is based upon the pressure that each blade will produce at a given RPM with good efficiency. This pressure is called 100% blade load. When blade load exceeds 110%, the fan will not only operate at lower efficiency, it may be subject to structural damage as well.

In selecting a fan, the total pressure divided by the pressure to be produced by one blade determines the number of blades required for the anticipated performance. Whenever information is available, The Moore Company checks the selection. Even so, underestimation of the pressure requirements by the system designer, or changes in the operating conditions over time, may result in overload conditions.

Why is a blade overload condition of such concern? We are all aware of the fact that an airplane traveling at a given speed can carry only a certain load. If the speed of the airplane is decreased or the load increased, stalling flow over the wing will occur. In the case of an airplane, approximately two-thirds of the lift provided by the wing is the result of the air flow over the top or convex portion of the wing. Lift is provided as a reaction to the flow of air being accelerated and deflected downward as it passes over the wing. A negative pressure area is thus formed on the top surface of the wing which tends to lift it upward.

So long as air flow over the wing is smooth and clings to the surface of the wing, little turbulence is present. When the load is increased, or the speed decreased, the angle of the wing to the air stream must be increased to a point where the air flow breaks away from the upper surface of the wing. This is known as stalling or burbling flow, since the air, instead of clinging to the wing, breaks away near the leading edge and leaves what might be called a turbulent void above the upper wing surface, nullifying the accelerated flow which was responsible for the greater part of the lift of the wing.

When this occurs, the wing loses a large portion of its lift. Flow, however, will re-establish briefly and break again, the cycle being repeated continuously, resulting in a severe

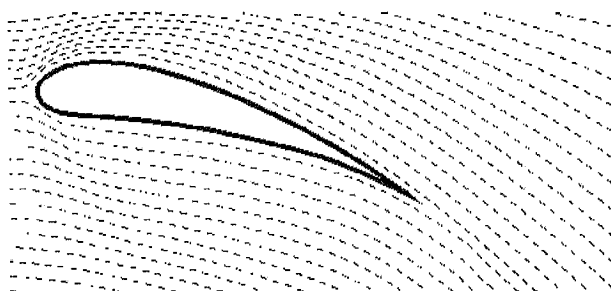
vibration throughout the aircraft as the flow alternately makes and breaks. Anyone who has experienced a stall in an airplane will be familiar with this violent phenomenon.

A fan blade is no different than an airplane wing except that the air usually is being deflected upward rather than downward, the convex side of the blade being the lower surface rather than the upper surface as in the case of an airplane. The result of blade overload is identical: When blade load exceeds that allowable, a violent vibration will take place in the blade as the laminar, or uniform, flow makes and breaks perhaps many times a second.

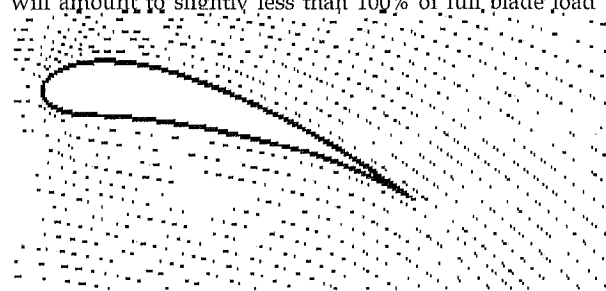
Another way of looking at this problem is to consider that the available number of blades are set at too steep an angle to be able to move air at the axial velocity which is necessary to maintain a smooth flow over the convex surface. In other words, to move air at the velocity necessary for this blade angle, plus overcoming the static resistance of the system, the total pressure which would have to be maintained for an air flow corresponding to this angle is greater than the total pressure capability of the given number of blades at this RPM. Such a condition can only be corrected by decreasing the blade angle until smooth flow is obtained or by increasing the number of blades and the total pressure potential of the fan until the fan's pressure potential equals the pressure necessary to move the specified quantity of air through the system.

Continued operation under conditions of stalling flow, or blade overload, will significantly shorten the life of the fan. Operation under these conditions will also reduce efficiency to a ridiculously low figure. See the chart under Section 4.4 Checking Blade Load which follows. Note that although air flow remains constant or decreases, horsepower continues to increase with increased blade angle.

In conclusion, if a given fan, in a given installation, can only absorb forty horsepower, for example, the blades may be pitched up to consume fifty horsepower without any increase in air delivery, and possibly with a decrease. As a result, the extra ten horsepower is totally wasted -- perhaps worse than wasted. It is good practice to select a sufficient number of blades so that blade load will amount to slightly less than 100% of full blade load



AIRFLOW IN NORMAL FLOW
Downward flow provides lift to the wing



AIRFLOW IN STALLING FLOW
Note lack of air deflection downward.

4.3 CAUSES OF IMPROPER BLADE LOADING

4.3.1 VARIATION FROM PREDICTED CONDITIONS

Although those who design air coolers and cooling towers undoubtedly do their best to accurately state the calculated static resistance of the system, a number of factors may cause the actual conditions to vary from the design conditions. When a variation occurs, it may be found, upon testing, that the static pressure for a given volume through the system is higher than anticipated. In this case, the number of blades provided may be inadequate to meet the performance. On the other hand, the static pressure may have been overestimated and excess blade area provided, resulting in a fan with unutilized capacity operating at low efficiency.

Inadequate Blade Area: The blade angle is selected to move the anticipated volume of air and the number of blades is selected to maintain the total anticipated pressure required to move this volume at a given RPM. If the static pressure turns out to be higher than predicted, the fan may then be operating in an overload condition. If the RPM cannot be increased, the only solution to this condition is to reduce the blade angle until the fan can carry the then reduced volume at the originally anticipated pressure. Since reducing the volume, while holding the total pressure as originally anticipated, can only reduce the horsepower, it is then impossible to consume the horsepower originally intended without overloading the fan. This is one of a number of reasons for providing some safety factor in blade loading at the time of original fan selection.

Excessive Blade Area: Occasionally, an excessive number of blades may be specified in the interest of making a conservative selection. If the static pressure has been overstated, the theoretical number of blades will be greater than needed. This theoretical number of blades is usually a fractional number and the actual number of blades used must, of course, be the next larger integer, resulting in some "safety factor" in the selection. If, in addition, a blade or two is added as a "safety factor" or in anticipation of increased future requirements, it may be impossible to meet the original performance requirement efficiently. The only way to provide the original performance and draw no more than the original horsepower is to flatten the blade angle. There is a limit, however, in how far the blade angle may be reduced before further reduction will decrease airflow without a further reduction in horsepower. For belt drive units, the most practical solution to this problem is to reduce the RPM of the fan.

4.3.2 EXCESSIVE TIP CLEARANCE

Unless the fan ring is very close to the tip of the blade, air from the high pressure surface of the

blade will flow around the tip and nullify the negative pressure on the underside of the blade for some distance in from the tip. For a fan of, say, 12-ft diameter, the last 12 to 18 inches of the blade could be producing no pressure whatever and performing no useful function. The balance of the fan blade toward the hub then must produce a higher pressure to compensate for the portion near the tip.

Excessive tip clearance also leaves an unswept area between the tip of the blade and the fan ring. Air that has been pumped by the fan will return downward through this unswept area at a velocity greater than that at which it passed through the fan in the desired direction. This condition adds even further to the requirements of the portion of the blade which is doing the work and efficiency will be greatly reduced.

With the loss of a foot at the tips of the blades, plus the back flow between the tips and the ring, the 12-ft fan in this example might be considered an effective 10-ft fan. It would have to deliver sufficient air to satisfy the performance requirements of the installation, plus the amount of air which is returning in the void between the tips and the throat. Under such circumstances, excessive blade loading could occur even though the required system pressure is not achieved.

4.3.3 POOR ENTRANCE CONDITIONS

Air will approach the fan from all possible directions, increasing in velocity as it nears the opening, then accelerating rapidly as it enters. The air approaching from the side must be turned through 90° to enter a ring whose entrance terminates in a flat plate. If the inlet end of the ring projects some distance out, with approach possible from all directions, a portion of the air must be turned through 180°. The inertia of the approaching air prevents it from turning sharply and advancing parallel to the desired flow. It consequently swoops toward the center, leaving the outer area of the fan with reduced flow or even reverse flow near the ring.

The effect of poor entrance conditions is similar to that previously described for excessive tip clearance in that the effective diameter has been reduced and excessive blade loading could occur even though the required system pressure is not achieved. Efficiency will be greatly reduced.

4.3.4 EXCESSIVE DEFLECTION

The pressure which the fan can achieve is dependent upon the square of the velocity of the blades relative to the air. If the air could be moved into the fan in an axial direction and passed through the fan into the discharge without changing direction, the relative velocity of the blades to the air stream would be the true velocity of the blades at any point. This, of course, is not the case. For the blades to accomplish work upon the air, they must also deflect the air in the direction of rotation of the fan. The air when rotated with the fan is moving with

a certain velocity in the same direction as the rotation of the fan, which reduces the relative velocity between the fan blades and the air by some portion of this rotational velocity.

Moore fans are designed in contemplation of a maximum deflection of 50° at the hub, decreasing to a very small value at the tip. This deflection is considered in the determination of the pressure which may be provided by each blade over its full length. If fans are selected, or if conditions exist, which cause the deflection to exceed 50° at the hub, the velocity of the blades relative to the air is less than anticipated and the blades will not provide the rated pressure. The test below, however, will show the full allowable pressure

capability of the fan, even though it does not reach the full rated pressure.

4.3.5 CONCLUSION

As can be seen by the various points discussed in this section, there are a number of complex factors which tend to cause fans to be operated in a condition of improper blade loading which can shorten fan life or lower efficiency. When blade angles are set to consume the specified horsepower (at the fan shaft), the resulting performance should be very close to the specified performance. If this is not the case and the problem cannot be identified or corrected, please contact Moore for assistance.

4.4 CHECKING BLADE LOAD

One method of checking blade load is to run a complete field test on the fan. Although laborious, this method will provide ample proof so long as neither excessive tip clearance nor poor entrance conditions are present. If either are present, however, the conditions set out above under Section 4.3.3 would apply and the fan could be overloaded even though the total pressure indicated by the test was within the allowable blade loading.

A better, more convenient and simpler method of detecting blade overload, or determining maximum allowable blade angle, is set out below. The equipment needed is a wrench, a torque wrench, a protractor and a draft gauge (or manometer).

All fans are shipped with the blade angle set for the anticipated performance requirements furnished to The Moore Company by the purchaser. This blade angle is called out on the Fan Specification Sheet. This angle refers to the angle measured at the location shown in Section 2.3.3. Hubs are shipped with the clevises set at this angle.

To start the test, adjust the blades to an angle of approximately half that called out on the specifications or measured on the units. Connect the draft gauge to as quiescent a spot in the plenum as possible, preferably in the corner of the plenum and either ahead of or following the fan, depending upon whether the application is induced or forced draft. Since the figures obtained are purely relative, it is not necessary that accurate static pressure readings be obtained, but rather that the readings taken represent a consistent series of pressures at the point of reading chosen.

Start the fan and record on the chart provided the blade angle and the static pressure indicated. Advance the blade angle by one or two degrees and repeat the performance, recording again these read-

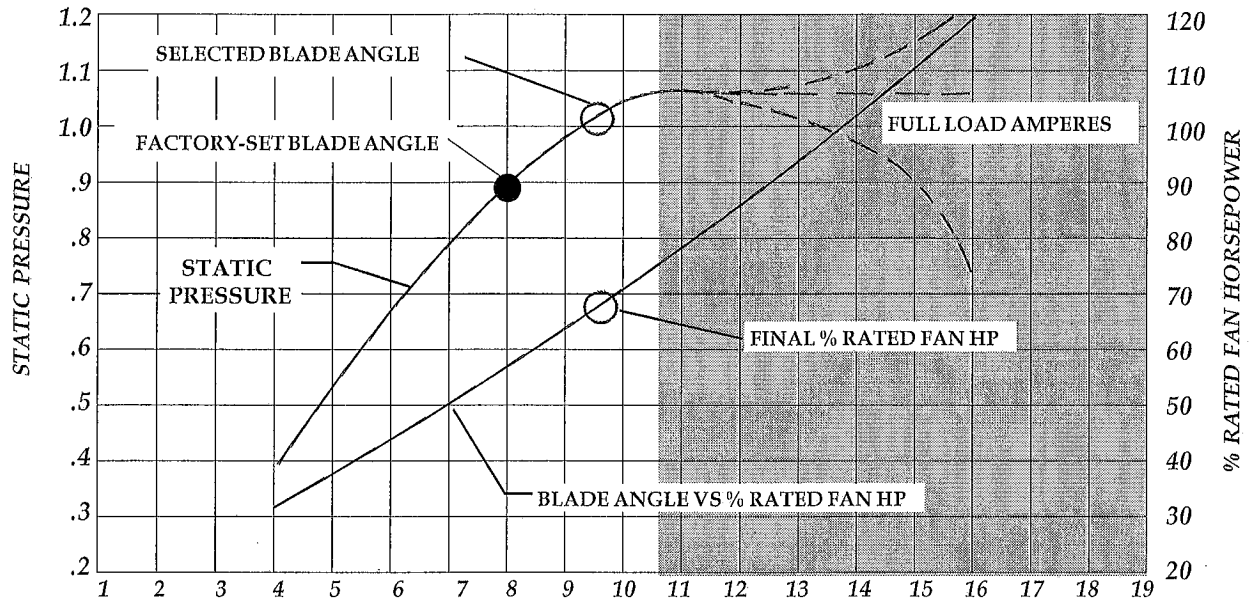
ings. Keep increasing the angle and following this procedure until the motor is fully loaded, in which case the fan is able to consume full rated fan horsepower without overload OR until the curve which will have started on a definite slope begins to approach the horizontal. It will be noted that the static pressure will be consistently increasing with increased blade angle until the blade loading reaches maximum, at which point it will level off.

Subsequent increases in blade angle may have quite different effects, depending on the individual installation. The static pressure curve may merely stay level or may drop off sharply. In rare cases, it may level off and again start rising as the fan begins operating as a centrifugal blower.

Typical examples are shown in dotted lines on the chart opposite. Operation beyond the first point of levelling, or in the area of the dotted lines, is indicative of blade overload. Note that power consumption load will continue to increase even though the fan has passed into overload condition. The maximum blade angle allowable is that which produces a static pressure about 5% below the point where the curve becomes level. This represents a safe loading, and the blades may be set and left at this angle regardless of the location on the chart, assuming the motor is not overloaded.

The point so selected will also approximate the point of the most efficient operation of the fan. Due to possible error in static pressure predictions, or in readings which are intended only to be relative, as well as other variables, the final blade setting chosen may fall below or above the specified static pressure.

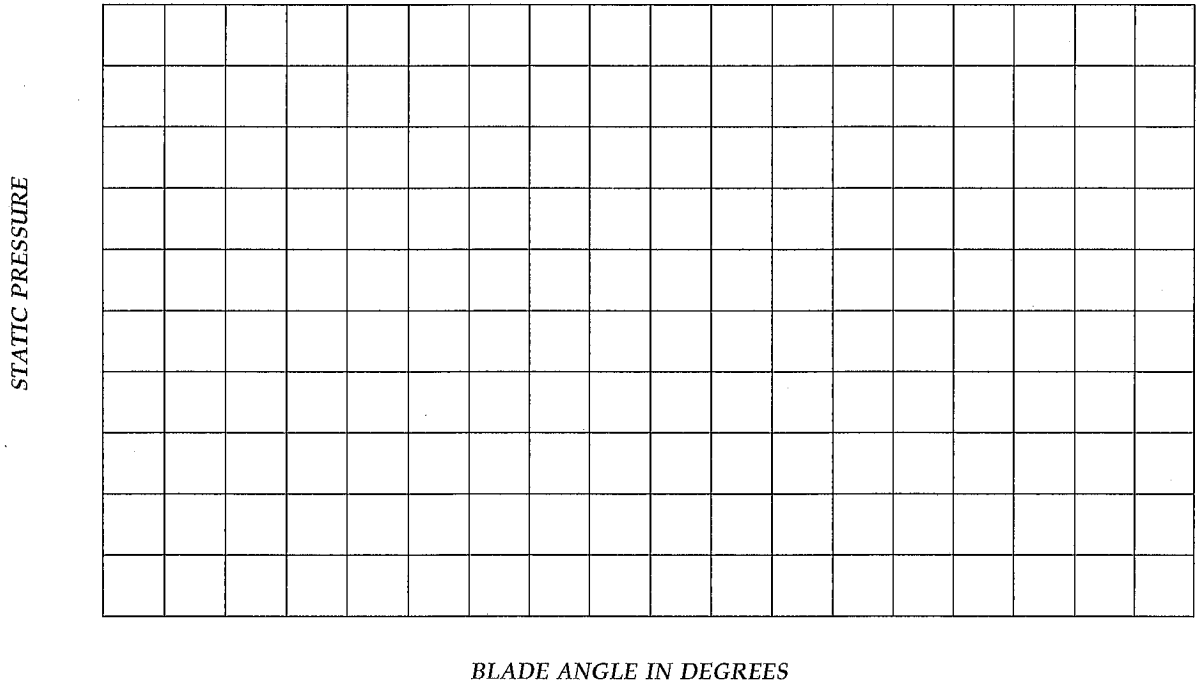
A typical performance chart is shown opposite for a fan capable of a higher blade loading than originally specified. A blank chart is also provided for your use.



4.4.1 Sample Graph of Blade Angle in Degrees

Note in the chart above that static pressure (and air flow) has reached its maximum at an 11 degree blade setting and blade overload is beginning. With further increase in blade angle, anything may happen, as indicated by the dotted extensions into the shaded overload area. Note that the final selected blade angle is

5% below the point where the static pressure curve becomes level. The horsepower curve has been added to illustrate the point that in an overload condition, horsepower will increase without increased performance.



BLANK CHART FOR CUSTOMER USE

4.5 DAMAGING OPERATING CONDITIONS

4.5.1 GENERAL

Any condition which causes repeated blade loading and unloading is detrimental to fan performance, both in terms of efficiency and structural durability. Normal obstructions, of course, must be expected in the air stream. There are certain conditions, however, which may be avoided by reasonable attention to the points briefly discussed in this section. Additional information on the importance of inlet and discharge conditions can be found in Moore's General Catalog.

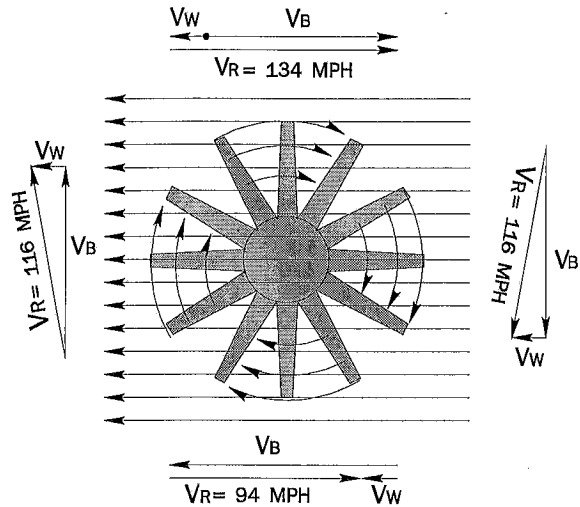
Ideally, air should approach a fan in an axial direction and at a uniform velocity over the area of the fan. Air approaching a fan at an angle tends to increase the relative velocity of the blades to the air on one side of the fan and decrease the relative velocity on the other side. This means that the fan blade during one-half of its revolution is picking up a heavier air load due to the higher relative velocity and, through the other half of its revolution, a lower air load as it goes "down wind". The net result is a repetitive loading and unloading of the blades at each revolution of the fan. This condition can be quite serious if the velocities are high and the angle of approach deviates considerably from axial.

4.5.2 WIND

With a vertically mounted fan blowing outward into the wind and surrounded by a short fan ring or stack, high winds may cause some concern. The farther the ring extends beyond the fan, the less effect would be expected from wind. It is a fact, however, that wind across the face of the ring will affect the direction of air flow well down into the ring. In the case of a fan installed near the outlet of the ring, the direction from axial of the fan discharge may be increased by as much as 45° under high wind conditions.

In the case of a fan blowing inward in a short ring, the condition is even more critical. In such an installation, the air on the inlet side of the fan has a horizontal velocity which may be quite high. It is necessary for the fan to pick up this air and direct it inward. In a strong wind, the angle of air moving through the fan may be increased more than 45°.

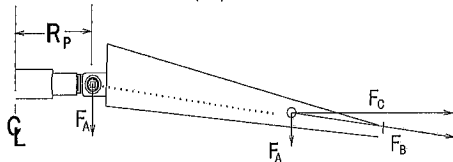
The illustration above assumes a fan operating with a tip speed (V_B) of 10,000 feet per minute (114 miles per



hour) with a horizontal component of wind velocity (V_W) of 20 miles per hour. Note that the velocity (V_R) of the fan blade relative to the air varies by a factor of 1.43. The blade load varies as the square of this velocity, or 2.05.

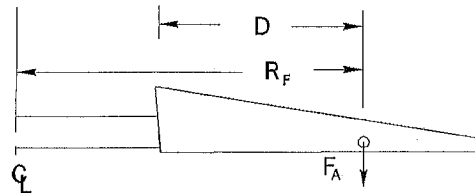
THE EFFECT OF AIR LOAD ON HUB AND DRIVE

Moore fan blades are attached to the hub by a pivot. As the fan rotates, centrifugal force causes the blades to rise (as do the blades of a helicopter). The air load (F_A) is uniform over the blade, but there is a point (shown on the blade in the drawing below) where, if the total load were applied at that point, the effect would be the same. The resultant of the air load (F_A), assumed in this example to be downward, and the horizontal centrifugal force (F_C) is the force on the blade (F_B). The blade automatically posi-



tions itself in the direction of this force with the result that the force is translated inward to the pivot point, as illustrated by the dotted line. The effect of this arrangement is exactly as if the total air load (F_A) were applied at the pivot point rather than at the point outward on the blade. The maximum bending moment applied to the shaft by the air load is equal to the load (F_A) multiplied by the distance from the fan centerline to the pivot point (R_p).

In conventional fans with rigidly attached blades, the bending moment at the shaft due to the air load is equal to the load (F_A) multiplied by the distance from the fan centerline to the point of application of the force on the blade (R_F). This moment will be from 2 to 4 times as great as that produced by the Moore fan under the same condi-



tions.

Also of concern with the conventional fan is the bending moment due to the air load at the point of attachment of the blades to the hub since this is usually the structurally weakest area of the fan. The moment due to the air load at this point is the load (F_A) times the distance (D). For the Moore fan, this moment is zero since the blades are attached at the pivot point.

A more complete discussion of the Moore fan design can be found in The Moore Company's General Catalog.

In this rather common wind condition, then, it can be seen that the blade load on the side where the blade is going against the wind will be double the load on the side where the blade is going with the wind. In a 40 mile per hour wind, the blade load would vary by a factor greater than 4. In a 60 mile per hour wind, the load would vary by a factor of more than 10! It is obvious that operation under such conditions will impose tremendous repetitive loadings on the fan blades.

In areas of unusually high wind velocities, it may be advisable to shield the fan in some manner.

4.5.3 OBSTRUCTIONS

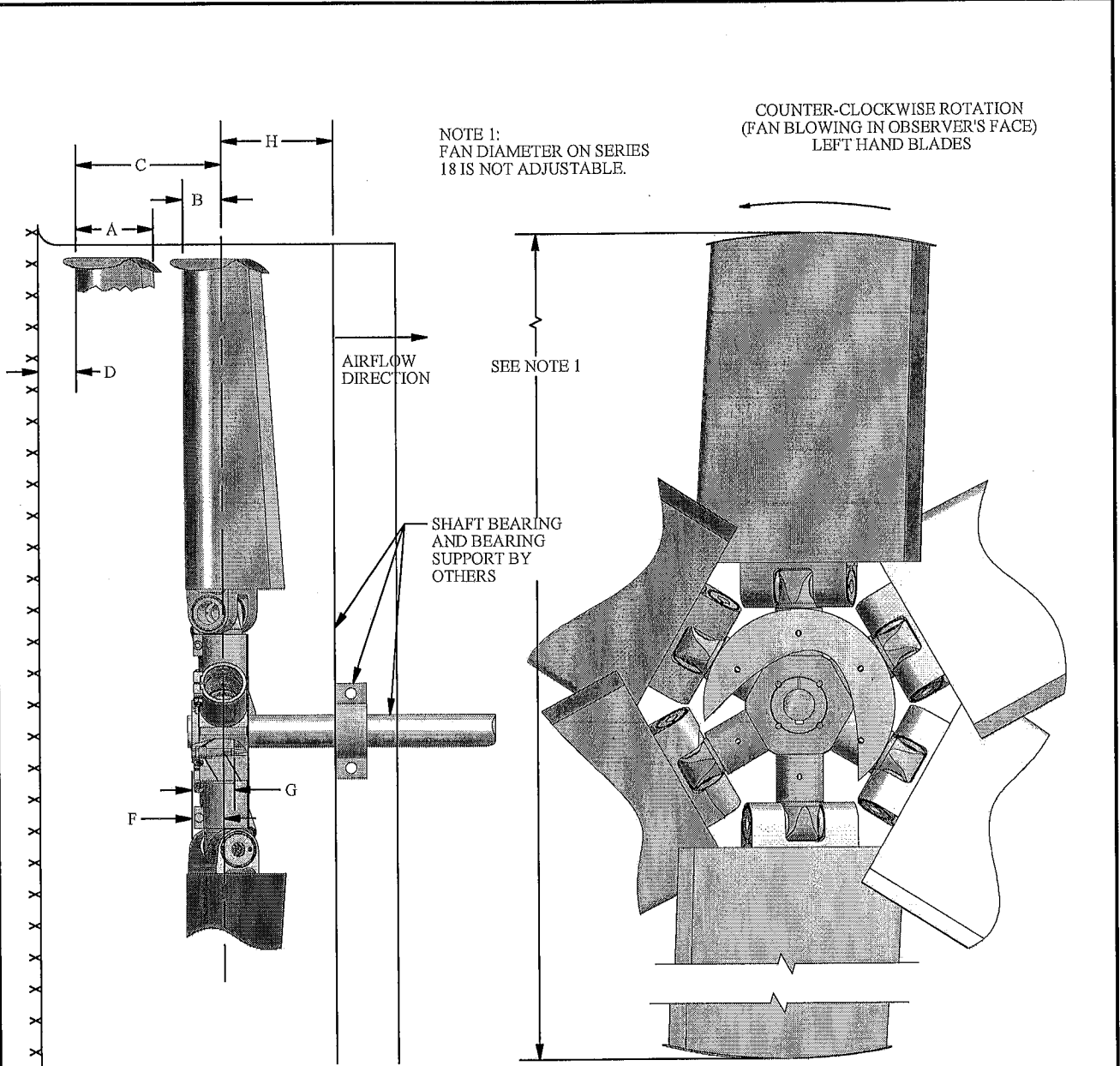
Obstructions of one type or another in the air stream, ahead of or behind the fan, are to be expected. In fact, it would be virtually impossible to eliminate all obstructions. Structural supporting members, foundations and the like, need not be of serious concern although all obstructions, even small ones, will increase the static pressure and must be taken into consideration by the system designer in specifying the fan performance.

The total free area from which the fan can draw air should be twice the net area of the fan (fan area minus hub area). In other words, the air approaching the inlet of the fan should have no more than half the velocity of the air passing through the fan. This area should be distributed reasonably uniformly. It would be unwise to attempt to operate a fan with one-half or one-third of

the fan area completely blanked off. Such a condition would cause stalling of the fan blade through one-half the revolution but create a condition of overload in the half which was not blocked off. Excessive vibration would result. Any condition which forces the air to approach the fan in a non-axial direction should be avoided.

4.5.4 UNEVEN TIP CLEARANCE

Where fan rings are out of round or not centered with the fan, the tip clearance of each blade will vary as it makes a revolution. If tip clearance is tight at one point and excessive at another, proper flow will establish itself at the tight point, loading the blade to the very tip, while at the loose point the air will flow from the high pressure side of the blade through the opening between the blade tip and the ring and nullify the negative pressure on the under side of the blade. This will unload the blade near the tip within the area of excessive tip clearance. Under this condition, the blade will load and unload near the tip one or more times per revolution, resulting in an undesirable repetitive vibration. Every effort should be made to keep the tip clearance to a minimum and to have this clearance as constant as possible around the entire ring.



BUSHING CAN BE INSTALLED ON INLET OR OUTLET SIDE OF FAN. AIR SEAL MUST BE OPPOSITE OF BUSHING.

MINIMUM ANGLE FOR INSTALLATION IS 7° FOR A 5 BLADE FAN AND 13° FOR A 6 BLADE FAN.

- A = BLADE TIP THICKNESS @ 19° BLADE ANGLE
- B = RUNNING POSITION OF BLADES
- C = MAXIMUM DROOP POSITION OF BLADES
- D = MINIMUM OBSTACLE CLEARANCE AT INLET
- F = CENTERLINE OF FAN TO BASE OF BUSHING
- G = BUSHING OVERALL HEIGHT
- H = MINIMUM OBSTACLE CLEARANCE AT OUTLET
- I = NOMINAL MECHANICAL HUB DIAMETER
- L = MAX. BUSHING TORQUE FT. LBS.
- # = WITH S.A.E. STANDARD SQUARE KEYWAY
- * = WITH SHALLOW KEYWAY IN BUSHING
- ° = MAX METRIC BORE WITH STANDARD KEYWAY

WITH FAN OPERATING AT 12000 FT. MINUTE BLADE TIP SPEED

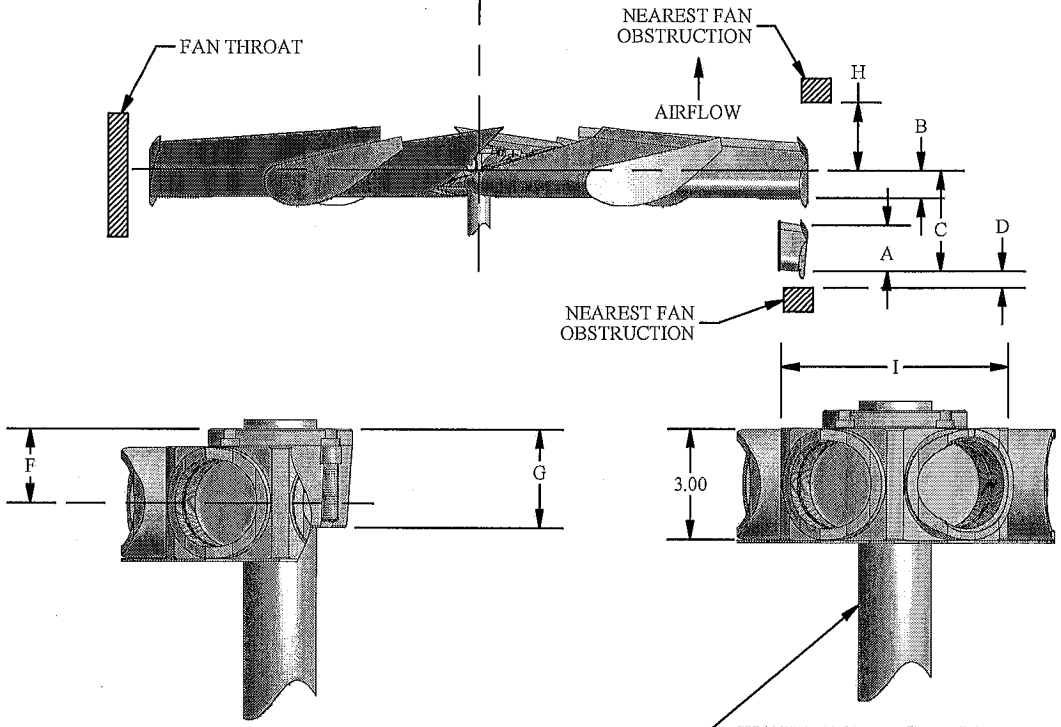
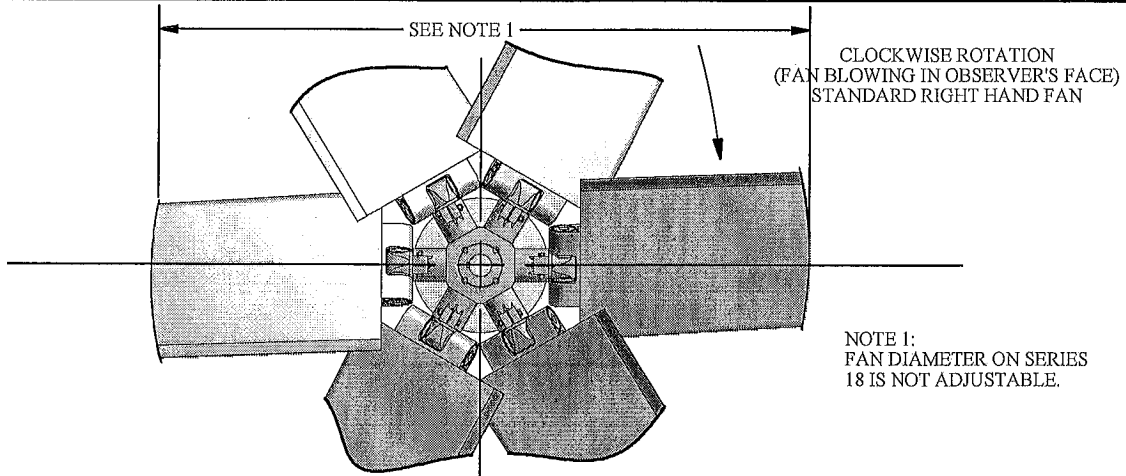
PERCENT BLADE LOADING

DIA	100%		75%		C	D	H
	A	B	A	B			
3'	5.2"	1.1"	0.8"	3.1"	2.0"	7.0"	
4'	4.8"	1.4"	1.0"	3.4"	2.0"	7.0"	
5'	4.4"	1.7"	1.3"	3.7"	2.0"	7.0"	
6'	4.0"	2.0"	1.5"	4.0"	2.0"	7.0"	

MAX BLADES	BUSHING TYPE	MAX #	MAX *	MAX °	I	F	G	L
		BORE	BORE	BORE				
6	U	2.750"	2.938"	75	7"	1.6"	2.7"	4000



SERIES 18 HD FAN LEFT HAND ROTATION



BUSHING CAN BE INSTALLED ON INLET OR OUTLET SIDE OF FAN. AIR SEAL MUST BE OPPOSITE OF BUSHING.

MINIMUM ANGLE FOR INSTALLATION IS 7° FOR A 5 BLADE FAN AND 13° FOR A 6 BLADE FAN.

- A = BLADE TIP THICKNESS @ 19° BLADE ANGLE
- B = RUNNING POSITION OF BLADES
- C = MAXIMUM DROOP POSITION OF BLADES
- D = MINIMUM OBSTACLE CLEARANCE AT INLET
- F = CENTERLINE OF FAN TO BASE OF BUSHING
- G = BUSHING OVERALL HEIGHT
- H = MINIMUM OBSTACLE CLEARANCE AT OUTLET
- I = NOMINAL MECHANICAL HUB DIAMETER
- L = MAX. BUSHING TORQUE FT. LBS.
- # = WITH S.A.E. STANDARD SQUARE KEYWAY
- * = WITH SHALLOW KEYWAY IN BUSHING
- ° = MAX METRIC BORE WITH STANDARD KEYWAY

WITH FAN OPERATING AT 12000 FT. MINUTE BLADE TIP SPEED

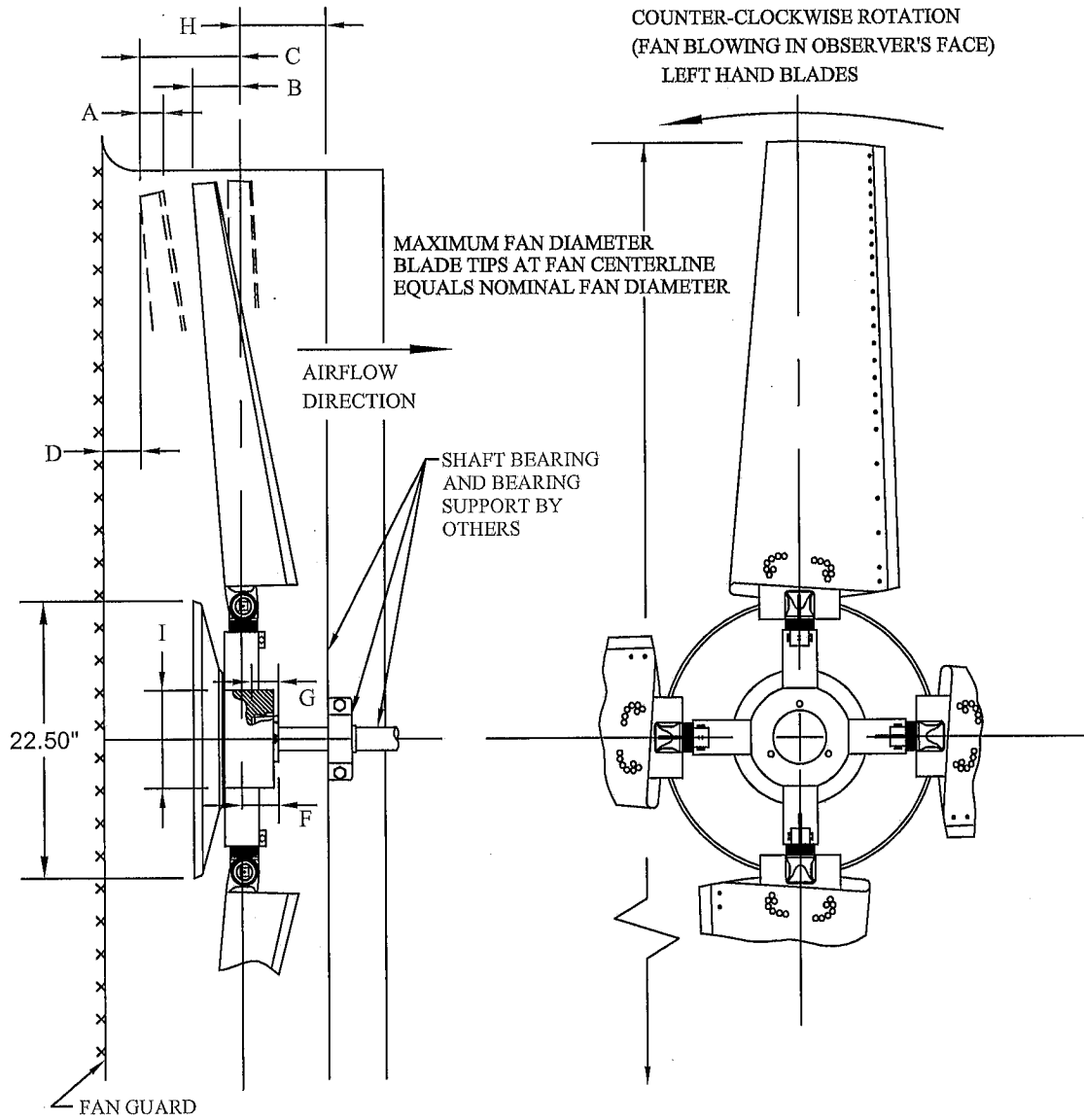
PERCENT BLADE LOADING

DIA	100%		75%		C	D	H
	A	B	C	D			
3'	5.2"	1.1"	0.8"	3.1"	2.0"	7.0"	
4'	4.8"	1.4"	1.0"	3.4"	2.0"	7.0"	
5'	4.4"	1.7"	1.3"	3.7"	2.0"	7.0"	
6'	4.0"	2.0"	1.5"	4.0"	2.0"	7.0"	

MAX BLADES	BUSHING TYPE	MAX # BORE	MAX * BORE	MAX ° BORE	I	F	G	L
6	U	2.750"	2.938"	75	7"	1.6"	2.7"	4000



SERIES 18 STANDARD HUB HD FAN RIGHT HAND ROTATION



NOTES

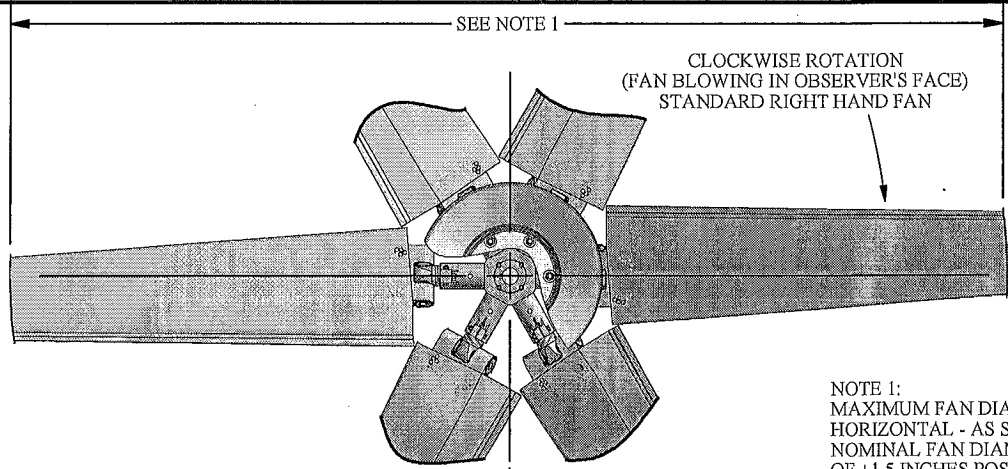
- A = BLADE TIP THICKNESS @ 19° BLADE ANGLE
- B = RUNNING POSITION OF BLADES
- C = MAXIMUM BLADE TRAVEL
- D = MINIMUM OBSTACLE CLEARANCE AT INLET
- F = CENTERLINE OF FAN TO BASE OF BUSHING
- G = BUSHING OVERALL HEIGHT
- H = MINIMUM OBSTACLE CLEARANCE AT OUTLET
- I = NOMINAL MECHANICAL HUB DIAMETER

DIA	BLADE LOAD		C	D	H
	A	B			
4	5.0	1.2	3.2	2.0	7.0
5	4.6	1.5	3.5	2.0	7.0
6	4.2	1.8	3.8	2.0	7.0
7	3.8	2.1	4.1	2.0	7.0
8	3.4	2.6	4.6	2.0	7.0

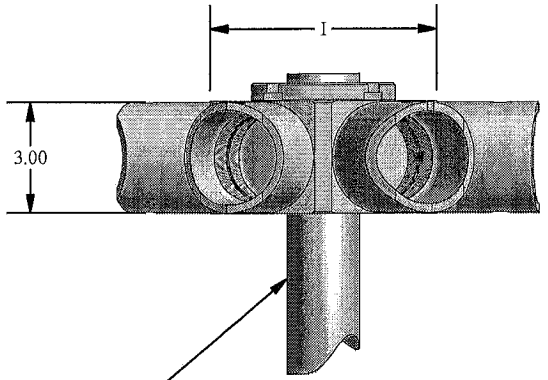
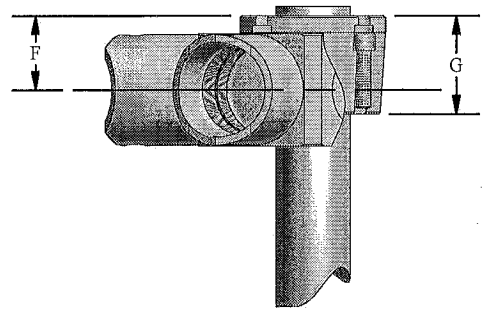
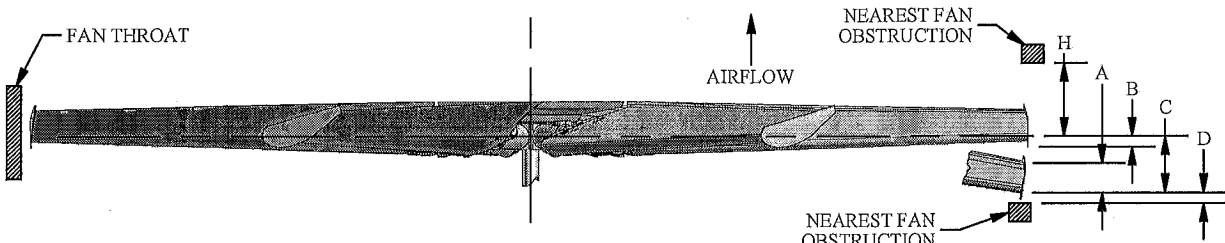
I	MAXIMUM BLADES	BUSHING TYPE	F	G	MAXIMUM BORE
7"	6	U	1.6"	2.7"	2.938

**SERIES 24 HD FAN
LEFT HAND ROTATION**





NOTE 1:
MAXIMUM FAN DIAMETER (BLADES HORIZONTAL - AS SHIPPED) EQUALS NOMINAL FAN DIAMETER. ADJUSTMENT OF ±1.5 INCHES POSSIBLE AT INSTALLATION



BUSHING AND/OR AIR SEAL CAN BE INSTALLED ON INLET OR OUTLET SIDE OF FAN.

- A = BLADE TIP THICKNESS @ 19° BLADE ANGLE
- B = RUNNING POSITION OF BLADES
- C = MAXIMUM DROOP POSITION OF BLADES
- D = MINIMUM OBSTACLE CLEARANCE AT INLET
- F = CENTERLINE OF FAN TO BASE OF BUSHING
- G = BUSHING OVERALL HEIGHT
- H = MINIMUM OBSTACLE CLEARANCE AT OUTLET
- I = NOMINAL MECHANICAL HUB DIAMETER
- L = MAX. BUSHING TORQUE FT. LBS.
- # = WITH S.A.E. STANDARD SQUARE KEYWAY
- * = WITH SHALLOW KEYWAY IN BUSHING
- ° = MAX METRIC BORE WITH STANDARD KEYWAY

WITH FAN OPERATING AT 12000 FT. MINUTE BLADE TIP SPEED

PERCENT BLADE LOADING

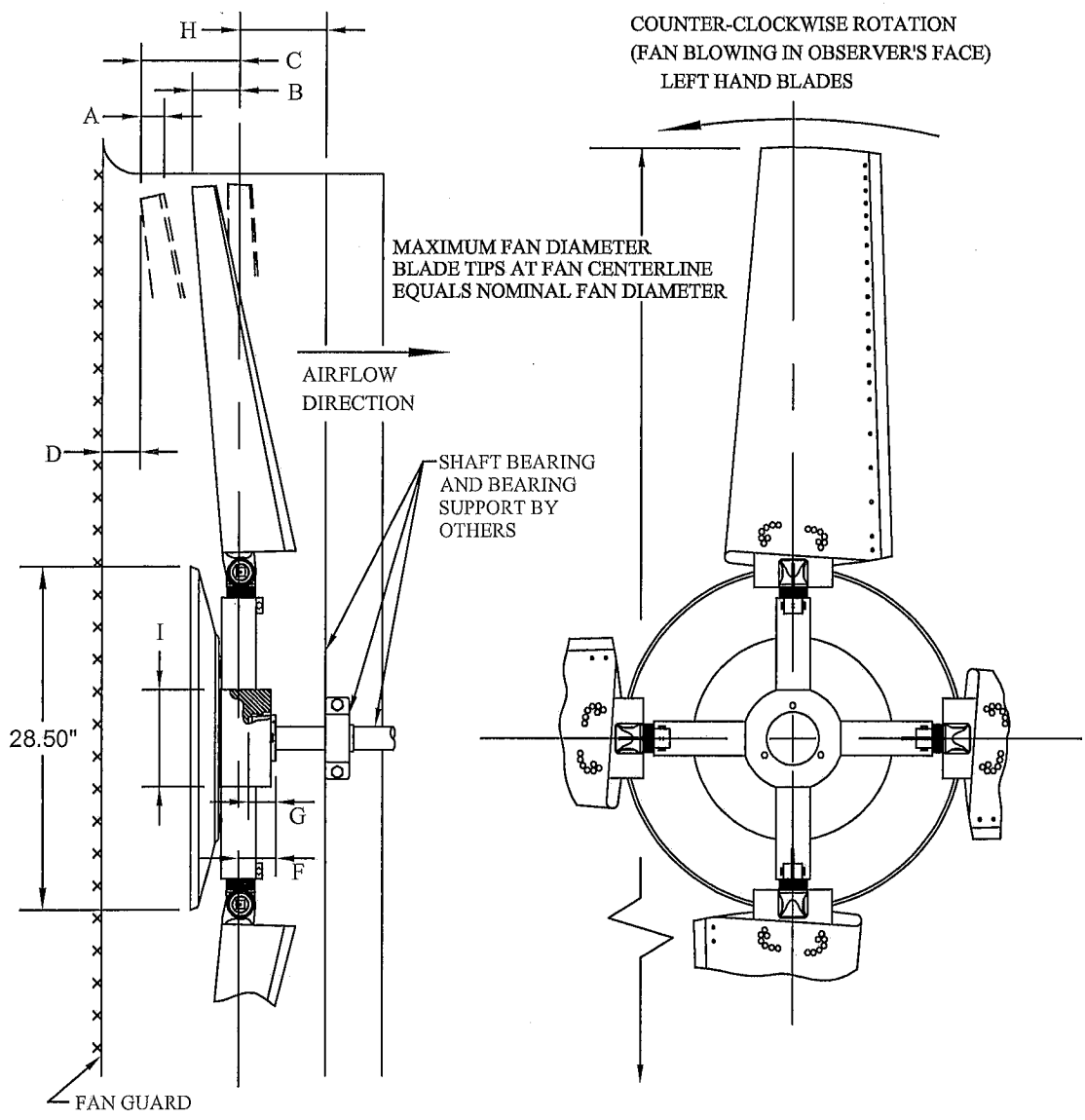
	100%	75%
--	------	-----

DIA	A	B	C	D	H	
4'	5.0"	1.2"	0.9"	3.2"	2.0"	7.0"
5'	4.6"	1.5"	1.1"	3.5"	2.0"	7.0"
6'	4.2"	1.8"	1.4"	3.8"	2.0"	7.0"
7'	3.8"	2.1"	1.6"	4.1"	2.0"	7.0"
8'	3.4"	2.6"	2.0"	4.6"	2.0"	7.0"

MAX BLADES	BUSHING TYPE	MAX # BORE	MAX * BORE	MAX ° BORE	I	F	G	L
6	U	2.750"	2.938"	75	7"	1.6"	2.7"	4000



SERIES 24 STANDARD HUB HD FAN RIGHT HAND ROTATION



NOTES

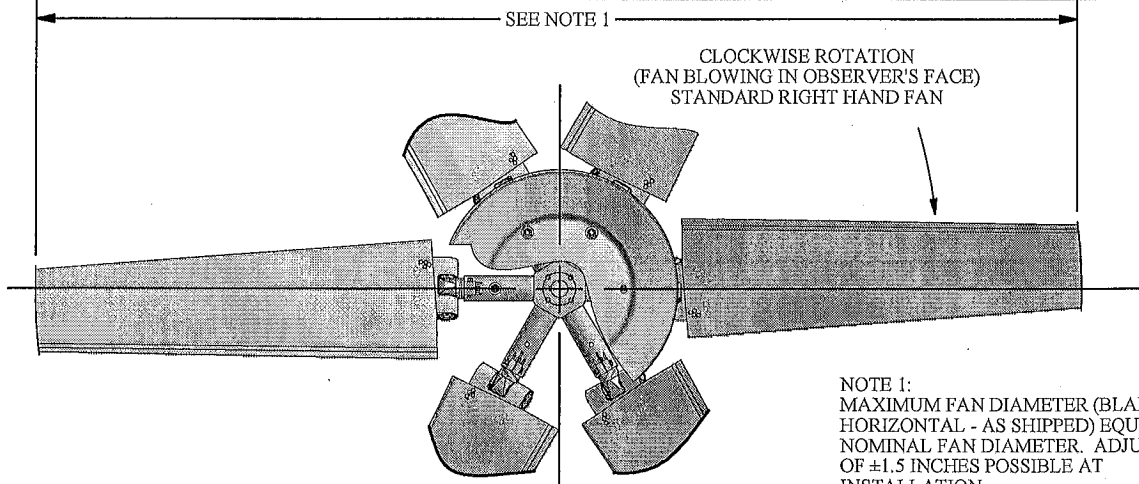
- A = BLADE TIP THICKNESS @ 19° BLADE ANGLE
- B = RUNNING POSITION OF BLADES
- C = MAXIMUM BLADE TRAVEL
- D = MINIMUM OBSTACLE CLEARANCE AT INLET
- F = CENTERLINE OF FAN TO BASE OF BUSHING
- G = BUSHING OVERALL HEIGHT
- H = MINIMUM OBSTACLE CLEARANCE AT OUTLET
- I = NOMINAL MECHANICAL HUB DIAMETER

DIA	BLADE LOAD		C	D	H
	A	B			
5	4.8	1.4	3.4	2.0	7.0
6	4.4	1.7	3.7	2.0	7.0
7	4.0	2.0	4.0	2.0	7.0
8	3.6	2.4	4.4	2.0	7.0
9	3.2	2.8	4.8	2.0	7.0
10	2.8	3.2	5.2	2.0	7.0

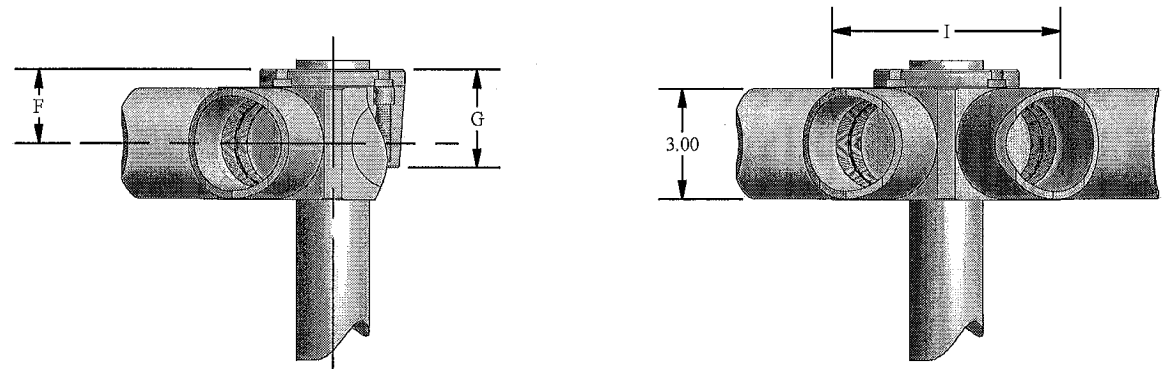
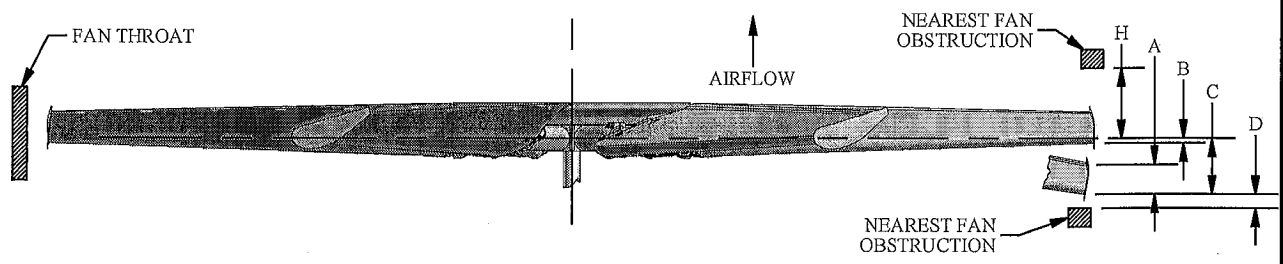
I	MAXIMUM BLADES	BUSHING TYPE	F	G	MAXIMUM BORE
7"	6	U	1.6"	2.7"	2.938
9"	8	U	1.6"	2.7"	2.938
9"	8	W	1.8"	2.8"	4.000



**SERIES 30 HD FAN
LEFT HAND ROTATION**



NOTE 1:
MAXIMUM FAN DIAMETER (BLADES HORIZONTAL - AS SHIPPED) EQUALS NOMINAL FAN DIAMETER. ADJUSTMENT OF ±1.5 INCHES POSSIBLE AT INSTALLATION



BUSHING AND/OR AIR SEAL CAN BE INSTALLED ON INLET OR OUTLET SIDE OF FAN.

A = BLADE TIP THICKNESS @ 19° BLADE ANGLE
 B = RUNNING POSITION OF BLADES
 C = MAXIMUM DROOP POSITION OF BLADES
 D = MINIMUM OBSTACLE CLEARANCE AT INLET
 F = CENTERLINE OF FAN TO BASE OF BUSHING
 G = BUSHING OVERALL HEIGHT
 H = MINIMUM OBSTACLE CLEARANCE AT OUTLET
 I = NOMINAL MECHANICAL HUB DIAMETER
 L = MAX. BUSHING TORQUE FT. LBS.
 # = WITH S.A.E. STANDARD SQUARE KEYWAY
 * = WITH SHALLOW KEYWAY IN BUSHING
 ° = MAX METRIC BORE WITH STANDARD KEYWAY

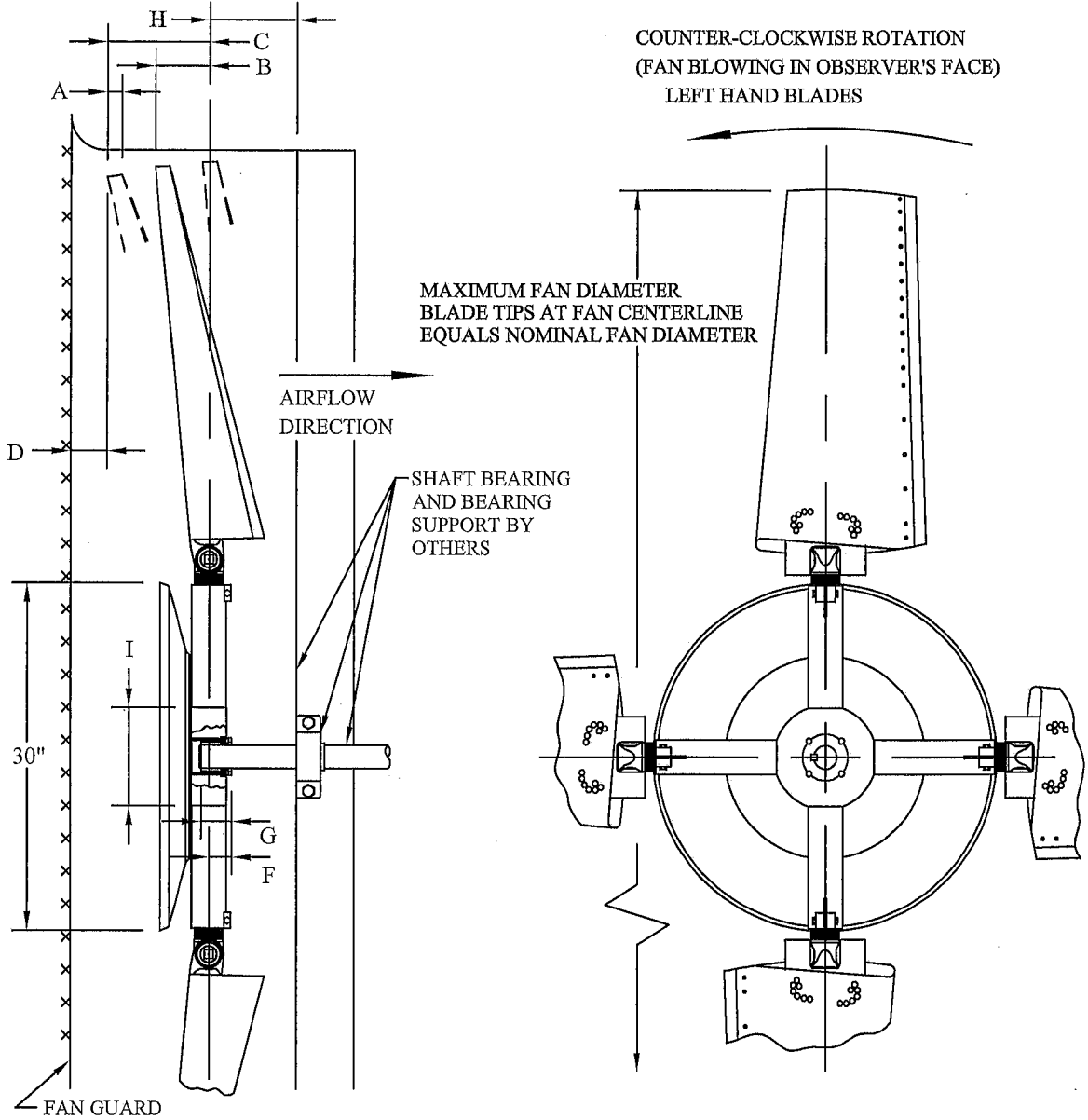
WITH FAN OPERATING AT 12000 FT. MINUTE BLADE TIP SPEED
PERCENT BLADE LOADING

DIA	100%		75%		C	D	H
	A	B	C	D			
5'	4.8"	1.4"	1.0"	3.4"	2.0"	7.0"	
6'	4.4"	1.7"	1.2"	3.7"	2.0"	7.0"	
7'	4.0"	2.0"	1.5"	4.0"	2.0"	7.0"	
8'	3.6"	2.4"	1.8"	4.4"	2.0"	7.0"	
9'	3.2"	2.8"	2.1"	4.8"	2.0"	7.0"	
10'	2.8"	3.2"	2.4"	5.2"	2.0"	7.0"	

MAX BLADES	BUSHING TYPE	MAX # BORE	MAX * BORE	I	F	G	L
				6	U	2.750"	2.938"
8	U	2.750"	2.938"	9"	1.6"	2.7"	4000
8	W	3.750"	4.000"	9"	1.8"	2.8"	7300



SERIES 30 STANDARD HUB HD FAN RIGHT HAND ROTATION



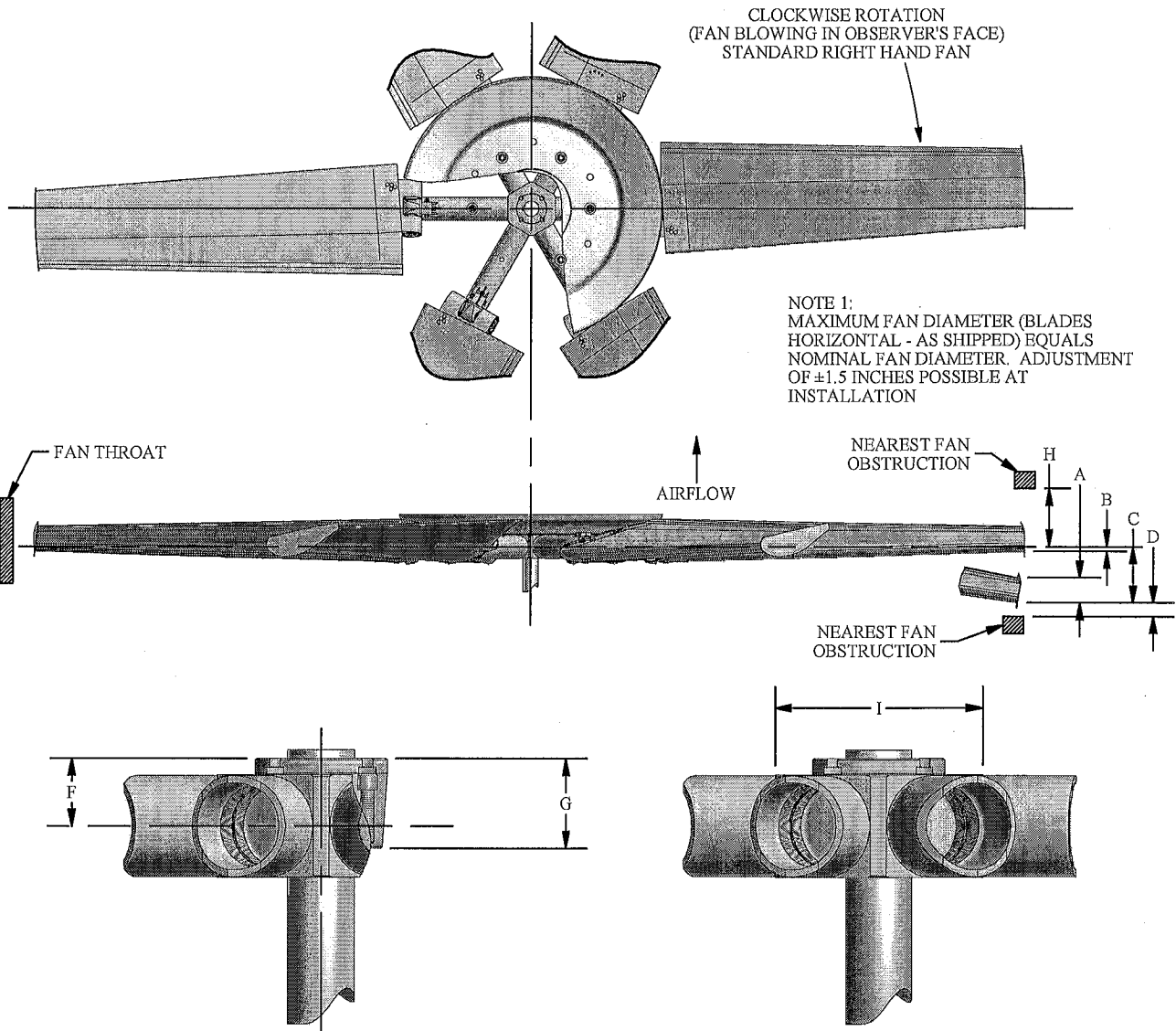
- A = BLADE TIP THICKNESS @ 19° BLADE ANGLE
- B = RUNNING POSITION OF BLADES
- C = MAXIMUM BLADE TRAVEL
- D = MINIMUM OBSTACLE CLEARANCE AT INLET
- F = CENTERLINE OF FAN TO BASE OF BUSHING
- G = BUSHING OVERALL HEIGHT
- H = MINIMUM OBSTACLE CLEARANCE AT OUTLET
- I = NOMINAL MECHANICAL HUB DIAMETER
- L = MAX. BUSHING TORQUE FT. LBS.
- # = WITH S.A.E. STANDARD SQUARE KEYWAY
- * = WITH SHALLOW KEYWAY IN BUSHING
- ° = MAX METRIC BORE WITH STANDARD KEYWAY

WITH FAN OPERATING
AT 12000 FT : MINUTE
BLADE TIP SPEED
PERCENT BLADE
LOADING

DIA	100%		75%		C	D	H	MAX BLADES	BUSHING TYPE	MAX # BORE	MAX * BORE	MAX ° BORE	I	F	G	L	
	A	B	A	B													
6'	4.6"	1.5"	1.3"	3.5"	2.0"	7.0"											
7'	4.2"	1.8"	1.5"	3.8"	2.0"	7.0"											
8'	3.8"	2.1"	1.8"	4.1"	2.0"	7.0"	6	U	2.750"	2.938"	75	7"	2.0"	2.7"		4000	
9'	3.4"	2.6"	2.1"	4.6"	2.0"	7.0"	8	U	2.750"	2.938"	75	9"	2.0"	2.7"		4000	
10'	3.0"	3.1"	2.4"	5.1"	2.0"	7.0"	8	W	3.750"	4.000"	100	9"	2.2"	2.8"		7300	
11'	2.6"	3.8"	3.1"	5.8"	2.0"	7.0"	8	X	3.750"	4.000"	100	9"	2.2"	4.0"		9800	
12'	2.2"	4.6"	3.6"	6.6"	2.0"	7.0"											



SERIES 36 HD FAN LEFT HAND ROTATION



CLOCKWISE ROTATION
(FAN BLOWING IN OBSERVER'S FACE)
STANDARD RIGHT HAND FAN

NOTE 1:
MAXIMUM FAN DIAMETER (BLADES
HORIZONTAL - AS SHIPPED) EQUALS
NOMINAL FAN DIAMETER. ADJUSTMENT
OF ±1.5 INCHES POSSIBLE AT
INSTALLATION

BUSHING AND/OR AIR SEAL CAN
BE INSTALLED ON INLET OR
OUTLET SIDE OF FAN

A = BLADE TIP THICKNESS @ 19° BLADE ANGLE
B = RUNNING POSITION OF BLADES
C = MAXIMUM DROOP POSITION OF BLADES
D = MINIMUM OBSTACLE CLEARANCE AT INLET
F = CENTERLINE OF FAN TO BASE OF BUSHING
G = BUSHING OVERALL HEIGHT
H = MINIMUM OBSTACLE CLEARANCE AT OUTLET
I = NOMINAL MECHANICAL HUB DIAMETER
L = MAX. BUSHING TORQUE FT. LBS.
= WITH S.A.E. STANDARD SQUARE KEYWAY
* = WITH SHALLOW KEYWAY IN BUSHING
° = MAX METRIC BORE WITH STANDARD KEYWAY

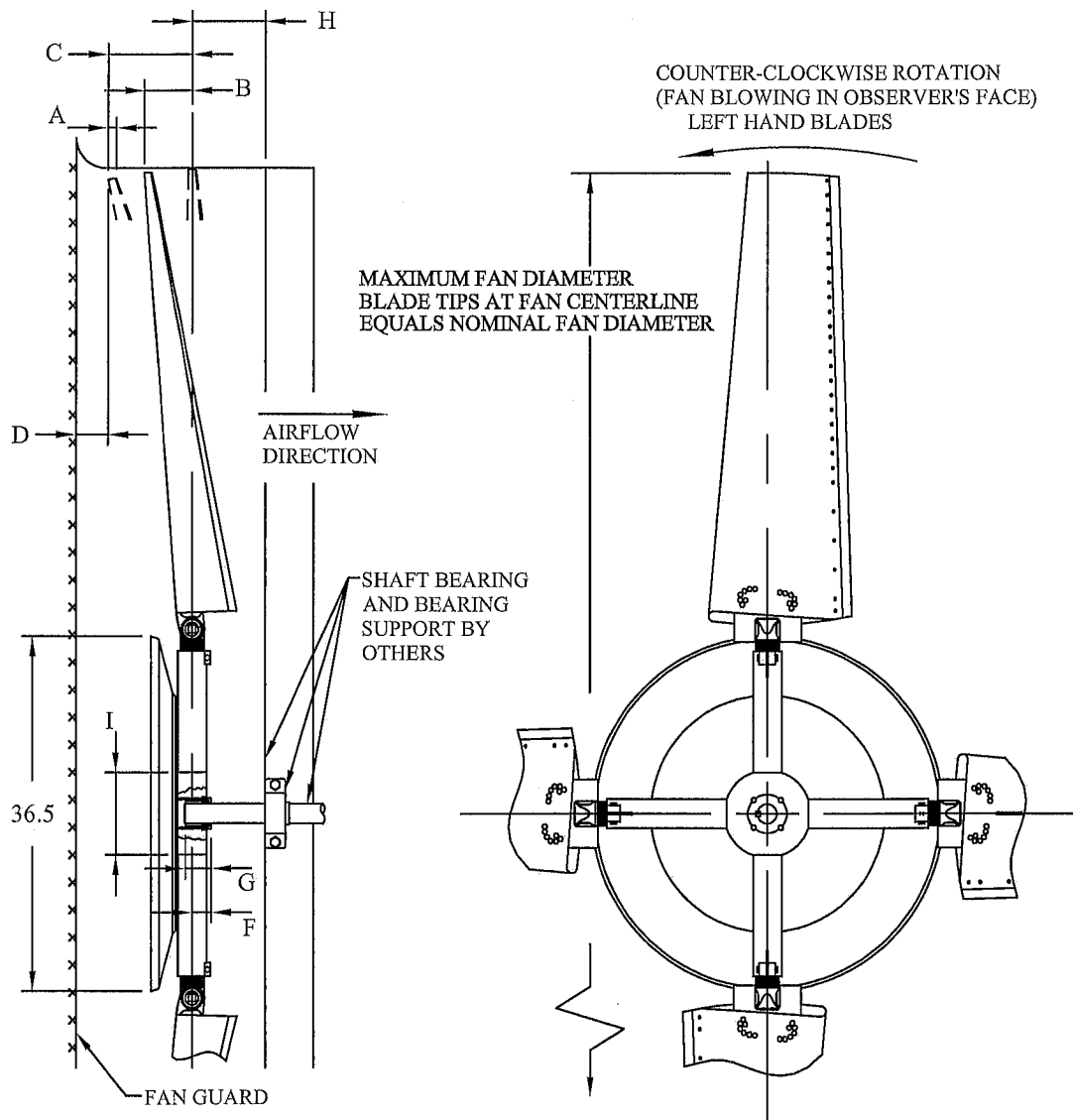
WITH FAN OPERATING
AT 12000 FT. MINUTE
BLADE TIP SPEED
PERCENT BLADE
LOADING

DIA	100% 75%		C	D	H
	A	B			
6'	4.6"	1.5" 1.3"	3.5"	2.0"	7.0"
7'	4.2"	1.8" 1.5"	3.8"	2.0"	7.0"
8'	3.8"	2.1" 1.8"	4.1"	2.0"	7.0"
9'	3.4"	2.6" 2.1"	4.6"	2.0"	7.0"
10'	3.0"	3.1" 2.4"	5.1"	2.0"	7.0"
11'	2.6"	3.8" 3.1"	5.8"	2.0"	7.0"
12'	2.2"	4.6" 3.6"	6.6"	2.0"	7.0"

MAX BLADES	BUSHING TYPE	MAX # BORE	MAX * BORE	MAX ° BORE	I	F	G	L
6	U	2.750"	2.938"	75	7"	2.0"	2.7"	4000
8	U	2.750"	2.938"	75	9"	2.0"	2.7"	4000
8	W	3.750"	4.000"	100	9"	2.2"	2.8"	7300
8	X	3.750"	4.000"	100	9"	2.2"	4.0"	9800



SERIES 36 STANDARD HUB HD FAN RIGHT HAND ROTATION



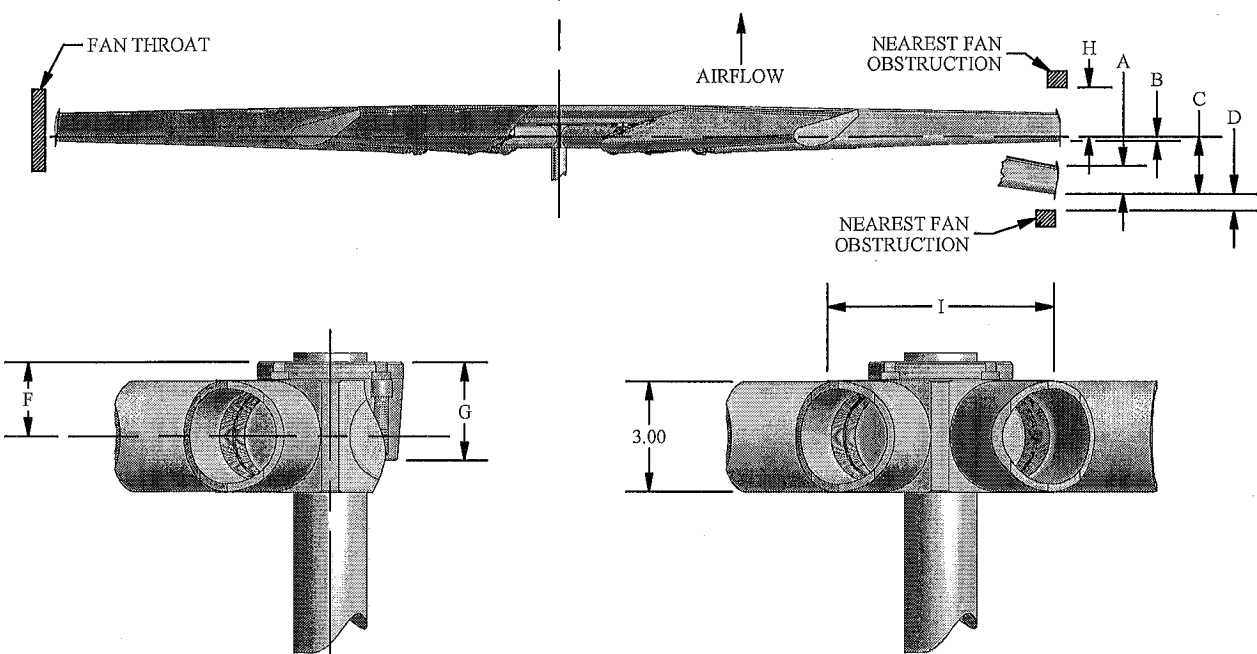
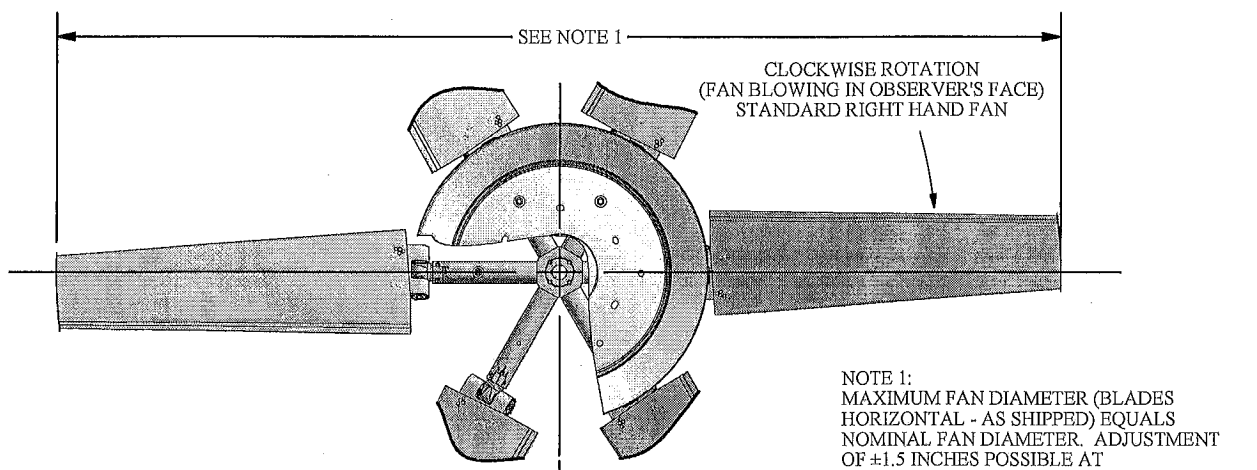
A = BLADE TIP THICKNESS @ 19° BLADE ANGLE
 B = RUNNING POSITION OF BLADES
 C = MAXIMUM BLADE TRAVEL
 D = MINIMUM OBSTACLE CLEARANCE AT INLET
 F = CENTERLINE OF FAN TO BASE OF BUSHING
 G = BUSHING OVERALL HEIGHT
 H = MINIMUM OBSTACLE CLEARANCE AT OUTLET
 I = NOMINAL MECHANICAL HUB DIAMETER
 L = MAX. BUSHING TORQUE FT. LBS.
 # = WITH S.A.E. STANDARD SQUARE KEYWAY
 * = WITH SHALLOW KEYWAY IN BUSHING
 ° = MAX METRIC BORE WITH STANDARD KEYWAY

WITH FAN OPERATING
 AT 12000 FT : MINUTE
 BLADE TIP SPEED
 PERCENT BLADE
 LOADING

DIA	100%		75%		C	D	H	MAX BLADES	BUSHING TYPE	MAX # BORE	MAX * BORE	MAX ° BORE	I	F	G	L	
	A	B	B	C													
7'	4.4"	1.7"	1.5"	3.7"	2.0"	7.0"											
8'	4.0"	2.2"	1.8"	4.2"	2.0"	7.0"											
9'	3.6"	2.7"	2.2"	4.7"	2.0"	7.0"											
10'	3.2"	3.3"	2.6"	5.3"	2.0"	7.0"											
11'	2.8"	4.0"	3.1"	6.0"	2.0"	7.0"	6	U	2.750"	2.938"	75	7"	2.0"	2.7"	4000		
12'	2.4"	4.8"	3.7"	6.8"	2.0"	7.0"	8	U	2.750"	2.938"	75	9"	2.0"	2.7"	4000		
13'	2.0"	5.7"	4.3"	7.7"	2.0"	7.0"	8	W	3.750"	4.000"	100	9"	2.2"	2.8"	7300		
14'	1.7"	6.7"	5.1"	8.7"	2.0"	7.0"	8	X	3.750"	4.000"	100	9"	2.2"	4.0"	9800		

**SERIES 42 HD FAN
 LEFT HAND ROTATION**





BUSHING AND/OR AIR SEAL CAN BE INSTALLED ON INLET OR OUTLET SIDE OF FAN.

- A = BLADE TIP THICKNESS @ 19° BLADE ANGLE
- B = RUNNING POSITION OF BLADES
- C = MAXIMUM DROOP POSITION OF BLADES
- D = MINIMUM OBSTACLE CLEARANCE AT INLET
- F = CENTERLINE OF FAN TO BASE OF BUSHING
- G = BUSHING OVERALL HEIGHT
- H = MINIMUM OBSTACLE CLEARANCE AT OUTLET
- I = NOMINAL MECHANICAL HUB DIAMETER
- L = MAX. BUSHING TORQUE FT. LBS.
- # = WITH S.A.E. STANDARD SQUARE KEYWAY
- * = WITH SHALLOW KEYWAY IN BUSHING
- ° = MAX METRIC BORE WITH STANDARD KEYWAY

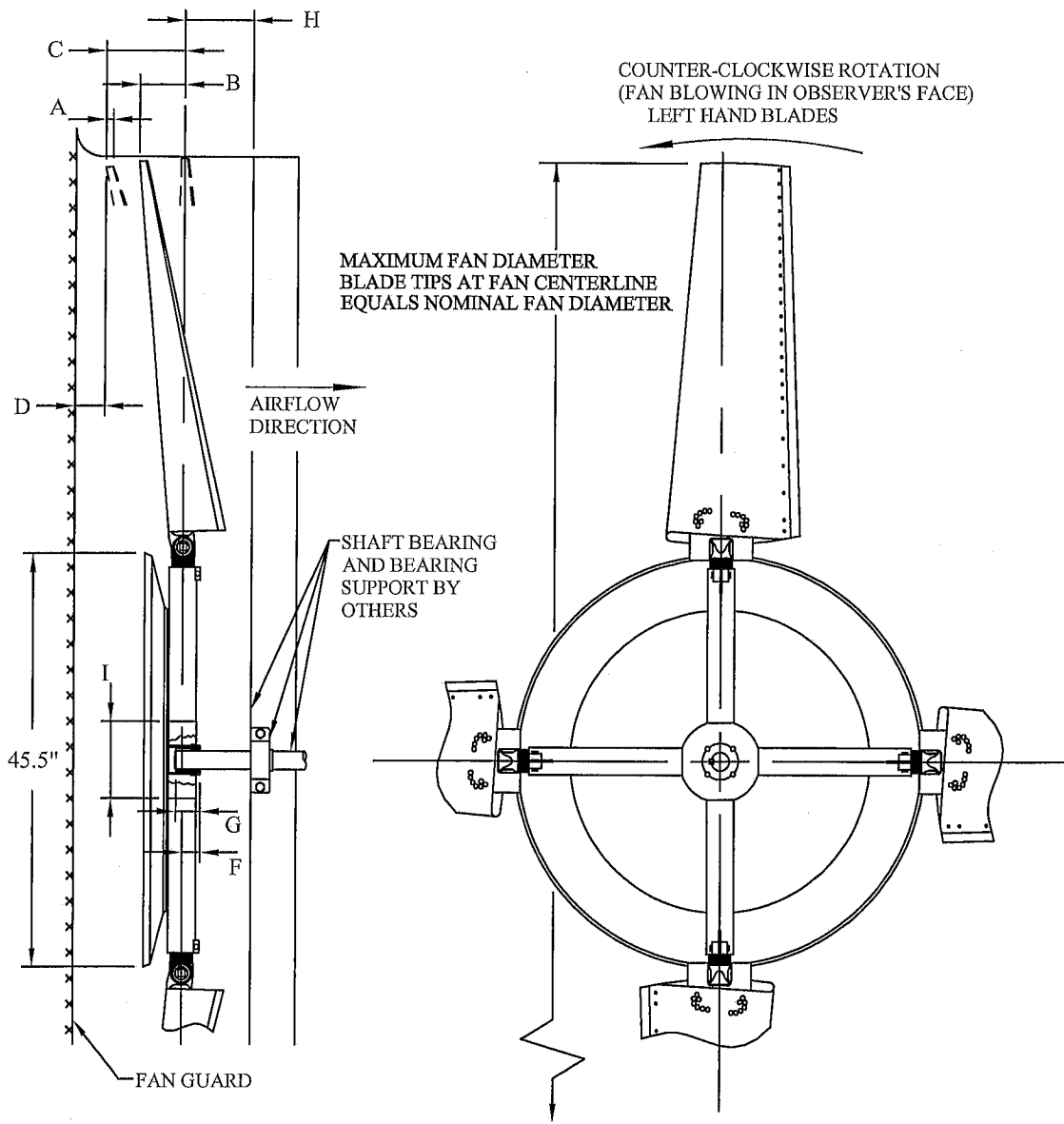
WITH FAN OPERATING AT 12000 FT: MINUTE BLADE TIP SPEED PERCENT BLADE LOADING

DIA	A	PERCENT BLADE LOADING		C	D	H
		100%	75%			
7'	4.4"	1.7"	1.5"	3.7"	2.0"	7.0"
8'	4.0"	2.2"	1.8"	4.2"	2.0"	7.0"
9'	3.6"	2.7"	2.2"	4.7"	2.0"	7.0"
10'	3.2"	3.3"	2.6"	5.3"	2.0"	7.0"
11'	2.8"	4.0"	3.1"	6.0"	2.0"	7.0"
12'	2.4"	4.8"	3.7"	6.8"	2.0"	7.0"
13'	2.0"	5.7"	4.3"	7.7"	2.0"	7.0"
14'	1.7"	6.7"	5.1"	8.7"	2.0"	7.0"

MAX BLADES	BUSHING TYPE	MAX # BORE	MAX * BORE	MAX ° BORE	I	F	G	L
8	U	2.750"	2.938"	75	9"	2.0"	2.7"	4000
8	W	3.750"	4.000"	100	9"	2.2"	2.8"	7300
8	X	3.750"	4.000"	100	9"	2.2"	4.0"	9800



SERIES 42 STANDARD HUB HD FAN RIGHT HAND ROTATION



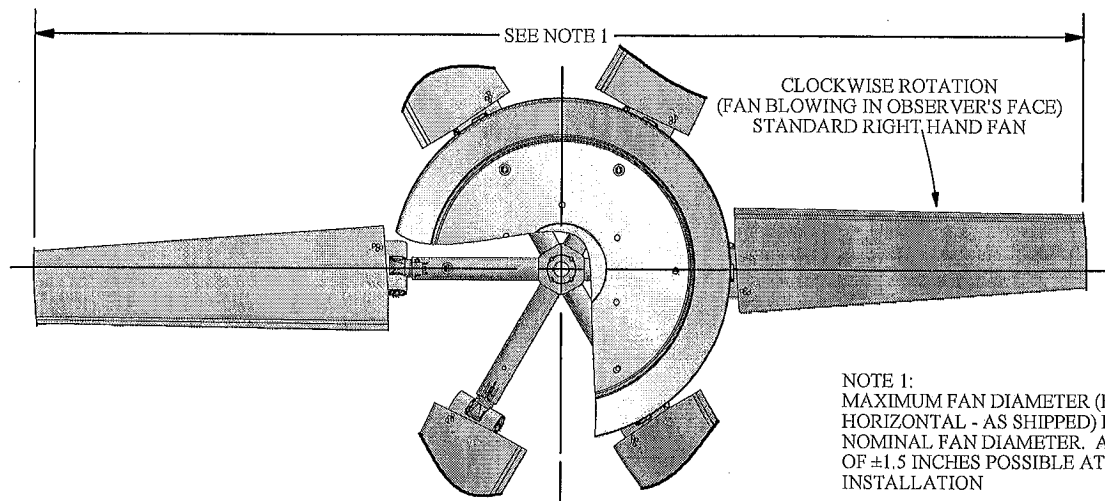
- A = BLADE TIP THICKNESS @ 19° BLADE ANGLE
- B = RUNNING POSITION OF BLADES
- C = MAXIMUM BLADE TRAVEL
- D = MINIMUM OBSTACLE CLEARANCE AT INLET
- F = CENTERLINE OF FAN TO BASE OF BUSHING
- G = BUSHING OVERALL HEIGHT
- H = MINIMUM OBSTACLE CLEARANCE AT OUTLET
- I = NOMINAL MECHANICAL HUB DIAMETER
- L = MAX. BUSHING TORQUE FT. LBS.
- # = WITH S.A.E. STANDARD SQUARE KEYWAY
- * = WITH SHALLOW KEYWAY IN BUSHING
- ° = MAX METRIC BORE WITH STANDARD KEYWAY

WITH FAN OPERATING
AT 12000 FT : MINUTE
BLADE TIP SPEED
PERCENT BLADE
LOADING

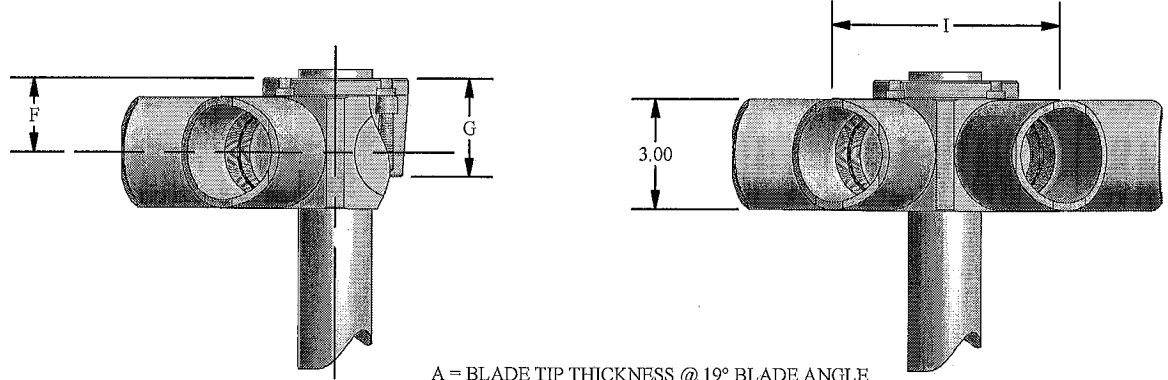
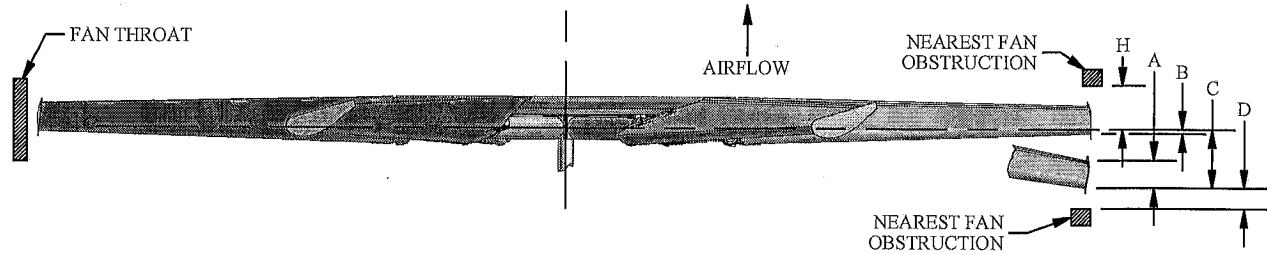
DIA	100%		75%		C	D	H	MAX BLADES	BUSHING TYPE	MAX # BORE	MAX * BORE	MAX ° BORE	I	F	G	L
	A	B	A	B												
8'	2.1"	2.3"	2.0"	2.8"	2.0"	7.0"	6	U	2.750"	2.938"	75	7"	2.0"	2.7"	4000	
9'	1.9"	2.7"	2.3"	3.6"	2.0"	7.0"	8	W	3.750"	4.000"	100	9"	2.0"	2.7"	4000	
10'	1.7"	3.3"	2.7"	4.4"	2.0"	7.0"	8	X	3.750"	4.000"	100	9"	2.2"	4.0"	9800	
11'	1.6"	3.9"	3.1"	5.3"	2.0"	7.0"	10	U	2.750"	2.938"	75	12"	2.0"	2.7"	4000	
12'	1.5"	4.5"	3.6"	6.4"	2.0"	7.0"	10	W	3.750"	4.000"	100	12"	2.2"	2.8"	7300	
13'	1.3"	5.3"	4.2"	7.5"	2.0"	7.0"	10	X	3.750"	4.000"	100	12"	2.2"	4.0"	9800	
14'	1.2"	6.1"	4.8"	8.7"	2.0"	7.0"	10	Z	5.000"	5.500"	140	12"	2.2"	4.0"	18000	



SERIES 48 HD FAN LEFT HAND ROTATION



NOTE 1:
 MAXIMUM FAN DIAMETER (BLADES HORIZONTAL - AS SHIPPED) EQUALS NOMINAL FAN DIAMETER. ADJUSTMENT OF ±1.5 INCHES POSSIBLE AT INSTALLATION



BUSHING AND/OR AIR SEAL CAN BE INSTALLED ON INLET OR OUTLET SIDE OF FAN

- A = BLADE TIP THICKNESS @ 19° BLADE ANGLE
- B = RUNNING POSITION OF BLADES
- C = MAXIMUM DROOP POSITION OF BLADES
- D = MINIMUM OBSTACLE CLEARANCE AT INLET
- F = CENTERLINE OF FAN TO BASE OF BUSHING
- G = BUSHING OVERALL HEIGHT
- H = MINIMUM OBSTACLE CLEARANCE AT OUTLET
- I = NOMINAL MECHANICAL HUB DIAMETER
- L = MAX. BUSHING TORQUE FT. LBS.
- # = WITH S.A.E. STANDARD SQUARE KEYWAY
- * = WITH SHALLOW KEYWAY IN BUSHING
- ° = MAX METRIC BORE WITH STANDARD KEYWAY

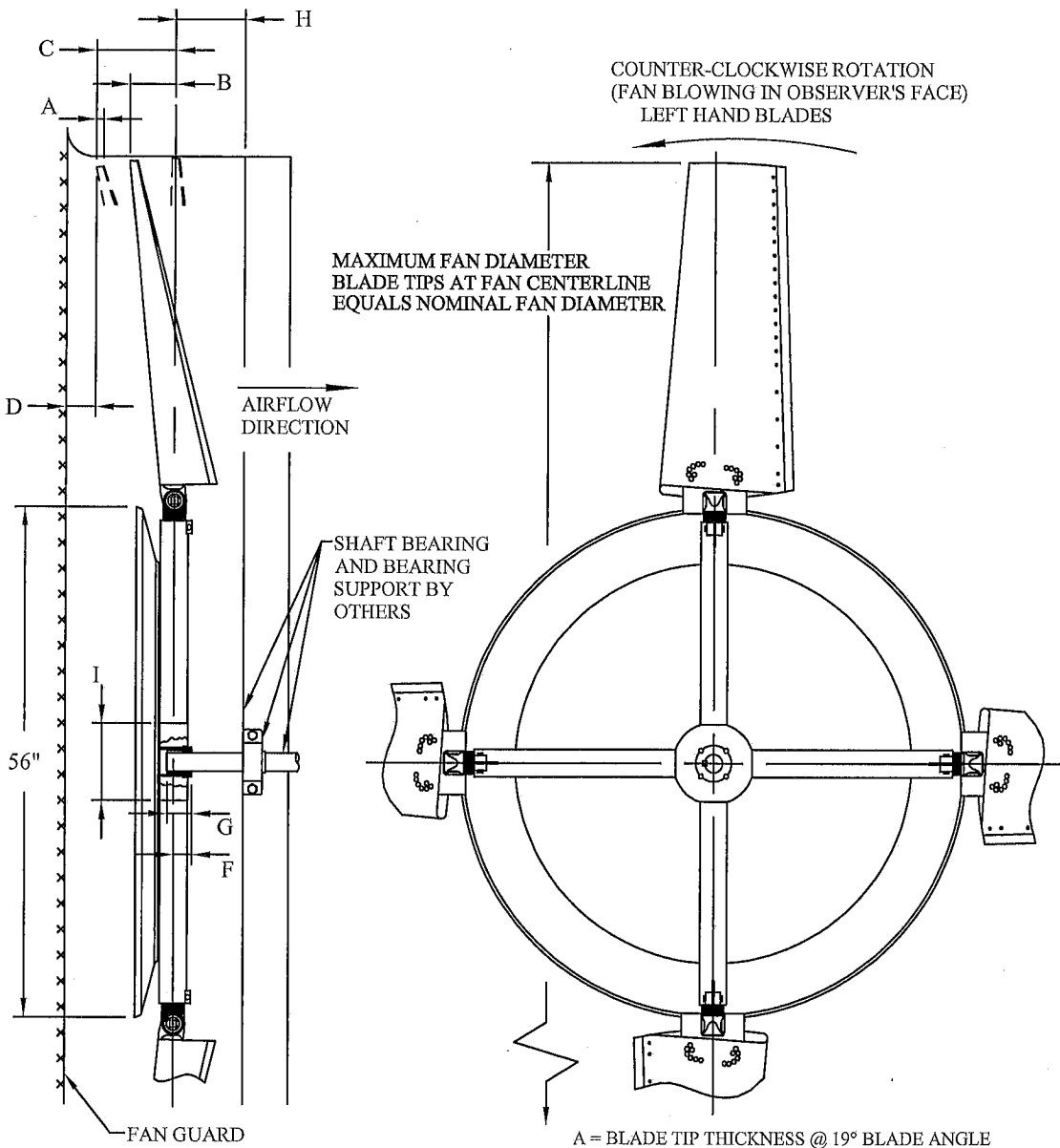
WITH FAN OPERATING AT 12000 FT. MINUTE BLADE TIP SPEED PERCENT BLADE LOADING

DIA	100%		75%		C	D	H
	A	B	B	C			
8'	2.1"	2.3"	2.0"	2.8"	2.0"	7.0"	
9'	1.9"	2.7"	2.3"	3.6"	2.0"	7.0"	
10'	1.7"	3.3"	2.7"	4.4"	2.0"	7.0"	
11'	1.6"	3.9"	3.1"	5.3"	2.0"	7.0"	
12'	1.5"	4.5"	3.6"	6.4"	2.0"	7.0"	
13'	1.3"	5.3"	4.2"	7.5"	2.0"	7.0"	
14'	1.2"	6.1"	4.8"	8.7"	2.0"	7.0"	
15'	1.1"	7.0"	5.5"	10.0"	2.0"	7.0"	
16'	1.0"	8.0"	6.2"	11.5"	2.0"	7.0"	

MAX BLADES	BUSHING TYPE	MAX # BORE	MAX * BORE	MAX ° BORE	I	F	G	L
6	U	2.750"	2.938"	75	7"	1.6"	2.7"	4000
8	U	2.750"	2.938"	75	9"	1.6"	2.7"	4000
10	U	2.750"	2.938"	75	12"	1.6"	2.7"	4000
8	W	3.750"	4.000"	100	9"	1.8"	2.8"	7300
10	W	3.750"	4.000"	100	12"	1.8"	2.8"	7300
10	Z	5.000"	5.500"	140	12"	2.2"	4.0"	18000



SERIES 48 STANDARD HUB HD FAN RIGHT HAND ROTATION



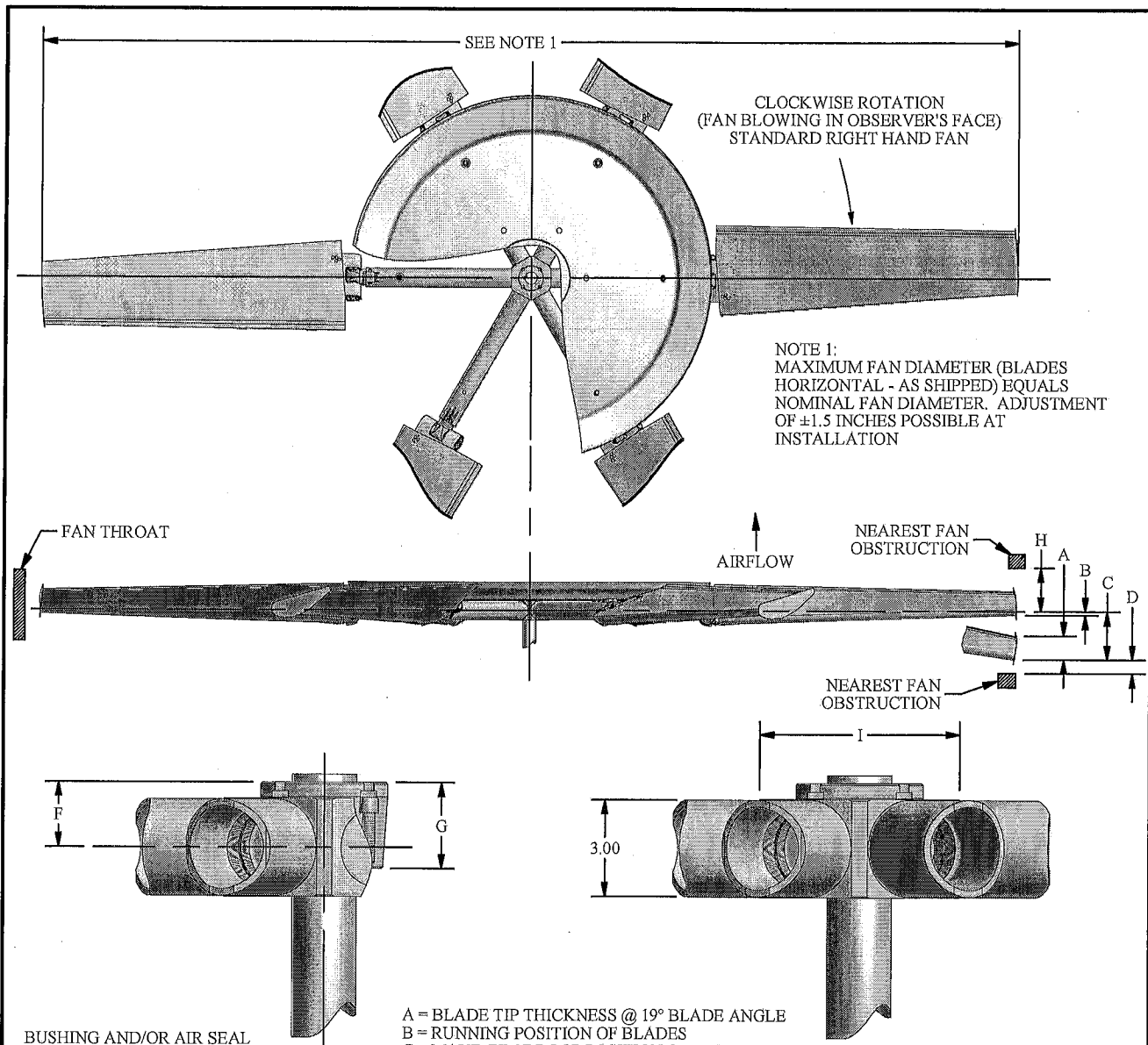
- A = BLADE TIP THICKNESS @ 19° BLADE ANGLE
- B = RUNNING POSITION OF BLADES
- C = MAXIMUM BLADE TRAVEL
- D = MINIMUM OBSTACLE CLEARANCE AT INLET
- F = CENTERLINE OF FAN TO BASE OF BUSHING
- G = BUSHING OVERALL HEIGHT
- H = MINIMUM OBSTACLE CLEARANCE AT OUTLET
- I = NOMINAL MECHANICAL HUB DIAMETER
- L = MAX. BUSHING TORQUE FT. LBS.
- # = WITH S.A.E. STANDARD SQUARE KEYWAY
- * = WITH SHALLOW KEYWAY IN BUSHING
- ° = MAX METRIC BORE WITH STANDARD KEYWAY

WITH FAN OPERATING
AT 12000 FT. MINUTE
BLADE TIP SPEED
PERCENT BLADE
LOADING

DIA	100%		75%		D	H	MAX BLADES	BUSHING TYPE	MAX # BORE	MAX * BORE	MAX ° BORE	I	F	G	L
	A	B	C	D											
10'	2.3"	2.5"	2.1"	3.2"	2.0"	7.0"	8	U	2.750"	2.938"	75	7"	2.0"	2.7"	4000
11'	2.2"	3.4"	2.8"	4.5"	2.0"	7.0"	8	U	2.750"	2.938"	75	9"	2.0"	2.7"	4000
12'	2.1"	4.3"	3.5"	5.8"	2.0"	7.0"	8	W	3.750"	4.000"	100	9"	2.2"	2.8"	7300
13'	1.9"	5.1"	4.1"	7.1"	2.0"	7.0"	8	X	3.750"	4.000"	100	9"	2.2"	4.0"	9800
14'	1.8"	6.0"	4.8"	8.5"	2.0"	7.0"	12	U	2.750"	2.938"	75	12"	2.0"	2.7"	4000
							12	W	3.750"	4.000"	100	12"	2.2"	2.8"	7300
							12	X	3.750"	4.000"	100	12"	2.2"	4.0"	9800
							12	Z	5.000"	5.500"	140	12"	2.2"	4.0"	18000



SERIES 60 HD FAN LEFT HAND ROTATION



BUSHING AND/OR AIR SEAL
CAN BE INSTALLED ON INLET
OR OUTLET SIDE OF FAN

- A = BLADE TIP THICKNESS @ 19° BLADE ANGLE
- B = RUNNING POSITION OF BLADES
- C = MAXIMUM DROOP POSITION OF BLADES
- D = MINIMUM OBSTACLE CLEARANCE AT INLET
- F = CENTERLINE OF FAN TO BASE OF BUSHING
- G = BUSHING OVERALL HEIGHT
- H = MINIMUM OBSTACLE CLEARANCE AT OUTLET
- I = NOMINAL MECHANICAL HUB DIAMETER
- L = MAX. BUSHING TORQUE FT. LBS.
- # = WITH S.A.E. STANDARD SQUARE KEYWAY
- * = WITH SHALLOW KEYWAY IN BUSHING
- ° = MAX METRIC BORE WITH STANDARD KEYWAY

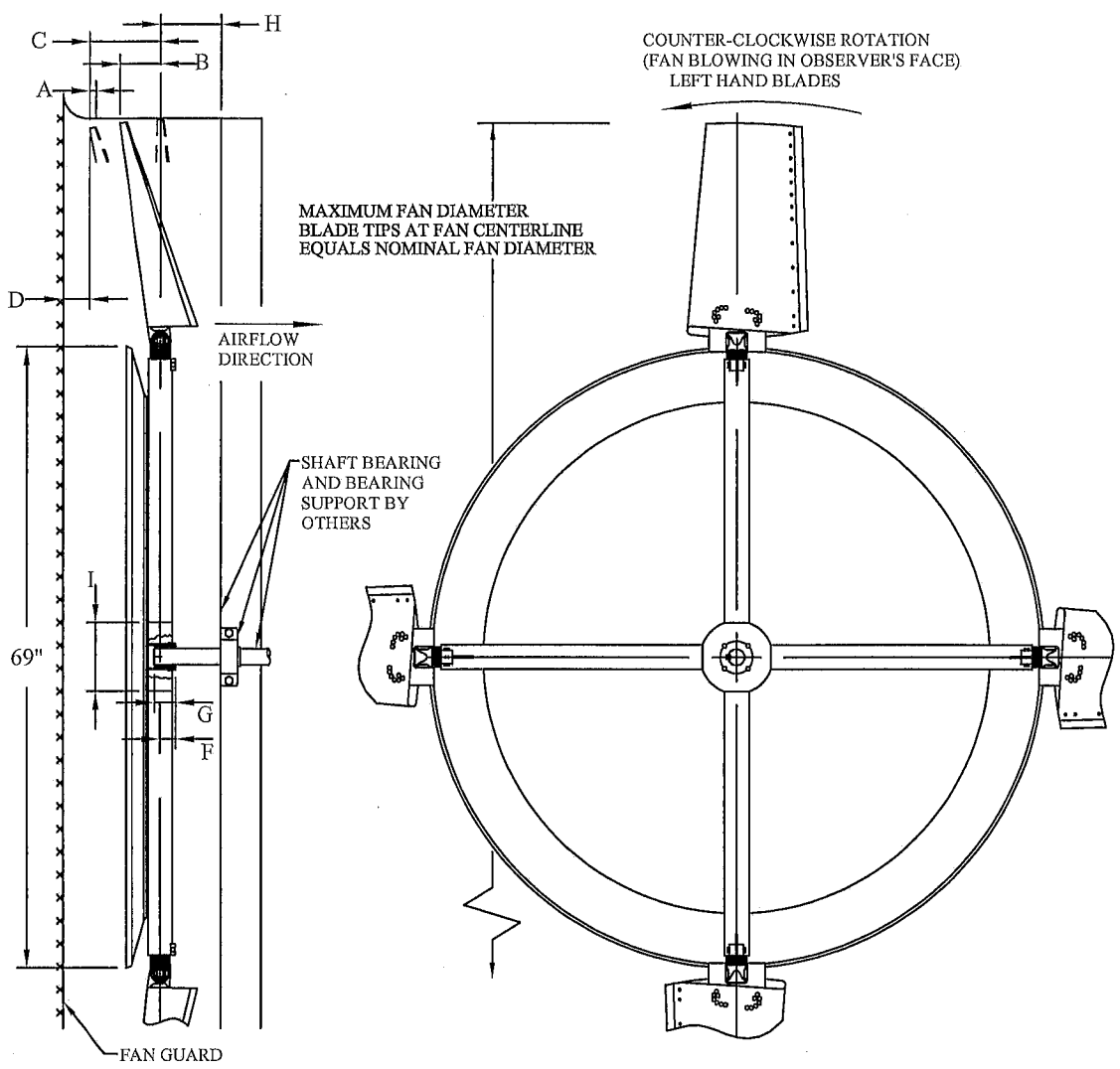
WITH FAN OPERATING
AT 12000 FT. MINUTE
BLADE TIP SPEED
PERCENT BLADE
LOADING

DIA	100%		75%		C	D	H
	A	B	B	C			
10'	1.9"	3.0"	2.5"	4.0"	2.0"	7.0"	
11'	1.7"	3.7"	3.0"	5.0"	2.0"	7.0"	
12'	1.6"	4.4"	3.6"	6.2"	2.0"	7.0"	
13'	1.5"	5.3"	4.2"	7.5"	2.0"	7.0"	
14'	1.4"	6.2"	4.9"	8.8"	2.0"	7.0"	
15'	1.2"	7.2"	5.6"	10.3"	2.0"	7.0"	
16'	1.1"	8.3"	6.4"	12.0"	2.0"	7.0"	
17'	1.0"	9.5"	7.4"	13.8"	2.0"	7.0"	
18'	1.0"	10.8"	8.4"	15.7"	2.0"	7.0"	
19'	0.9"	12.2"	9.4"	17.8"	2.0"	7.0"	
20'	0.8"	13.8"	10.6"	20.1"	2.0"	7.0"	

MAX BLADES	BUSHING TYPE	MAX # BORE	MAX * BORE	MAX ° BORE	I	F	G	L
6	U	2.750"	2.938"	75	7"	2.0"	2.7"	4000
8	U	2.750"	2.938"	75	9"	2.0"	2.7"	4000
12	U	2.750"	2.938"	75	12"	2.0"	2.7"	4000
8	W	3.750"	4.000"	100	9"	2.2"	2.8"	7300
12	W	3.750"	4.000"	100	12"	2.2"	2.8"	7300
8	X	3.750"	4.000"	100	9"	2.2"	4.0"	9800
12	X	3.750"	4.000"	100	12"	2.2"	4.0"	9800
12	Z	5.000"	5.500"	140	12"	2.2"	4.0"	18000



SERIES 60 STANDARD HUB HD FAN RIGHT HAND ROTATION



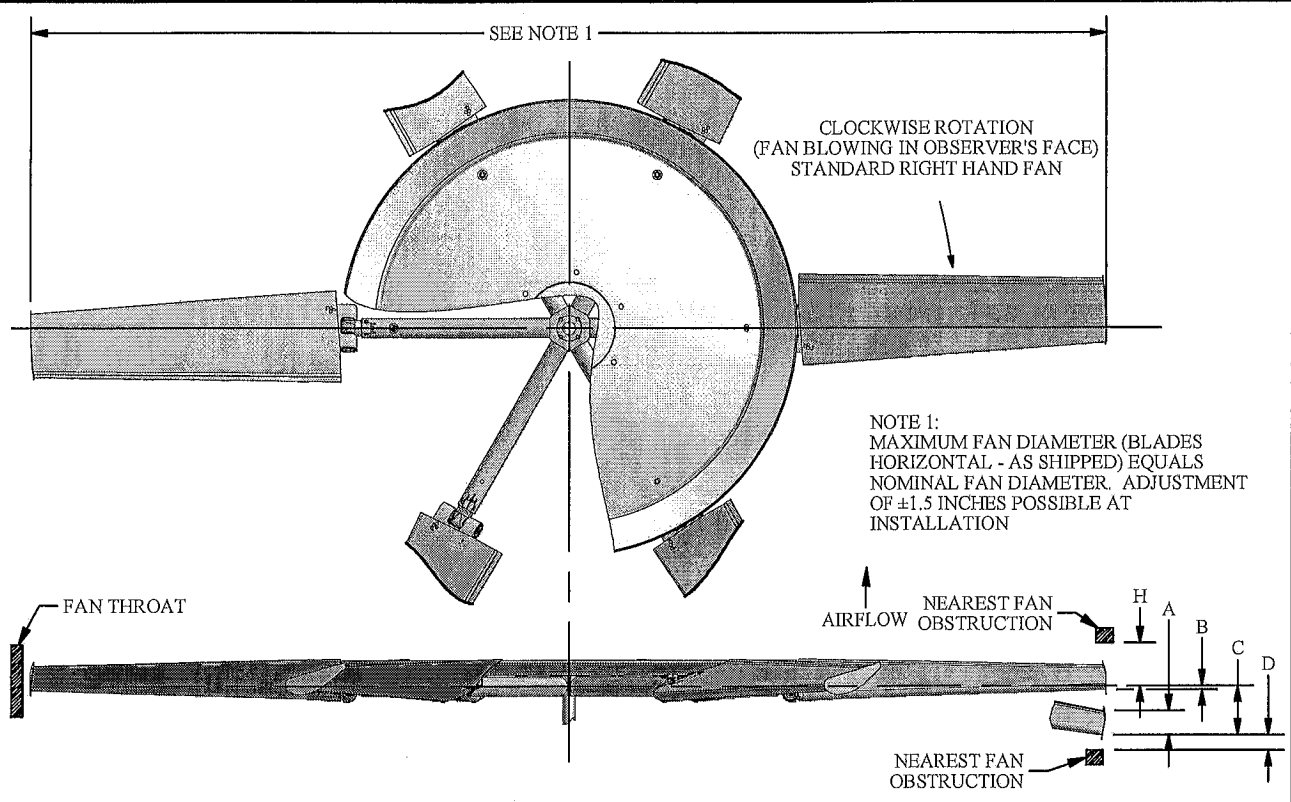
A = BLADE TIP THICKNESS @ 19° BLADE ANGLE
 B = RUNNING POSITION OF BLADES
 C = MAXIMUM BLADE TRAVEL
 D = MINIMUM OBSTACLE CLEARANCE AT INLET
 F = CENTERLINE OF FAN TO BASE OF BUSHING
 G = BUSHING OVERALL HEIGHT
 H = MINIMUM OBSTACLE CLEARANCE AT OUTLET
 I = NOMINAL MECHANICAL HUB DIAMETER
 L = MAX BUSHING TORQUE FT. LBS.
 # = WITH S.A.E. STANDARD SQUARE KEYWAY
 * = WITH SHALLOW KEYWAY IN BUSHING
 ° = MAX METRIC BORE WITH STANDARD KEYWAY

WITH FAN OPERATING
AT 12000 FT : MINUTE
BLADE TIP SPEED
PERCENT BLADE
LOADING

DIA	A	WITH FAN OPERATING AT 12000 FT : MINUTE BLADE TIP SPEED PERCENT BLADE LOADING		C	D	H	MAX BLADES	BUSHING TYPE	MAX # BORE	MAX * BORE	MAX ° BORE	I	F	G	L
		100%	75%												
11'	2.2"	3.4"	2.8"	4.5"	2.0"	7.0"	6	U	2.750"	2.938"	75	7"	2.0"	2.7"	4000
12'	2.1"	4.3"	3.5"	5.8"	2.0"	7.0"	8	U	2.750"	2.938"	75	9"	2.0"	2.7"	4000
13'	1.9"	5.1"	4.1"	7.1"	2.0"	7.0"	8	W	3.750"	4.000"	100	9"	2.2"	2.8"	7300
14'	1.8"	6.0"	4.8"	8.5"	2.0"	7.0"	8	X	3.750"	4.000"	100	9"	2.2"	4.0"	9800
							12	U	2.750"	2.938"	75	12"	2.0"	2.7"	4000
							12	W	3.750"	4.000"	100	12"	2.2"	2.8"	7300
							12	X	3.750"	4.000"	100	12"	2.2"	4.0"	9800
							12	Z	5.000"	5.500"	140	12"	2.2"	4.0"	18000
							14	U	2.750"	2.938"	75	14"	2.0"	2.7"	4000
							14	W	3.750"	4.000"	100	14"	2.2"	2.8"	7300
							14	X	3.750"	4.000"	100	14"	2.2"	4.0"	9800
							14	Z	5.000"	5.500"	140	14"	2.2"	4.0"	18000
							16	U	2.750"	2.938"	75	16"	2.0"	2.7"	4000
							16	W	3.750"	4.000"	100	16"	2.2"	2.8"	7300
							16	X	3.750"	4.000"	100	16"	2.2"	4.0"	9800
							16	Z	5.000"	5.500"	140	16"	2.2"	4.0"	18000

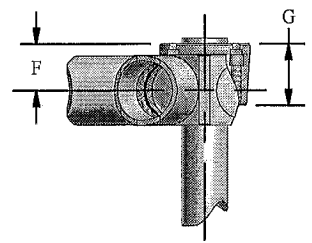
SERIES 72 HD FAN LEFT HAND ROTATION



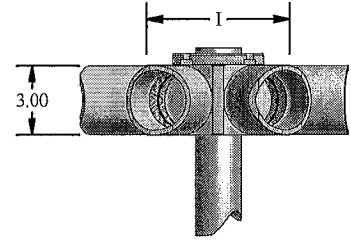


CLOCKWISE ROTATION
(FAN BLOWING IN OBSERVER'S FACE)
STANDARD RIGHT HAND FAN

NOTE 1:
MAXIMUM FAN DIAMETER (BLADES
HORIZONTAL - AS SHIPPED) EQUALS
NOMINAL FAN DIAMETER. ADJUSTMENT
OF ±1.5 INCHES POSSIBLE AT
INSTALLATION



BUSHING AND/OR AIR SEAL
CAN BE INSTALLED ON INLET
OR OUTLET SIDE OF FAN



- A = BLADE TIP THICKNESS @ 19° BLADE ANGLE
- B = RUNNING POSITION OF BLADES
- C = MAXIMUM DROOP POSITION OF BLADES
- D = MINIMUM OBSTACLE CLEARANCE AT INLET
- F = CENTERLINE OF FAN TO BASE OF BUSHING
- G = BUSHING OVERALL HEIGHT
- H = MINIMUM OBSTACLE CLEARANCE AT OUTLET
- I = NOMINAL MECHANICAL HUB DIAMETER
- L = MAX. BUSHING TORQUE FT. LBS.
- # = WITH S.A.E. STANDARD SQUARE KEYWAY
- * = WITH SHALLOW KEYWAY IN BUSHING
- ° = MAX METRIC BORE WITH STANDARD KEYWAY

WITH FAN OPERATING
AT 12000 FT. MINUTE
BLADE TIP SPEED
PERCENT BLADE
LOADING

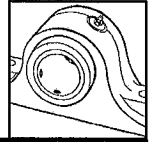
DIA	100%		75%		D	H
	A	B	C	D		
11"	2.2"	3.4"	2.8"	4.5"	2.0"	7.0"
12"	2.1"	4.3"	3.5"	5.8"	2.0"	7.0"
13"	1.9"	5.1"	4.1"	7.1"	2.0"	7.0"
14"	1.8"	6.0"	4.8"	8.5"	2.0"	7.0"
15"	1.7"	7.0"	5.6"	10.0"	2.0"	7.0"
16"	1.5"	8.1"	6.4"	11.6"	2.0"	7.0"
17"	1.4"	9.2"	7.2"	13.3"	2.0"	7.0"
18"	1.3"	10.4"	8.1"	15.1"	2.0"	7.0"
19"	1.2"	11.7"	9.0"	16.9"	2.0"	7.0"
20"	1.1"	13.0"	10.1"	18.9"	2.0"	7.0"
21"	1.0"	14.4"	11.1"	21.0"	2.0"	7.0"
22"	0.9"	15.9"	12.2"	23.2"	2.0"	7.0"
23"	0.8"	17.4"	13.4"	25.5"	2.0"	7.0"
24"	0.7"	19.1"	14.7"	27.9"	2.0"	7.0"

MAX BLADES	BUSHING TYPE	MAX # BORE	MAX * BORE	MAX ° BORE	I	F	G	L
6	U	2.750"	2.938"	75	7"	2.0"	2.7"	4000
8	U	2.750"	2.938"	75	9"	2.0"	2.7"	4000
12	U	2.750"	2.938"	75	12"	2.0"	2.7"	4000
14	U	2.750"	2.938"	75	14"	2.0"	2.7"	4000
8	W	3.750"	4.000"	100	9"	2.2"	2.8"	7300
12	W	3.750"	4.000"	100	12"	2.2"	2.8"	7300
14	W	3.750"	4.000"	100	14"	2.2"	2.8"	7300
16	W	3.750"	4.000"	100	16"	2.2"	2.8"	7300
8	X	3.750"	4.000"	100	9"	2.2"	4.0"	9800
12	X	3.750"	4.000"	100	12"	2.2"	4.0"	9800
14	X	3.750"	4.000"	100	14"	2.2"	4.0"	9800
16	X	3.750"	4.000"	100	16"	2.2"	4.0"	9800
12	Z	5.000"	5.500"	140	12"	2.2"	4.0"	18000
14	Z	5.000"	5.500"	140	14"	2.2"	4.0"	18000
16	Z	5.000"	5.500"	140	16"	2.2"	4.0"	18000



SERIES 72 STANDARD HUB HD FAN RIGHT HAND ROTATION

FEATURES/BENEFITS



Type E/DOUBLE-INTERLOCK/Type K/TAF

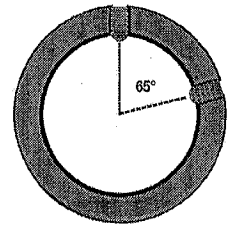
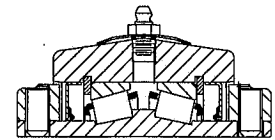
These four product lines have many common features and benefits that are shown on this page. Unique features for each product are shown on the following pages.

The common components used by all four lines include:

- Bearings
- Seals
- Locking collars
- Bore range

General Features:

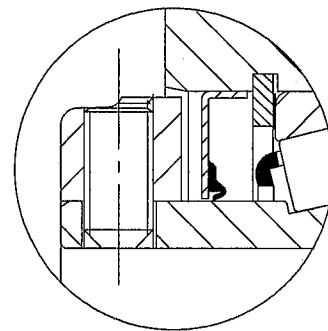
- Factory assembled, adjusted and pre-lubricated
- Case hardened rollers and races
- Easy installation and maintenance
- 65 degree set screw angle
Springlok collar/flingers—
More holding power than 90 or 120 degree
- Single rubber lip contacting seals



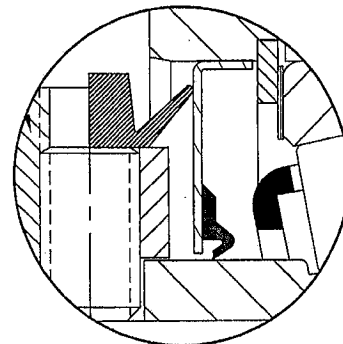
EXCLUSIVE SEALING DESIGNS AND FEATURES

Rolling Elements Never Exposed to Contaminants

- Exclusive "R" Seal features a combination metal shield and positive land riding contacting lip seal. Keeps contaminants out, lubricants in.
- E-TECT Seal option gives extra protection with a combination face rubbing seal in addition to the "R" Seal System. (See page B5-58)
- TIMKEN™ tapered roller bearing inserts allow for combination radial and thrust loads.
- Lip design conforms to cones. Permits grease to purge.
- Close fit oversized collars act as flingers for added protection in dusty or damp environments.

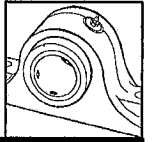


Standard "R" Seal System



E-TECT Seal System

FEATURES/BENEFITS



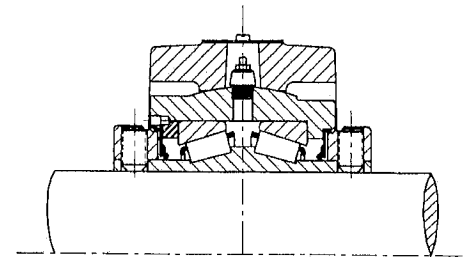
TAF

TAF Is A Cost Saving Alternative To SAF

SPHERICAL BEARINGS

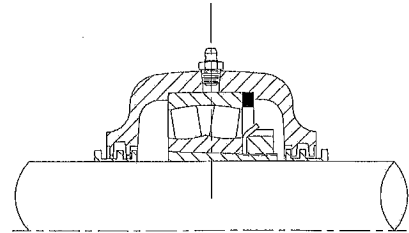
**Mounts Fast, Stays Cleaner
And Extends Service Life**

- **Shaft ready** - mounts six times faster than SAF
- Interchangeable with SAF style pillow blocks
- Self-aligning, factory assembled, adjusted and lubricated
- Available in 1-7/16" up to 7" shaft diameters
- Equipped with expansion or non-expansion housing
- E-TECT seal option available up to 7"
- Optional Smart Housings accommodate speed, vibration and temperature sensor kits



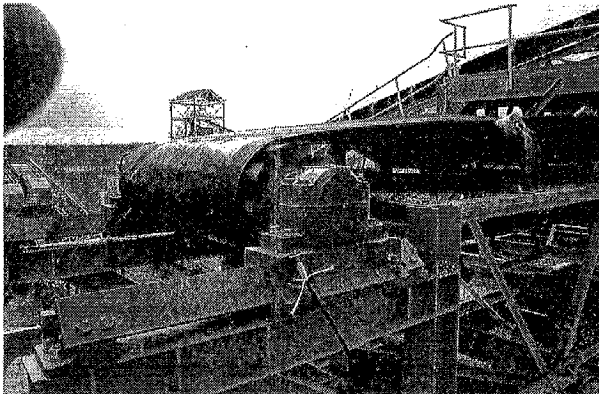
TAF

Self-alignment provided by spherically machined housing.

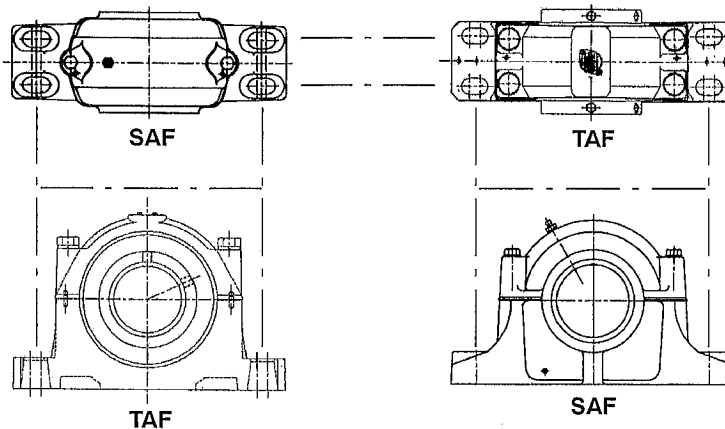


SAF

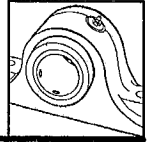
Self-alignment provided by insert, limited by seal interference.



**TAF Is Interchangeable
With SAF Mounting Dimensions**



FEATURES/BENEFITS



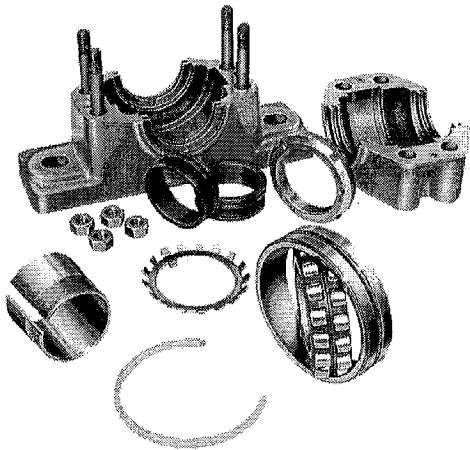
Type K/DOUBLE-INTERLOCK/TAF

DODGE BEARINGS SAVE YOU TIME AND MONEY

Compare These DODGE TAF, Type K & DOUBLE-INTERLOCK Bearing Advantages Against Standard SAF Pillow Blocks

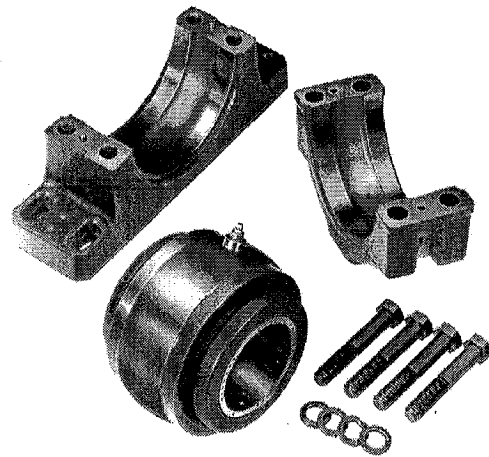
Standard SAF

- Four prices
- Up to six packages
- Open bearing
- Feeler gauge required
- Grease required



DODGE TAF, Type K and DOUBLE-INTERLOCK

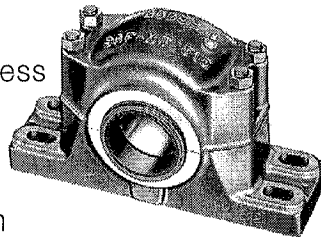
- One price
- Sealed bearing
- Factory adjusted
- Factory lubricated
- **Shaft ready**



Compare Standard SAF and DODGE Sealing Designs

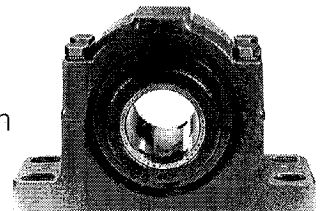
STANDARD SAF

- Seals ride independently of bearing
- Less than 1° static misalignment
- Sealing effectiveness decreases as misalignment increases
- Seals distort when misalignment occurs

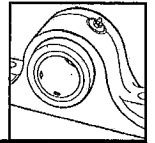


DODGE TAF, TYPE K, DOUBLE-INTERLOCK

- Inner unit carries seal
- Up to 5° static misalignment
- Seal and bearing ride together in inner unit
- Seals maintain contact on cones even with misalignment



SPECIFICATION



Type E, Type K, DOUBLE-INTERLOCK and TAF

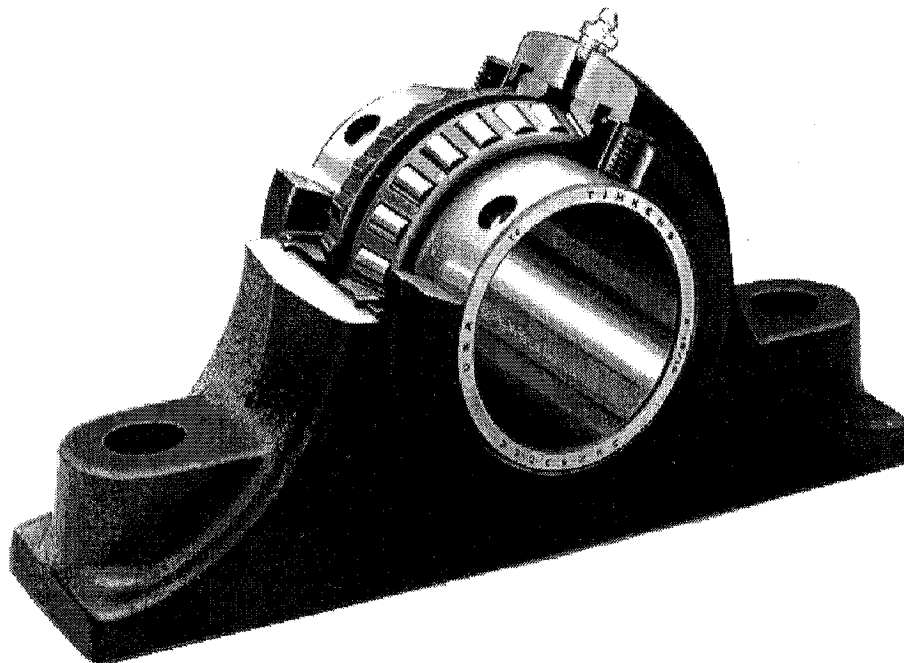
Type E, Type K, DOUBLE-INTERLOCK and TAF mounted bearings are all general purpose high capacity tapered roller bearings capable of handling any combination of radial and thrust load within the capacity of the bearing.

All of these bearings are mounted to the shaft by means of set screw collars having 65 degree set screw spacing for optimum clamping force. The Type E, DOUBLE-INTERLOCK, and TAF mounted bearings have a locking collar at each end of their extended inner races. Type K has a single locking collar. The tapered roller bearings for these mounted bearings all have case carburized inner races (cones), outer races (cups), and rollers.

Bearings are preassembled, prelubricated and factory adjusted. They are normally equipped with land riding contact type seals with a metal deflector guard.

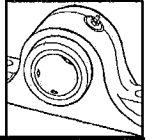
The standard housing material for most of these mounted bearings is ASTM A48 Class 30 Iron having a minimum tensile strength of 30,000 psi. The outer housing for the Type K and DOUBLE-INTERLOCK flange bearings thru 4" bore size utilize housings made of ductile iron (ASTM A536 Grade 65-45-12) with 65,000 psi tensile strength. Type E pillow blocks are also available with cast steel housing having a tensile strength of 70,000 psi for 2 bolt base thru 3-1/2" bore size and 4 bolt base from 3-15/16" thru 5" bore size on an assembled or order basis.

The Type K, DOUBLE-INTERLOCK pillow blocks and flange bearings plus the TAF pillow blocks all have split outer housings used with completely assembled, lubricated and adjusted inner units simplifying replacement of the bearing in the pillow block or flange bearing. All Type E mounted bearings, Type K take up units and all D units, S-1 units, and B-1 units have solid one piece housings.

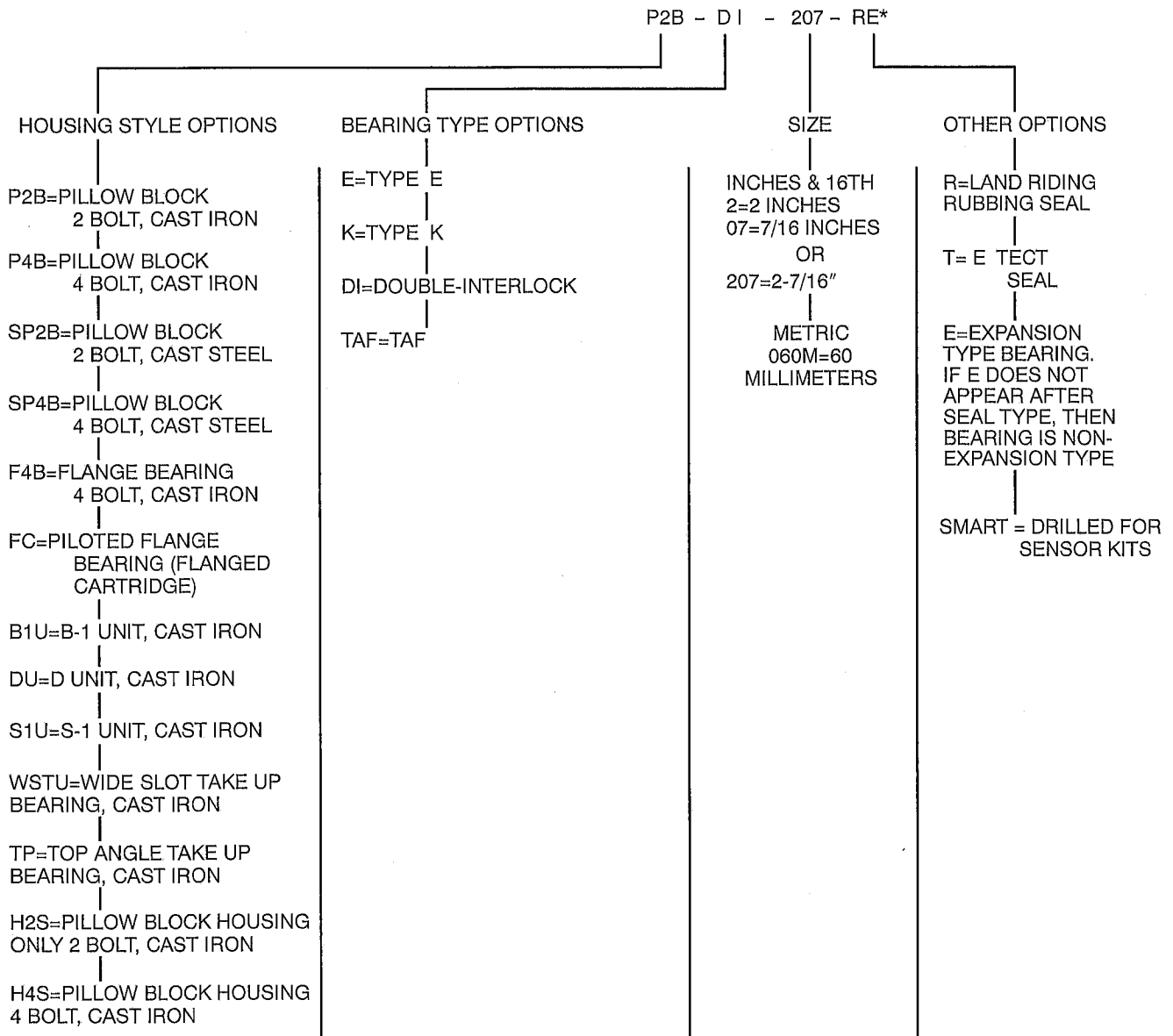


SELECTION/DIMENSIONS TYPE E PAGE B5-11/B5-22	SELECTION/DIMENSIONS TYPE K PAGE B5-11/B5-34	SELECTION/DIMENSIONS DOUBLE-INTERLOCK PAGE B5-11/B5-44	SELECTION/DIMENSIONS TAF PAGE B5-11/B5-52
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NOMENCLATURE

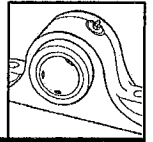


Type E, Type K, DOUBLE-INTERLOCK and TAF NOMENCLATURE



SELECTION/DIMENSIONS TYPE E PAGE B5-11/B5-22	SELECTION/DIMENSIONS TYPE K PAGE B5-11/B5-34	SELECTION/DIMENSIONS DOUBLE-INTERLOCK PAGE B5-11/B5-44	SELECTION/DIMENSIONS TAF PAGE B5-11/B5-52
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SELECTION



Type E, Type K, DOUBLE-INTERLOCK And TAF Tapered Roller Bearings

DODGE Type E, K, DI and TAF Double Row Tapered Roller Bearings have the capacity to carry heavy radial loads and combined radial and thrust loads. The maximum recommended load which can be applied is limited by various components in the system such as bearing, housing, shaft, shaft attachment, speed and life requirements as listed in this catalog. DODGE tapered roller bearings have been applied successfully even when these limits have been exceeded under controlled operating conditions. Contact DODGE Application Engineering (864) 297-4800 for applications which exceed the recommendations of this catalog.

L₁₀ Hours Life --- The life which may be expected from at least 90% of a given group of bearings operating under identical conditions.

$$L_{10} = \left(\frac{C_{90}}{P} \right)^{10/3} \times \left(\frac{1,500,000}{\text{RPM}} \right)$$

Where: C₉₀ = Dynamic Capacity (Table 1, pg.B5-14), lbs.
P = Equivalent Radial Load, lbs.

GENERAL

Heavy Service --- For heavy shock loads, frequent shock loads, or severe vibrations, add up to 50% (according to severity of conditions) to the Equivalent Radial Load. Consult DODGE Application Engineering for additional selection assistance.

Thrust load values shown in the table below are recommended as a guide for general applications that will give adequate L₁₀ life for pillow blocks. The maximum thrust load should not exceed values shown on Table 3. Where substantial radial load is also present, it is advisable to calculate actual L₁₀ life to assure that it meets the requirements. The effectiveness of the shaft attachment to carry thrust load depends on proper tightening of the setscrews, shaft tolerance and shaft deflections. Therefore, it is advisable to use auxiliary thrust carrying devices such as shaft shoulder, snap ring

or a thrust collar to locate the bearing under thrust loads heavier than shown below, or where extreme reliability is desired.

RPM RANGE		20-200	201-2000	over 2000
RECOMMENDED	E, DI, TAF	C ₉₀ /4	C ₉₀ /8	C ₉₀ /12
THRUST LOAD	K	C ₉₀ /5	C ₉₀ /8	C ₉₀ /12

The shaft tolerances recommended below are adequate for normal radial and radial/thrust load applications. The radial load is limited by the attachment to the shaft (see Table 1). Where the applied radial load (F_R) exceeds this limit (maximum allowable slip fit radial load), a snug-to-light press fit of the shaft is required. Since the allowable load, especially at a low speed, is very large, the shaft should be checked to assure adequate shaft strength.

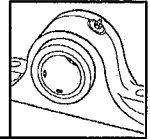
The magnitude and direction of both the thrust and radial load must be taken into account when selecting a housing. **When pillow blocks are utilized, heavy loads should be directed through the base. Where uplift loads are involved, see Tables 6, 7, and, pg.B5-19 for maximum values.** Where a load pulls the housing away from the mounting base, both the hold-down bolts and housing must be of adequate strength. Auxiliary load carrying devices such as shear bars are advisable for side or end loading of pillow blocks and radial load for flange units.

SHAFT SIZE	TOLERANCE, INCHES
UP TO 1-1/2"	+ .0000 - .0005"
1-5/8 TO 4	+ .000 - .001"
4-7/8 TO 6	+ .000 - .0015"
6-7/16-8"	+ .000 - .002"

NOTE: The L₁₀ life calculated using the above formula is subject to life adjustment factors in accordance with ABMA standards described on page B14-45.

HOW TO ORDER PAGE B5-8	EASY SELECTION PAGE B5-15	ENGINEERING/TECHNICAL PAGE B5-17	SELECTION/DIMENSIONS TYPE E, METRIC PAGE B5-61/B5-68
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SELECTION



Type E, Type K, DOUBLE-INTERLOCK And TAF Tapered Roller Bearings

SELECTING BEARINGS SUPPORTING RADIAL LOADS ONLY

1. Define L_{10} Life Hours desired.
2. Establish bearing radial load, F_R
($F_R = P$ for Pure Radial Load Conditions).
The DODGE program BEST™* can be used to find application loads.
3. Establish RPM.

Using the easy selection Table 2, pg. B5-15 find, under the RPM column, the equivalent radial load that equals or is higher than the application radial load for the desired life. The shaft size on the far left will be the minimum shaft size that you can use for your application. If the desired life is different than the values shown on the chart, use alternate Method A shown below.

- Example: 1. L_{10} Life = 30,000 Hours
2. Radial load = 3800 lbs.
3. RPM = 1,000

At the intersection of the 1,000 RPM column and the 30,000 hours L_{10} life row, the equivalent radial load of 3910 lbs. exceeds the 3800 lbs. radial load for shaft sizes 2-11/16"-3". A bearing with bore ranging from 2-11/16" to 3" may be used for this application.

ALTERNATE METHOD A --- SELECTING A BEARING FOR AN L10 LIFE VALUE NOT SHOWN IN THE EASY SELECTION CHART.

The L_{10} life equation can be rearranged so that the bearing dynamic capacity C_{90} is identified in terms of L_{10} , RPM and P.

$$C_{90} = \left(\frac{L_{10} \times \text{RPM}}{1,500,000} \right)^{0.3} \times P$$

($P = F_R$ for Pure Radial Load Conditions)

Since the L_{10} , RPM, and P are known, solve for C_{90} . Select from the dynamic capacity column on Table 1, pg. B5-14 the C_{90} value equal to or greater than the C_{90} value just calculated. The bore size on the far left represents the bore size selection. Check that the application RPM does not exceed the MAX. RPM on Table 1. Also check that the radial load does not exceed the Maximum Allowable Slip Fit Radial Load shown on Table 1. If it does, a line to line to light press fit of shaft is required. When selecting an L_{10} life of less than 30,000 hours, particular attention must be paid to shaft deflection and proper lubricant selection.

SELECTING BEARINGS SUPPORTING COMBINATION RADIAL AND THRUST LOADS

When a bearing supports both a radial load and a thrust load, the loading on the two rows is shared unequally depending on the ratio of thrust to radial load. The use of the X (radial factor) and Y (thrust factor) from Table 1 converts the applied thrust load and radial loads to an equivalent radial load having the same effect on the life of the bearing as a radial load of this magnitude.

The equivalent radial load $P = XF_R + YF_A$

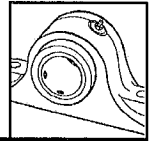
- Where: P = Equivalent radial load, lbs.
 F_R = Radial load, lbs. (see Table 1 for allowable slip fit maximum)
 F_A = Thrust (axial) load, lbs.
 e = Thrust load to radial load factor (Table 1)
 X = Radial load factor (Table 1)
 Y = Thrust load factor (Table 1)

To find X and Y, calculate F_A/F_R and compare to e for the selected bore size. Determine X and Y from Table 1, pg. B5-14 depending on whether F_A/F_R is equal to or less than e , or F_A/F_R is greater than e . Substitute all known values into the equivalent radial load equation. P (equivalent radial load) can be used in the life formula to determine L_{10} , or it can be compared to the allowable equivalent radial load ratings for the speed and hours life desired in the easy selection Table 2, pg. B5-15.

*The DODGE Bearing Evaluation and Selection Technique (BEST) is a menu driven computer program that calculates bearing loads, fatigue life and operating temperature for a two bearing shaft system based on user supplied input parameters. To order, call (864) 287-4800.

SELECTION/DIMENSIONS TYPE E PAGE B5-11/B5-22	SELECTION/DIMENSIONS TYPE K PAGE B5-11/B5-34	SELECTION/DIMENSIONS DOUBLE-INTERLOCK PAGE B5-11/B5-44	SELECTION/DIMENSIONS TAF PAGE B5-11/B5-52
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SELECTION



Type E, Type K, DOUBLE-INTERLOCK and TAF

SELECTING BEARINGS SUPPORTING ONLY THRUST LOADS

Tapered Roller Bearings perform extremely well under pure thrust load applications. Use $P = YF_A$ for the equivalent radial load. The value of Y is obtained from Table 1, pg. B5-14 for $F_A/F_R > e$. Substitute Y and F_A into the equivalent load equation. P (equivalent radial load) can be used in the life formula to determine L_{10} or it can be compared to the allowable equivalent radial load ratings for the speed and hours life desired in the easy selection Table 2, pg. B5-15.

LUBRICATION

DODGE E, K, DI, and TAF tapered roller bearings up to 5" bore are lubricated at the factory with Shell Alvania #2 grease. Above 5" bore they are lubricated with Mobil Mobilux #2EP.

Shell Alvania #2 and Mobil Mobilux #2EP greases are superior industrial greases using a lithium hydroxystearate thickener and highly refined base oil. These greases will adequately handle low and medium speeds with low and medium loads at normal temperatures as defined on Table 5, pg. B5-18. For very low and high speeds, for heavy loads and for low and high temperatures, special greases must be used. Contact DODGE Application Engineering (864) 297-4800. DODGE engineers will recommend bearings and lubricants for the above unusual conditions. DODGE also has the expertise to custom design and build special bearings for your needs. The only maintenance requirement for DODGE Tapered Roller Bearings is periodic relubrication at regular intervals as outlined in the appropriate instruction manuals.

RELUBRICATION SCHEDULE

Hours Run per Day	SUGGESTED LUBRICATION PERIOD IN WEEKS							
	1 to 250 RPM	251 to 500 RPM	501 to 750 RPM	751 to 1000 RPM	1001 to 1500 RPM	1501 to 2000 RPM	2001 to 2500 RPM	2501 to 3000 RPM
8	12	12	10	7	5	4	3	2
16	12	7	5	4	2	2	2	1
24	10	5	3	2	1	1	1	1

High Speed Operation --- In the higher speed ranges too much grease will cause overheating. The amount of grease that the bearing will take for particular high speed application can only be determined by experience --- see "Operating Temperature" below. If excess grease in the bearing caused overheating, it will be necessary to remove grease fitting (also drain plug when furnished) to permit excess grease to escape. When establishing a relubrication schedule, note that a small amount of grease at frequent intervals is preferable to a large amount at infrequent intervals.

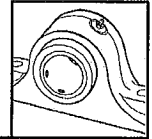
Operation in Presence of Dust, Water or Corrosive Vapors --- Under these conditions the bearing should contain as much grease as speed will permit, since a full bearing with consequent slight leakage is the best protection against entrance of foreign material. In the higher speed ranges too much grease will cause overheating --- see "High Speed Operation". In the lower speed ranges, it is advisable to add extra grease to a new bearing before putting into operation. Bearings should be greased as often as necessary (daily if required) to maintain a slight leakage at the seals.

INSTALLATION AND MAINTENANCE

In nearly all applications good design practice requires two bearings supporting the shaft. In cases where three or more bearings are installed, unless precautions are taken to line the bearings up, both vertically and horizontally, it is possible to induce heavy loads. In the case of two bearings, alignment is not as critical, especially with DODGE K, DI, and TAF Tapered Roller Bearings. K, DI, and TAF bearings are designed to allow as much as 2° to 7° of static misalignment depending on bore size. To ensure good alignment, mounting surfaces must be checked for flatness and must lie in the same plane. When tightening base bolts and cap bolts, each bolt should be alternately tightened in incremental torque values until full torque is achieved to prevent the angular shifting of the pillow block that occurs when one bolt is tightened to its full torque. Shimming may be required to minimize misalignment.

FEATURES/BENEFITS PAGE B5-2	SPECIFICATIONS PAGE B5-7	HOW TO ORDER PAGE B5-8	SELECTION/DIMENSIONS TYPE E, METRIC PAGE B5-61/B5-68
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SELECTION



Type E, Type K, DOUBLE-INTERLOCK and TAF

TABLE 1 - E, K, DI, AND TAF TAPERED ROLLER BEARINGS RADIAL AND THRUST FACTORS

SHAFT SIZE	e	F _A /F _R ≤e		F _A /F _R >e		DYNAMIC CAPACITY C ₉₀ *		MAXIMUM RPM	MAXIMUM RPM	MAXIMUM ALLOWABLE SLIP FIT RADIAL LOAD, F _R ** , LBS	
		X	Y	X	Y	LBS.	NEWTONS	R-SEAL	E-TECT	E,DI,&TAF	K
1-3/16 1-1/4	.49	.87	1.77	.70	2.14	2,980	13,260	4,490	3,100	3,100	2,100
1-3/8 1-7/16	.46	.87	1.89	.70	2.28	4,760	21,180	3,820	2,675	5,000	3,300
1-1/2 1 5/8 1-11/16	.44	.87	1.96	.70	2.37	6,140	27,320	3,320	2,325	6,400	4,300
1-3/4 1-7/8 1-15/16 2	.33	.87	2.64	.70	3.18	8,070	35,908	3,050	2,135	8,400	5,600
2-3/16 2-1/4 2-7/16 2-1/2	.40	.87	2.17	.70	2.63	9,090	40,447	2,420	1,700	9,500	6,300
2-11/16 2-3/4 2-15/16 3	.46	.87	1.87	.70	2.26	9,600	42,716	2,060	1,440	10,000	6,700
3-3/16 3-1/4 3-7/16 3-1/2	.50	.87	1.71	.70	2.07	15,300	68,078	1,640	1,145	16,000	10,500
3-15/16 4	.49	.87	1.77	.70	2.14	21,000	93,440	1,530	1,070	22,000	14,600
4-7/16 4-1/2	.53	.87	1.63	.70	1.97	25,800	114,799	1,360	950	27,000	----
4-15/16 5	.47	.87	1.83	.70	2.21	35,500	157,959	1,200	840	35,000	----
5-7/16 5-15/16 6	.49	.87	1.76	.70	2.12	40,700	181,097	915	640	42,400	----
6-7/16 6-1/2 6-15/16 7	.54	.87	1.61	.70	1.95	69,200	307,910	790	550	72,000	----

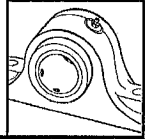
Comparing Spherical To Taper Roller Bearings: The dynamic capacity C (spherical) and C90 (taper) are not to the same base. To compare basic dynamic capacities, multiply C x .259 and compare to C90.

* C₉₀ - Dynamic capacity based on a rated life of 90 million revolutions or 3000 hours at 500 RPM.

** If load exceeds maximum allowable slip fit radial load, (F_R), line-to-line, to light press fit of shaft required. Application up to maximum slip fit radial load may be applied if recommended shaft tolerances are used.

SELECTION/DIMENSIONS TYPE E PAGE B5-11/B5-22	SELECTION/DIMENSIONS TYPE K PAGE B5-11/B5-34	SELECTION/DIMENSIONS DOUBLE-INTERLOCK PAGE B5-11/B5-44	SELECTION/DIMENSIONS TAF PAGE B5-11/B5-52
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SELECTION



Type E, Type K, DOUBLE-INTERLOCK and TAF

TABLE 2 - EASY SELECTION TABLE TYPE E, K, DI, AND TAF

Shaft Size	L10 Hours Life	Allowable Equivalent Radial Load Rating (Lbs.) at Various Revolutions Per Minute														
		50	100	150	250	500	750	1000	1250	1500	1750	2000	2500	2700	3000	3500
1-3/16 1-1/4	10,000	4145	3365	2980	2555	2075	1840	1685	1575	1495	1425	1370	1280	1250	1215	1160
	30,000	2980	2420	2145	1840	1495	1320	1215	1135	1075	1025	985	920	900	870	835
	40,000	2735	2220	1965	1685	1370	1215	1110	1010	985	940	905	845	825	800	765
	60,000	2420	1965	1740	1495	1215	1075	985	920	870	835	800	750	730	710	675
	100,000	2075	1685	1495	1280	1040	920	845	790	750	715	685	640	625	610	580
1-3/8 1-7/16	10,000	6620	5375	4760	4085	3315	2935	2695	2520	2385	2275	2190	2045	2000	1935	1850
	30,000	4760	3865	3425	2935	2385	2110	1935	1810	1715	1640	1575	1470	1440	1395	1330
	40,000	4365	3545	3140	2695	2190	1935	1775	1660	1575	1500	1445	1350	1320	1280	1220
	60,000	3865	3140	2780	2385	1935	1715	1575	1470	1395	1330	1280	1195	1170	1130	1080
	100,000	3315	2695	2385	2045	1660	1470	1350	1260	1195	1140	1095	1025	1000	970	925
1-1/2 1-5/8 1-11/16	10,000	8535	6935	6140	5265	4280	3790	3475	3250	3075	2940	2820	2640	2580	2500	
	30,000	6140	4985	4415	3790	3075	2725	2500	2335	2215	2115	2030	1900	1855	1795	
	40,000	5630	4575	4050	3475	2820	2500	2290	2145	2030	1940	1860	1740	1700	1650	
	60,000	4985	4050	3585	3075	2500	2215	2030	1900	1795	1715	1650	1540	1505	1460	
	100,000	4280	3475	3075	2640	2145	1900	1740	1630	1540	1470	1415	1325	1290	1250	
1-3/4 1-7/8 1-15/16 2	10,000	11220	9115	8070	6925	5625	4980	4565	4270	4045	3860	3710	3470	3390	3285	
	30,000	8070	6555	5805	4980	4045	3580	3285	3070	2910	2775	2670	2495	2440	2360	
	40,000	7400	6010	5325	4565	3710	3285	3015	2820	2670	2545	2445	2290	2235	2165	
	60,000	6555	5325	4715	4045	3285	2910	2670	2495	2360	2255	2165	2025	1980	1920	
	100,000	5625	4565	4045	3470	2820	2495	2290	2140	2025	1935	1860	1740	1700	1645	
2-3/16	10,000	11885	9655	8550	7335	5960	5275	4840	4525	4285	4090	3930	3675	2590		
	30,000	8550	6945	6150	5275	4285	3795	3480	3255	3080	2940	2825	2645	2585		
	40,000	7845	6370	5640	4840	3930	3480	3190	2985	2825	2700	2595	2425	2370		
	60,000	6945	5640	4995	4285	3480	3080	2825	2645	2505	2390	2295	2145	2100		
	100,000	5960	4840	4285	3675	2985	2645	2425	2270	2145	2050	1970	1840	1800		
2-1/4 2-7/16 2-1/2	10,000	12640	10265	9090	7800	6335	5610	5145	4810	4555	4350	4180	3910			
	30,000	9090	7385	6535	5610	4555	4035	3700	3460	3275	3130	3005	2810			
	40,000	8340	6770	5995	5145	4180	3700	3395	3175	3005	2870	2755	2580			
	60,000	7385	5995	5310	4555	3700	3275	3005	2810	2660	2540	2440	2285			
	100,000	6335	5145	4555	3910	3175	2810	2580	2410	2285	2180	2095	1960			

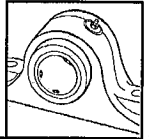
For maximum RPM see Table 1 on page B5-14.

In the shaded area, E, DI, and TAF mounted units require a line-to-line to light press fit of shaft.

In the boxed area, Type K mounted units require a line-to-line to light press fit of shaft.

NOMENCLATURE PAGE B5-10	EASY SELECTION TYPE E, METRIC PAGE B5-64	SELECTION/DIMENSIONS TYPE E, METRIC PAGE B5-61/B5-68	ENGINEERING/TECHNICAL PAGE B5-17
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SELECTION



Type E, Type K, DOUBLE-INTERLOCK and TAF

TABLE 2 (continued) – EASY SELECTION TABLE TYPE E, K, DI, AND TAF

Shaft Size	L10 Hours Life	Allowable Equivalent Radial Load Rating (Lbs.) at Various Revolutions Per Minute														
		50	100	150	250	500	750	1000	1250	1500	1750	2000	2500	2700	3000	3500
2-11/16 2-3/4 2-15/16 3	10,000	13345	10840	9600	8235	6690	5925	5435	5080	4810	4595	4415				
	30,000	9600	7795	6905	5925	4810	4260	3910	3655	3460	3305	3175				
	40,000	8805	7150	6335	5435	4415	3910	3585	3350	3175	3030	2910				
	60,000	7795	6335	5610	4810	3910	3460	3175	2970	2810	2685	2580				
100,000	6690	5435	4810	4125	3350	2970	2725	2545	2410	2300	2210					
3-3/16 3-1/4 3-7/16 3-1/2	10,000	21370	17280	15300	13125	10665	9440	8660	8100	7670	7320					
	30,000	15300	12425	11005	9440	7670	6790	7230	5825	5515	5625					
	40,000	14035	11400	10095	8660	7035	5230	5715	5345	5060	4830					
	60,000	12425	10095	8940	7670	6230	5515	5060	4730	4480	4275					
100,000	10660	8660	7670	6580	5345	4730	4340	4060	3845	3670						
3-15/16 4	10,000	29200	23715	21000	18015	14635	12955	11885	11115	10525						
	30,000	21000	17055	15105	12955	10525	9320	8550	7995	7570						
	40,000	19265	15645	13855	11885	9655	8550	7840	7335	6945						
	60,000	17055	13855	12270	10525	8550	7570	6945	6495	6150						
100,000	14635	11885	10525	9030	7335	6495	5955	5570	5275							
4-7/16 4-1/2	10,000	35870	29135	25800	22135	17980	15920	14605	13655							
	30,000	25800	20955	18555	15920	12930	11450	10500	9820							
	40,000	23665	19225	17020	14605	11860	10500	9635	9010							
	60,000	20955	17020	15070	12930	10500	9300	8530	7980							
100,000	17980	14605	12930	11095	9010	7980	7320	6845								
4-15/16 5	10,000	49360	40090	35500	30455	24740	21905	20095	18790							
	30,000	35500	28835	25530	21905	17790	15755	14450	13515							
	40,000	32565	26450	23420	20095	16320	14550	13255	12400							
	60,000	28835	23420	20740	17790	14450	12795	11740	10980							
100,000	24740	20095	17790	15265	12400	10980	10070	9420								
5-7/16 5-15/16 6	10,000	56590	45965	40700	34915	28360	25115	23035								
	30,000	40700	33060	29270	25115	20400	18060	16570								
	40,000	37335	30325	26850	23035	18710	16570	15200								
	60,000	33060	26850	23775	20400	16570	14670	13455								
100,000	28360	23035	20400	17500	14215	12585	11545									
6-7/16 6-1/2 6-15/16 7	10,000	96215	78150	69200	59365	48220	42700									
	30,000	69200	56205	49770	42700	34680	30710									
	40,000	63480	51560	45655	39170	31815	28170									
	60,000	56205	45655	40425	34680	28170	24945									
100,000	48220	39170	34680	29755	24170	21400										

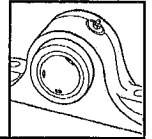
For maximum RPM see Table 1 on page B5-14.

In the shaded area, E, DI, and TAF mounted units require a line-to-line to light press fit of shaft.

In the boxed area, Type K mounted units require a line-to-line to light press fit of shaft.

FEATURES/BENEFITS PAGE B5-2	SPECIFICATIONS PAGE B5-7	HOW TO ORDER PAGE B5-8	
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SELECTION



Type E, Type K, DOUBLE-INTERLOCK and TAF

TABLE 3 – PERMISSIBLE THRUST LOAD, LBS. *

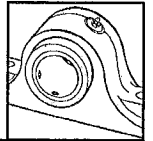
SHAFT SIZE INCHES	*E		K/DI		TAF	
	2-Bolt	4-Bolt	2-Bolt	4-Bolt	2-Bolt	4-Bolt
1-3/16	2000		2000			
1-1/4	2000		2000			
1-3/8	2590		2100			
1-7/16	2590		2100		2100	
1-1/2	2590		2100			
1-5/8	2590		2100			
1-11/16	2590		2100		2100	
1-3/4	3454		2900			
1-7/8	3454		2900			
1-15/16	3454		2900		2900	
2	3454		2900			
2-3/16	3454		2900		2900	
2-1/4	3454	3454	3454	3454		
2-7/16	3454	3454	3454	3454	3454	3454
2-1/2	3454	3454	3454	3454	3454	3454
2-11/16	5181	5181	5181	5181	5181	
2-3/4	5181	5181	5181	5181	5181	
2-15/16	5181	5181	5181	5181	5181	5181
3	5181	5181	5181	5181	5181	5181
3-3/16	5181	5181	5181	5181		
3-1/4	5181	5181	5181	5181		
3-7/16	5181	5181	5181	5181	5181	5181
3-1/2	5181	5181	5181	5181	5181	5181
3-15/16		6908		6908		6908
4		6908		6908		6908
4-7/16		6908		6908		6908
4-1/2		6908		6908		6908
4-15/16		6908		6908		6908
5		6908		6908		6908
5-7/16		8635		8635		8635
5-15/16		8635		8635		8635
6		8635		8635		8635
6-7/16		8635		12282		12282
6-1/2		8635		12282		12282
6-15/16		8635		12282		12282
7		8635		12282		12282

Note: The limits above apply to set screw shaft mounting or pillow block over turning force. Under heavy thrust loads it is always wise to use shear bars. At all times the L10 life of the bearing should be checked for proper selection and life requirements. For thrust loads larger than listed or heavy thrust loading on other style housing, contact DODGE Engineering for recommendation.

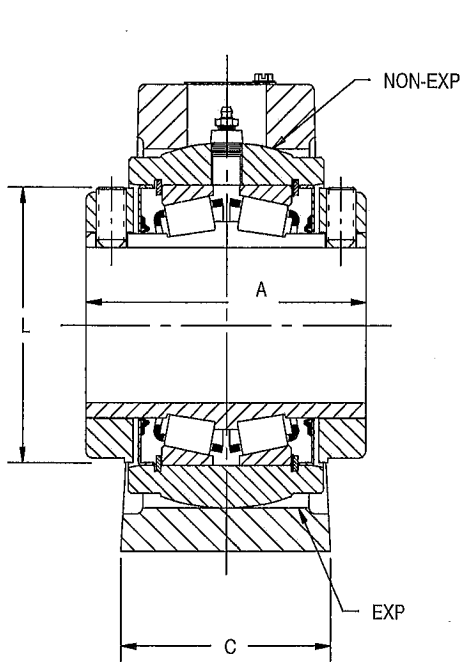
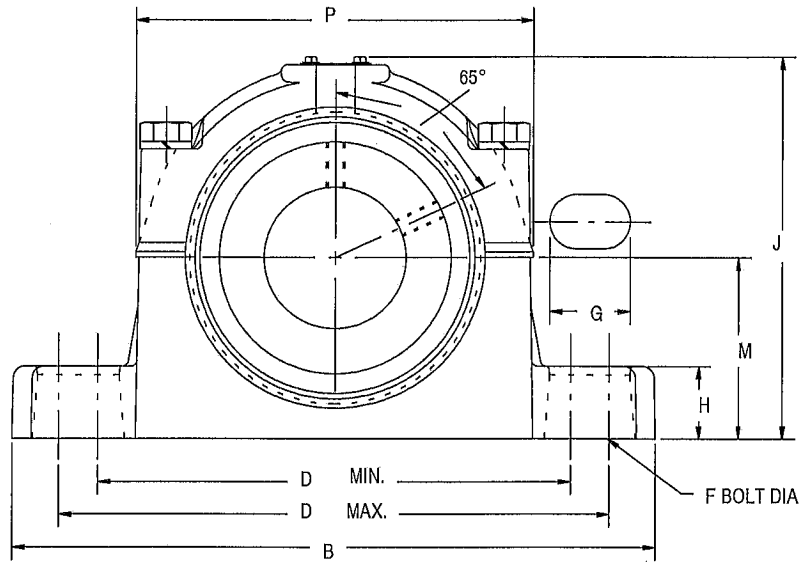
* Does not include Piloted Flange.

SELECTION/DIMENSIONS TYPE E PAGE B5-11/B5-22	SELECTION/DIMENSIONS TYPE K PAGE B5-11/B5-34	SELECTION/DIMENSIONS DOUBLE-INTERLOCK PAGE B5-11/B5-44	SELECTION/DIMENSIONS TAF PAGE B5-11/B5-52
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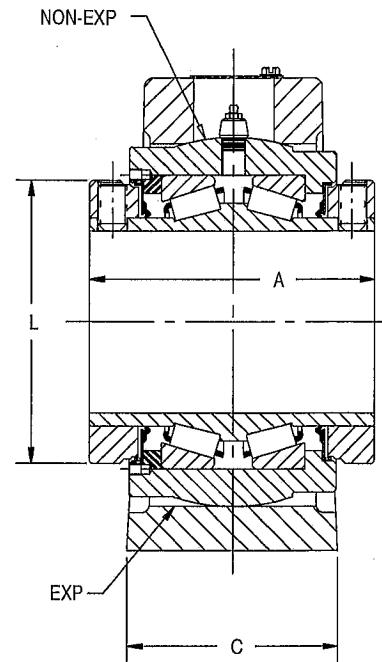
SELECTION/DIMENSIONS



TAF Pillow Block – Inch 2-BOLT BASE

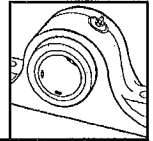


1-7/16" THRU 3" CONSTRUCTION



3-7/16" THRU 3-1/2" CONSTRUCTION

<p>FEATURES/BENEFITS PAGE B5-2</p>	<p>SPECIFICATIONS PAGE B5-7</p>	<p>HOW TO ORDER PAGE B5-8</p>	<p>NOMENCLATURE PAGE B5-10</p>
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SELECTION/DIMENSIONS

TAF Pillow Block – Inch 2-BOLT BASE

GRAY IRON NON-EXPANSION †						
SHAFT SIZE INCHES #	SHAFT SIZE SYMBOL	SAF HOUSING NUMBER	PILLOW BLOCK P/N	HSG ASSEM. P/N	UNIT P/N	PIL. BLK. WT. APRX LBS
1-7/16	107	509	037580	037540	037632	12
1-11/16	111	510	037581	037541	037633	15
1-15/16	115	511	037582	037542	037634	17
2-3/16	203	513	037583	037543	037635	25
2-7/16	207	515	037584	037544	037636	30
2-1/2	208	515	037585	037544	037637	30
2-11/16	211	516	037586	037545	037638	38
2-3/4	212	516	037587	037545	037639	38
2-15/16	215	517	037588	037546	037640	45
3	300	517	037589	037546	037641	44
3-7/16	307	520	037590	037547	037642	71
3-1/2	308	520	037591	037547	037643	70

GRAY IRON EXPANSION						
SHAFT SIZE INCHES #	SHAFT SIZE SYMBOL	SAF HOUSING NUMBER	PILLOW BLOCK P/N	HSG ASSEM. P/N	UNIT P/N	PIL. BLK. WT. APRX LBS
1-7/16	107	509	037592	037555	037632	12
1-11/16	111	510	037593	037556	037633	15
1-15/16	115	511	037594	037557	037634	17
2-3/16	203	513	037595	037558	037635	25
2-7/16	207	515	037596	037559	037636	30
2-1/2	208	515	037597	037559	037637	30
2-11/16	211	516	037598	037560	037638	38
2-3/4	212	516	037599	037560	037639	38
2-15/16	215	517	037600	037561	037640	45
3	300	517	037601	037561	037641	44
3-7/16	307	520	037602	037562	037642	71
3-1/2	308	520	037603	037562	037643	70

† Furnished Unless Otherwise Specified.
Description = P2b-taf-207re For 2-7/16" Size
Consult DODGE For Sizes Not Shown

Description = P2b-taf-207re For 2-7/16" Size
Consult DODGE For Sizes Not Shown

SHAFT SIZE INCHES	SAF SERIES	A	B	C	D		F BOLT DIA	G	H	J	L	M	P	EXP*
					MIN.	MAX.								
1-7/16	509	3	8-1/4	2-3/16	6-1/4	7	1/2	15/16	7/8	5-7/64	2-3/4	2-1/4	5-33/64	3/32
1-11/16	510	3-3/8	8-1/4	2-3/8	6-1/2	7	1/2	7/8	1-1/32	5-5/8	3-3/16	2-1/2	5-13/16	3/32
1-15/16	511	3-1/2	9-5/8	2-3/4	7-3/8	8-1/4	5/8	1-13/64	1-1/32	6-9/64	3-7/16	2-3/4	6-23/64	9/32
2-3/16	513	3-3/4	11	3-1/4	8-21/32	9-1/2	5/8	1-7/16	1-1/32	6-33/64	3-3/4	3	6-61/64	9/32
2-7/16	515	4	11-1/8	3-1/8	8-5/8	9-5/8	5/8	1-17/64	1-1/4	7-1/32	4-1/16	3-1/4	7-3/8	9/32
2-1/2														
2-11/16	516	4-1/2	12-19/32	3-1/2	9-7/8	11	3/4	1-7/16	1-1/4	7-43/64	4-23/32	3-1/2	8-5/16	9/32
2-3/4														
2-15/16	517	4-1/2	12-19/32	3-1/2	9-7/8	11	3/4	1-7/16	1-1/4	7-59/64	4-23/32	3-3/4	8-5/16	9/32
3														
3-7/16	520	5	14-1/4	4-11/32	11-13/16	13-1/8	7/8	1-21/32	1-21/32	9-27/64	5-5/16	4-1/2	10-3/32	9/32
3-1/2														

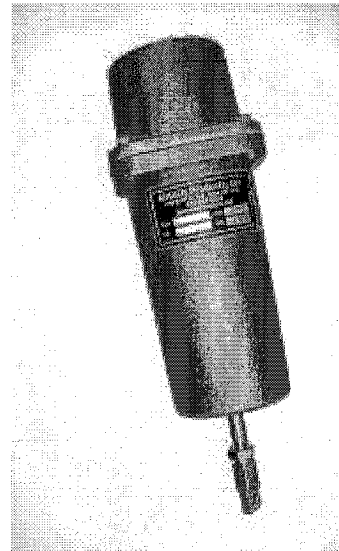
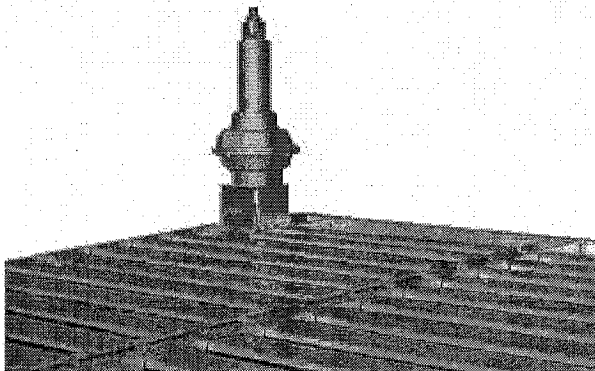
*EXP Total Expansion Divided Equally On Both Sides Of Bearing (Expansion Bearing Only).

Dowel Hole Locations For Precision Positioning – See Page B9-30 – B9-31

EASY SELECTION PAGE B5-15	SELECTION/DIMENSIONS TYPE E PAGE B5-11/B5-22	SELECTION/DIMENSIONS TYPE K PAGE B5-11/B5-34	SELECTION/DIMENSIONS DOUBLE-INTERLOCK PAGE B5-11/B5-44
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Durastroke Pneumatic Actuators

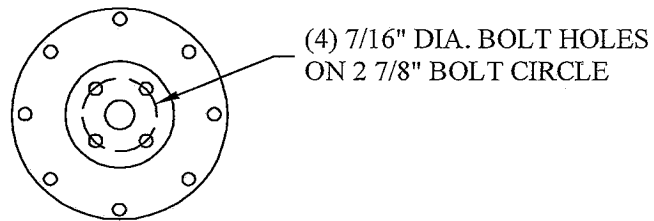
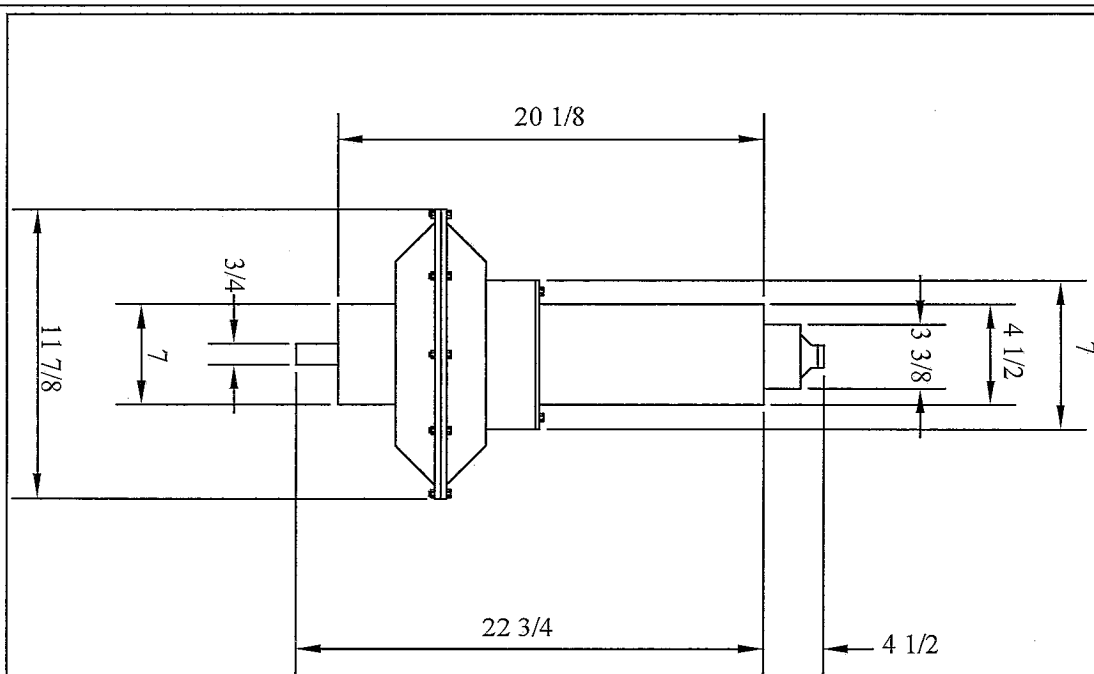


- 1 Heavy Duty Construction
 - 1 Durable Cast Aluminum Housing
 - 1 Available for "extreme duty" temperatures & climates
 - 1 Mounting Versatility
 - 1 Some models available with Fisher DVC Positioner
 - 1 Long life diaphragms
 - 1 Low maintenance
-
- 1 Short Lead Times
 - 1 Competitive Pricing
 - 1 Various spring rates available

AIRTECH Products, Inc.
1550 S. 81st W. Avenue
Tulsa, OK 74127
Phone: 918-241-0264
Fax: 918-241-0270
www.airtechproducts.com

Technical Information

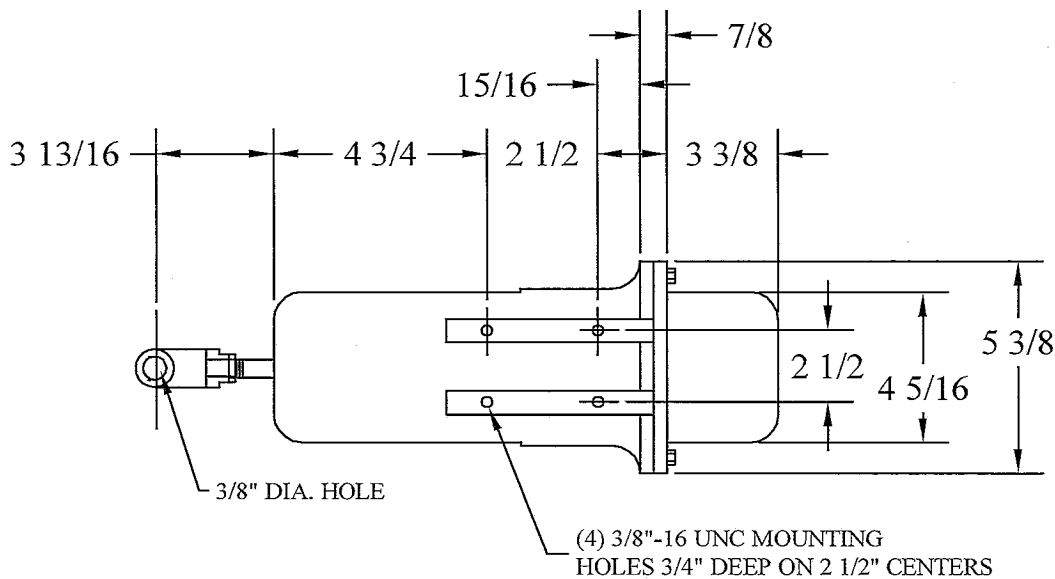
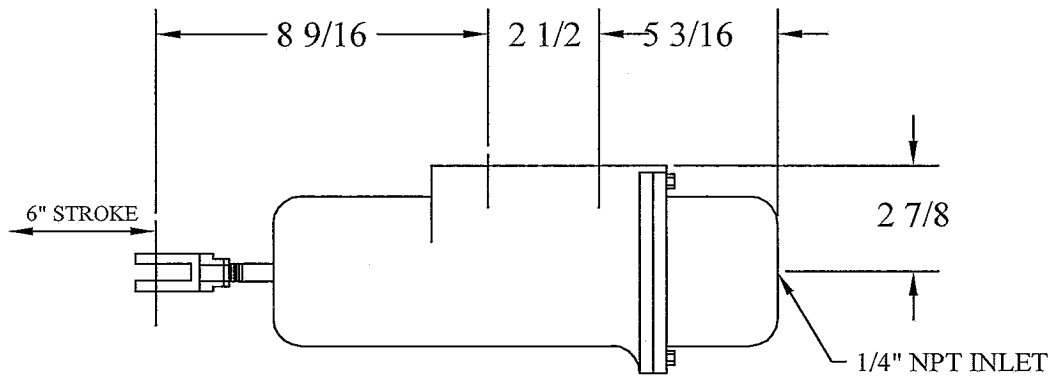
Parameter	Model		
	60 Series	120 Series	1000 – 2000 Series
356-T6 Alum Housing	yes	yes	yes
303 S.S. Travel Stem	yes	yes	yes
Piston	356-T6 Alum	356-T6 Alum	NA
Includes Clevis	yes	yes	yes
Clevis Material	Zinc Plate	Zinc Plate	6061-T6 Alum
Diaphragm	Polyester Fabric w/Nitrile		Nitrile / EPDM
Available Force			320 #
3-15 Spring	18# (20 psi)	36# (20 psi)	NA
6-30 Spring	36# (40 psi)	72# (40 psi)	NA
Stem Travel	4"	6"	3.5"
Consumption (full stroke)	.01 scfm	.03 scfm	.5 scfm
At positioner	.3 scfm (40 psi)		.25 scfm
Weight			
With positioner	8.25 #	14.75 #	44 #
Without positioner	6.25 #	12.75 #	42 #
Spring	Zinc Plate	Zinc Plate	17-7 SS
Extreme duty available	Optional	Optional	Optional
Use w/Air or Sour Gas	yes	yes	Optional
Lubrication Required	no	no	no



Parameter

Housing:	356-T6 Alum.
Travel Stem:	303 Stainless Steel
Includes Clevis:	Yes
Clevis Material:	6061-T6 Aluminum
Available force:	320#
Stem Travel:	3.5"
Consumption (Full Stroke)	.5 scfm
At positioner	.25 scfm
Weight	
With Positioner:	44 Lbs.
Without Positioner	42 Lbs.
Spring	17-7 Stainless Steel
Extreme duty available	Optional
Use w/Air or Sour Gas	Optional
Lubrication Required	No

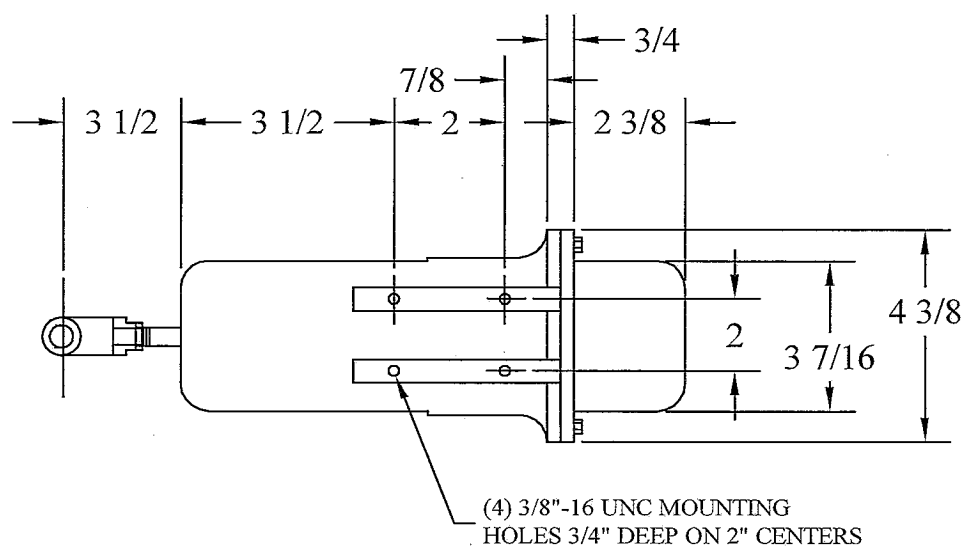
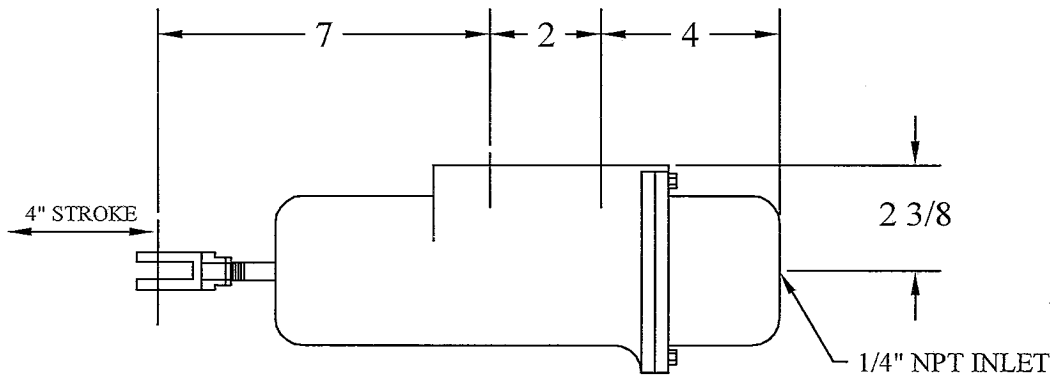
AIRTECH PRODUCTS, INC.	
Dwg. Name: DURASTROKE 1100 DETAIL	
Date: 9-25-06	By: Miller
Customer:	File #: AIR MOTOR



Parameter

Housing:	356-T6 Alum.
Travel Stem:	303 Stainless Steel
Piston:	356-T6 Alum.
Includes Clevis:	Yes
Clevis Material:	Zinc Plate
Available force	
3 - 15 Spring	18#
6 - 30 Spring	36#
Stem Travel:	4"
Consumption (Full Stroke)	.01 scfm
At positioner	.3 scfm (40 psi)
Weight	
With Positioner	14.75 Lbs.
Without Positioner	12.75 Lbs.
Spring	Zinc Plated
Extreme duty available	Optional
Use w/Air or Sour Gas	Yes
Lubrication Required	No

AIRTECH PRODUCTS, INC.	
Dwg. Name: DURASTOKE 120 ACTUATOR	
Date: 9-21-06	By: Miller
Customer:	File #:



Parameter

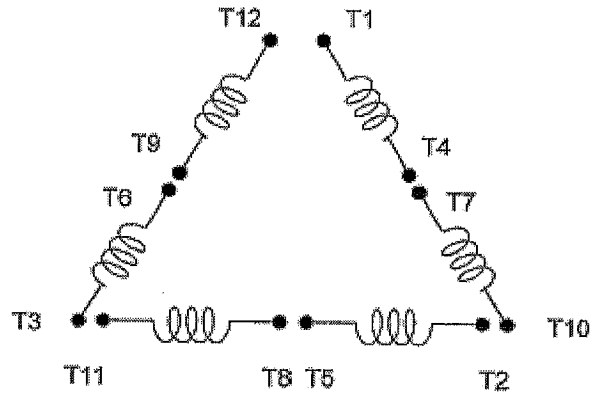
Housing:	356-T6 Alum.
Travel Stem:	303 Stainless Steel
Piston:	356-T6 Alum.
Includes Clevis:	Yes
Clevis Material:	Zinc Plate
Available force	
3 - 15 Spring	18#
6 - 30 Spring	36#
Stem Travel:	4"
Consumption (Full Stroke)	.01 scfm
At positioner	.3 scfm (40 psi)
Weight	
With Positioner	8.25 Lbs.
Without Positioner	6.25 Lbs.
Spring	Zinc Plated
Extreme duty available	Optional
Use w/Air or Sour Gas	Yes
Lubrication Required	No

AIRTECH PRODUCTS, INC.	
Dwg. Name: DURASTOKE 60 ACTUATOR	
Date: 9-21-06	By: Miller
Customer:	File #:

DATE:
June 22, 2005

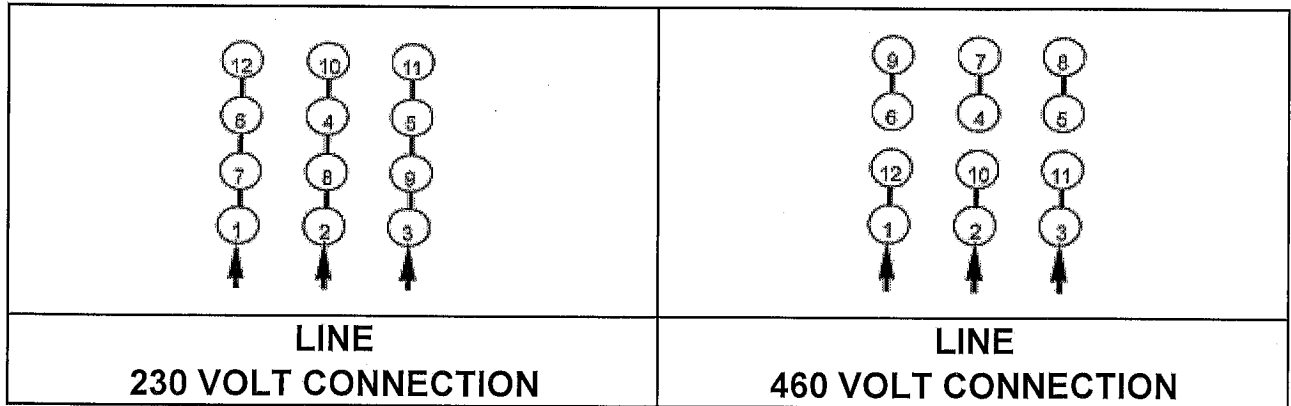
CONNECTION DIAGRAM

CATALOG NO.:
EP0254

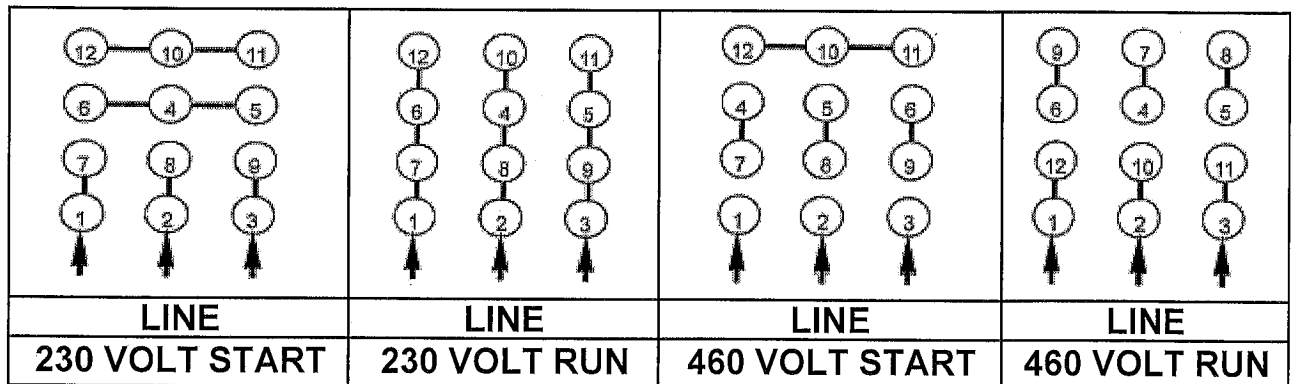


SCHEMATIC - Δ / Y CONNECTION

ACROSS THE LINE CONNECTION



WYE START-DELTA RUN CONNECTION



TECO **Westinghouse**

DWG NO.
DAC-1565-4

TECO   **Westinghouse**

OPERATION

&

MAINTENANCE

MANUAL

FOR

THREE PHASE

INDUCTION

MOTORS

TECO-Westinghouse Motor Company
5100 North IH-35
Round Rock, Tx. 78681

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1. INTRODUCTION

This and the following instruction address the more common situations encountered in motor installation, operation and maintenance. For the TWMC motor warranty to be and to remain in effect, the motor must be installed and operated in strict accordance with the outline drawing, motor nameplates and these instructions and must not be altered or modified in any unauthorized manner.

During the installation and operation of motors in heavy industrial applications there is a danger of live electrical parts and rotating parts. Therefore to prevent injury and/or damage the basic planning work for installation, transportation, assembly, operation, etc... needs to be done and checked by authorized and competent personnel only.

Since these instructions cannot cover every eventuality of installation, operation and maintenance, the following points should be considered and checked.

- The technical data and information on permissible use such as assembly, connection, ambient and operating conditions given in the related catalogue, operating instructions, nameplates and other production documentation.
- The general erection and safety regulations.
- The local and plant-specific specifications and requirements.
- The proper use of transport, lifting devices and tools.
- The use of personal protective equipment.

Following indications should be observed when reading these instructions.

Safety instructions are marked as follows:



Warning of electric hazards for personnel.



Warning of dangers for personnel.

ATTENTION! Warning of damage for the motor or installation.

2. ACCEPTING, INSPECTION, STORAGE, TRANSPORTATION

Inspection upon receipt

Check to following points upon receipt:

- Are the nameplate ratings identical with what you ordered?
- Are dimensions and color in compliance with your specifications?
- Are the nameplate ratings for space heater, thermal protector, temperature detector, etc. identical with what you ordered?
- Is there any damage?
- Are all accessories and accompanying instruction manuals in good order?
- Please ensure that the arrow head indicator really indicates direction of rotation.
- If there are any specific requirements, please ensure they are in conformity with your specifications.

2.1 Storage

When motors are not in operation, the following precautionary measures should be undertaken to assure best performance.

2.2 Place

- (a) High and dry, well ventilated without direct sun, dust or corrosive gas.
- (b) Not located near to a boiler or freezer.
- (c) Entirely free from vibration and easy for movements.
- (d) Motors should be put on pallets to prevent moisture.

2.3 Moisture prevention

Since moisture can be very detrimental to electrical components, the motor temperature should be maintained about 3°C above the dew point temperature by providing either external or internal heat. If the motor is equipped with space heaters, they should be energized at the voltage shown by the space heater nameplate attached to the motor. Incandescent light bulbs can be placed within the motor to provide heat. However, if used, they must not be allowed to come in contact with any parts of the motor because of the concentrated hot spot that could result.

2.4

Even during storage, the insulation resistance should be kept above the specified values.

- (a) For measurement of insulation resistance and acceptable standard values, please refer to measures stated in 3.1.2 "Measurement of insulation resistance".
- (b) Insulation resistance test should be performed once every three months.

2.5

If the motor is not in operation for a long period (one week and above) after installation or has been in operation but stopped for a period of time, the following precautions must be taken.

- (a) Protect the motor as measures stated in 2.2.3.
- (b) Insulation resistance test should be performed as stated in 2.2.4.

2.6 Bearing protection

- (a) If the motor has been provided with a shaft shipping brace to prevent shaft movement during transit, it must be removed before operating the motor. It is very important that this brace be re-installed exactly as it was originally, before the motor is moved from storage or any time when the motor is being transported. This prevents axial rotor movement that might damage the bearings.
- (b) Motors equipped with sleeve bearings are shipped from the factory with the bearing oil reservoirs drained. In storage, the oil reservoirs should be properly filled to the center of the oil level gauge with a good grade of rust inhibiting oil. To keep the bearing journals well oiled and to prevent rusting, the motor shaft should be rotated several revolutions about every month ensuring the shaft does not come to rest in its original position. While the shaft is rotating, it should be pushed to both extremes of the endplay.
- (c) Motors with anti-friction bearings are properly lubricated with the correct grade of grease at the factory and no further greasing is required in storage. The shaft should be rotated several revolutions about every month to maintain proper distribution of the grease within the bearings.
- (d) Tilt-pad bearings are a type of sleeve bearing used in special design applications. Due to the nature of this bearing, a loose oil ring for delivering lubricant cannot be provided. Therefore, during the storage interval, oil must be periodically manually introduced into the pads and housing to prevent the occurrence of oxidation of the precision machined components.
 - (1) Remove the pipe plug from the bearing cap located above the tilt-bearing shell.
 - (2) Pour in approximately one cup of oil every month and rotate the shaft a few revolutions about every two (2) weeks.
 - (3) For long periods of storage, the oil that accumulates in the housing should be removed.

ATTENTION!

Care should be taken to keep parts such as fitting surfaces, key, shaft extension and axial central hole from any collision with foreign matter. Grease should also be generously applied to prevent rusting.

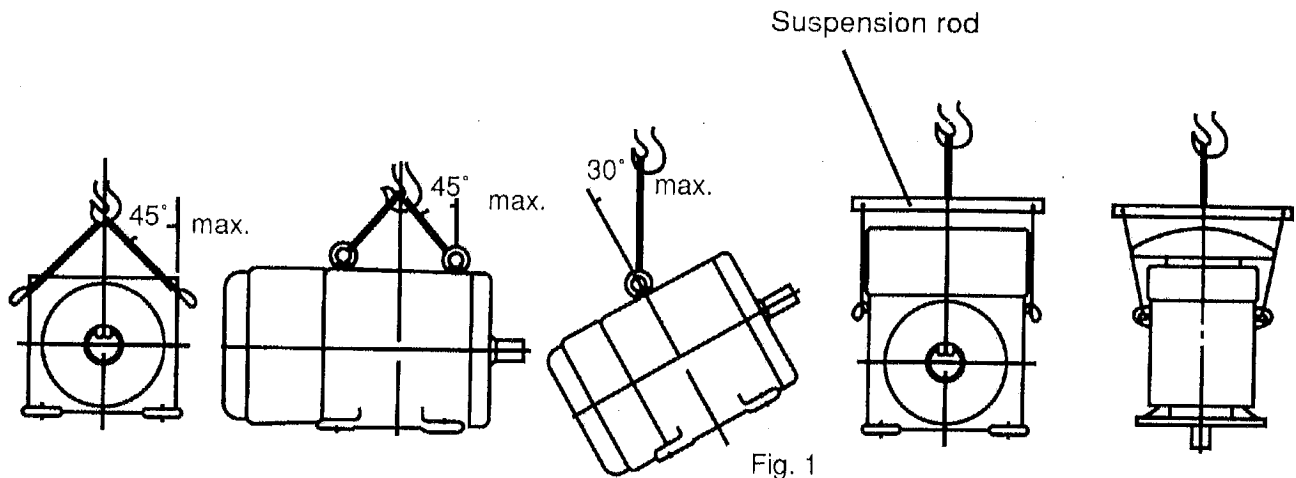
2.7 Transportation

To keep the rotating parts of motors from moving, thus preventing damage and scratching during transportation, they should be held securely with a locking device. Remove all transit clamps before operating the motor. It is very important that this device be reinstalled exactly as it was originally, before the motor is moved from storage or any time when the motor is being transported. The vertical mounting type motors should be transported in the vertical position.



Do not use the hoisting hook/eyebolts to lift more than the motor itself. They are designed to support the motor only. Make sure the hoisting hook is correctly attached to the eyebolt(s)/lug(s) are fully screwed in before hoisting. Also note such parts as fan cover, ventilation box, bracket, slip-ring, etc. may have their own hoisting lugs which can only carry their own weight. Nothing extra should be attached while hoisting.

Do not twist the steel wires and make sure the eyebolts have been firmly screwed and the sling angle is correct.



3 INSTALLATION

Site and environment for motor installation

3.1.1

Standard environment and site conditions for the installation of motors are usually set as follows:

- (a) Ambient temperature: $-10\sim 40^{\circ}\text{C}$
- (b) Humidity: Relative humidity below 90%RH for totally enclosed types, and below 80%RH for semi-enclosed types.
- (c) Elevation: below 1000 meters or 3300 feet.
- (d) Harmful gases, liquids, dusts, high moisture should be absent.
- (e) Foundations should be strong and free of vibration.

If there are any special environmental conditions, please inform TWMC prior to ordering.

3.1.2 Ventilation and space

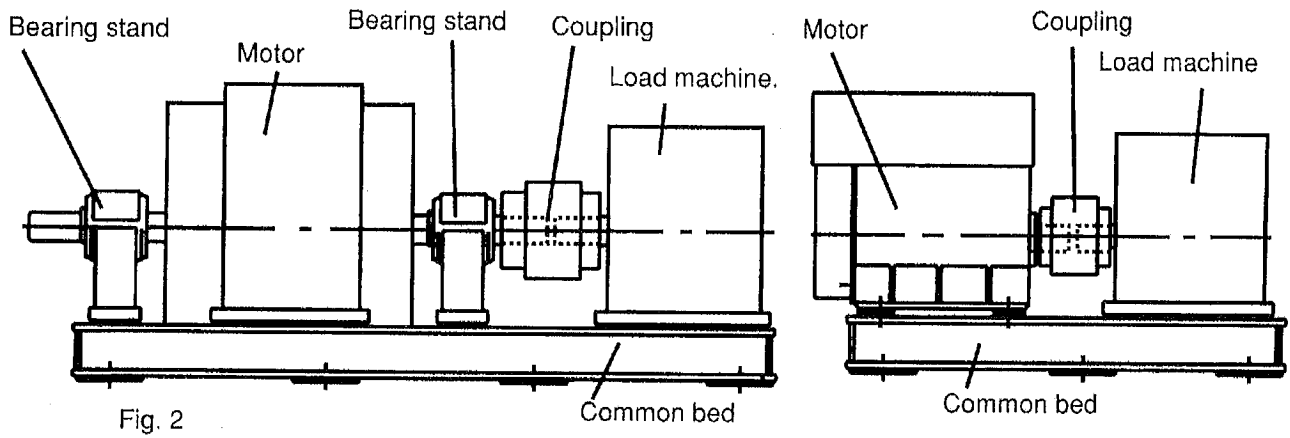
- (a) Installation area should be well ventilated.
- (b) The installation space should be large enough to facilitate heat dissipation and maintenance.

3.2 Foundation

3.2.1

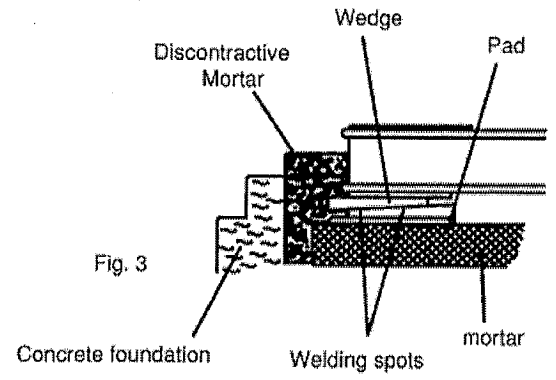
Use rigid and solid sole plate or common bed as foundation.

For best motor performance, it is advisable to use a sole plate or common bed, particularly when using a shaft coupling.



3.2.2 Installation

- (a) Select an appropriate foundation surface for the sole plate or common bed, which will be, considered the ultimate level.
- (b) Align the position of the common bed with reference to that level.
- (c) Align the level accuracy at least at four points such as bearing mounting, shaft extension etc. The accuracy should be within 0.04mm or .0015 inches
- (d) Sole plate or common bed should be embedded in concrete foundation as illustrated in Fig. 3. Stiff pads should also be installed beneath the wedges, which are welded together at various spots about 400-500mm (15.75-19.70 inches) apart etc., to enable the foundation to carry evenly the weight of the whole motor.
- (e) The base should be sturdy and rigid to keep it flat and level.
- (f) Make sure the mortar and concrete are completely dry, and the precision of the level is acceptable, and then set the motor on the mounting foundation.
- (g) Accurately install shaft couplings, belt sheaves etc., then weld the wedges solid to prevent untoward change in position.



3.2.3 The foundation of vertical induction motors: (Also the foundation of pump)

- (a) Foundation of motor/pump must be rigid and secure to provide adequate support. There must be no vibration, twisting, misalignment etc. due to inadequate foundations.
- (b) A massive concrete foundation is preferred in order to minimize vibration. Rigidity and stability are enhanced by prop plate and foundation bolt. As shown in Fig. 4.

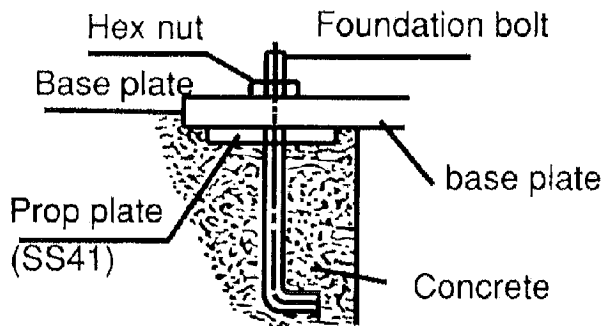


Fig. 4

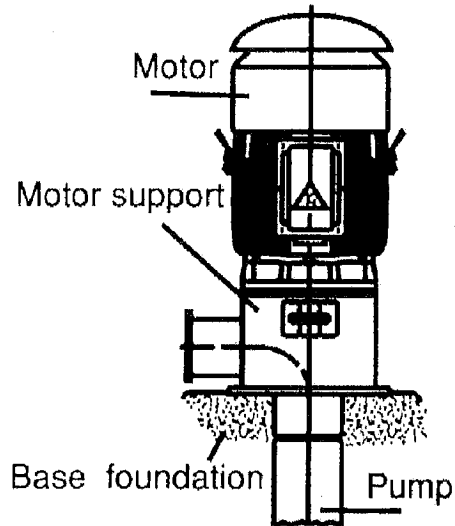


Fig. 5

3.2.4 Installation of vertical motors:

- (a) All mounting surfaces must be clean and level.
- (b) Foundation must be leveled at least at 4 points and guaranteed to be below 0.04mm (.0015 in.) flat and level.
- (c) Make sure the mortar and concrete are completely dry, and the precision of the level is acceptable, and then set the motor on the mounting foundation.
- (d) Accurately install shaft couplings.

3.3 Installation of shaft coupling

ATTENTION!

Motors must always be accurately aligned, and this applies especially where they are directly coupled. Incorrect alignment can lead to bearing failure, vibration and even shaft fracture. As soon as bearing failure or vibration is detected, the alignment should be checked.

3.3.1

Field application of a coupling to the motor shaft should follow the procedures recommended by the coupling manufacturer. The motor shaft extension must not be subjected to either extreme heat or cold during coupling installation.

ATTENTION!

Basically, the coupling should be heated and pushed onto the shaft extension with slight axial force. Do not hammer coupling to prevent bearing damage.

3.3.2

Although the sleeve bearings are equipped with thrust faces, these are intended only to provide momentary axial restraint of rotor movement either during start-up or when operating the motor disconnected from the driven equipment. They must not be operated under a constant thrust load unless they were originally designed for this condition.

Motors with either sleeve or anti-friction bearings are suitable for connection to the driven load through a flexible coupling. Coupling solidly to the load is not acceptable. With sleeve bearings, the flexible coupling should be of the limited end float type to prevent the possibility of any end thrust from load being transmitted to the motor bearings, which could cause bearing damage. The recommended limits of end float are as follows:

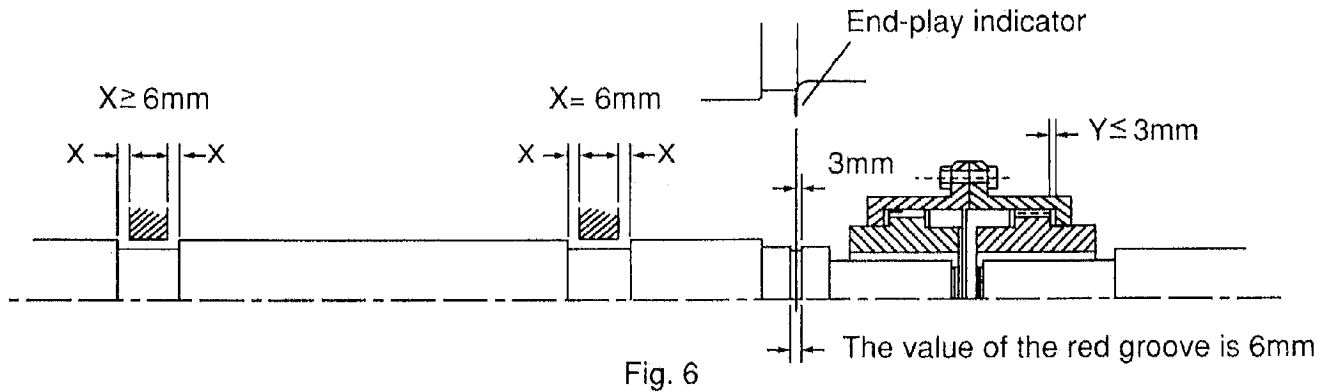


Fig. 6

- When the motor is in operation after installation, be sure that the end-play indicator is within the 6mm (.236 in.) of the groove on the shaft or aligned to the shaft shoulder immediately outboard of the drive-end bearing to assure there is low friction between shaft and bearing.
- Unless otherwise specified, the designed end-play value X of the groove for TWMC motors in general is within 6mm (.236 in.) as illustrated in Fig. 6. In essence, the endplay indicator is adjusted to point at the center of the groove or the drive-end shaft shoulder; thus X equals to 6 ± 1 mm or so, and the endplay value (Y) of the couplings should equal or be smaller than 3mm (.118 in.).
- If the desired value Y is greater than 3mm (.118 in.) caused for instance by a thrust load and/or load machine with large end-play, please inform TWMC prior to entering an order.

3.3.3

In aligning the motor (and rotor) axially with the driven equipment, consideration should be given not only to the endplay indicator position but also to axial shaft expansion and increase in shaft centerline height due to thermal effects. In general, the axial shaft growth for motors can be disregarded since neither bearing is fixed and any shaft growth due to temperature increase will produce an elongation away from the coupling.

Shaft height growth (change in shaft centerline elevation) for TEFC machines can be calculated as follows:

$$\Delta = (0.0005") \times (\text{motor foot to shaft } \text{L dimension})$$

For non-TEFC machines, divide the number by 2.

3.3.4

It is desirable, in normal operation that the motor operates on its magnetic center, so that no axial force is exerted on the coupling.

The motor shaft and the driven shaft should be aligned within the following tolerances in both angular and parallel alignment:

Unit: mm

TIR	Range of rotating speed	Solid coupling	Flexible coupling
C	2500 rpm and above	0.03	0.03
	Below 2500 rpm	0.04	0.05
A	2500 rpm and above	0.03	0.03
	Below 2500 rpm	0.03	0.04

Angular misalignment is the amount by which the centerlines of driver and driven shafts are skewed. It can be measured using a dial indicator set up as shown in Fig. 7. The couplings are rotated together through 360 degrees so that the indicator does not measure runout of the coupling hub face. The shafts should be forced against either the in or out extreme of their end float while being rotated.

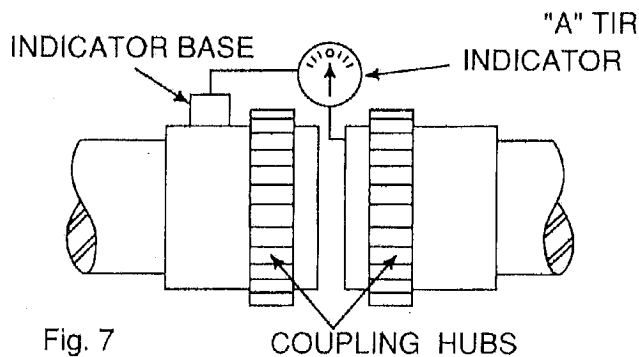


Fig. 7
TIR=Total indicator reading (by dial indicator)

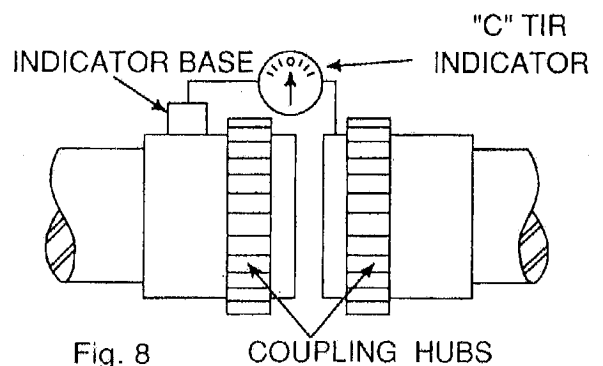


Fig. 8

Parallel misalignment is the amount by which the centerlines of the driver and driven shafts are out of parallel. It can be measured using a dial indicator set up as shown in Fig. 8. Again, the couplings are rotated together through 360 degrees so that the indicator does not measure runout of the coupling hub outside diameter.

3.3.5

After the motor has been properly aligned with the driven equipment and the hold-down bolts have been installed and tightened, for motors with fabricated frames, at least two dowel pins should be installed in two diagonally opposite motor feet.

3.3.6 Installation of shaft coupling: (Vertical hollow shaft motor only)

Bolted Coupling as shown in Fig. 9

- (a) Bearings are provided to absorb some upward shaft thrust when the coupling is fitted.
- (b) The coupling is fastened with bolts.
- (c) This coupling type is not auto-release type.

Note: Standard high thrust motors can absorb momentary up-thrust load up to 30% of the standard down thrust load. If the up-thrust is long in duration (over 10 Seconds) and/or exceeds 30% of the standard high thrust rating, special design arrangements are required and standard motor is not suitable.

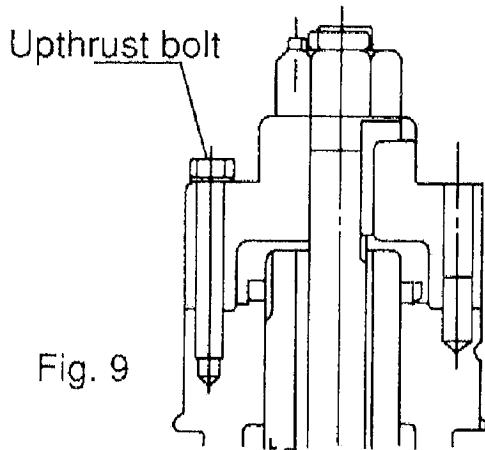


Fig. 9

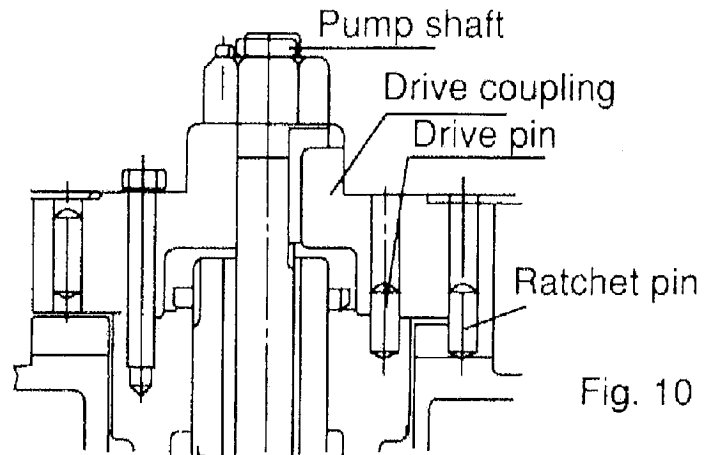


Fig. 10

3.3.7 Non-reverse ratchet/coupling, as Fig. 10 (If necessary)

The non-reverse coupling is also a bolted type and,

- (a) It prevents the pump and motor from rotating in the reverse direction.
- (b) It also prevents damage from over speeding and damage to pump shaft and bearings.
- (c) The ratchet pins are lifted by the ratchet teeth and are held clear by centrifugal force and friction as the motor comes up to speed.
- (d) When power is removed, speed decreases, and the pins fall. At the instant of reversal, a pin will catch in a ratchet tooth and prevent backward rotation.
- (e) When installing the non-reverse coupling, do not use lubricant. Lubricant will interfere with proper operation. The top half of the coupling should seat solidly on the lower half and the pins should touch the bottom of the pockets between the teeth in the plate.
- (f) As with the bolted coupling, the up-thrust capabilities are 30% of the standard high thrust rating for down thrust.

ATTENTION!

Do not apply non-reverse ratchets on applications in which the pump reversal time from shutdown (the instant the stop button is pressed) to zero speed is less than one second.

3.4 Installation for belt drive

In general, power transmission through direct flexible coupling is appropriate for large motors. Such motors are not suitable for belt, chain or gear connection unless specially designed for such service. However, for small and medium motors of which outputs within the ranges shown on table below, it is acceptable to use belt transmission as indicated. Beyond these ranges, do not apply belt sheaves unless specially designed.

3.4.1

The diameter ratio between conveyance sheaves should not be greater than 5 to 1 for flat belts, and 8 to 1 for V-belts. It is also advisable to limit the belt velocity to under 35m/sec (115 ft/sec) to limit belt abrasion and vibration. The smaller the outer diameter of the V-belt sheave, the greater the shaft bending stress will be. If the bending stress is in excess of the shaft fatigue stress, the shaft may break. Therefore, please inform TWMC when you have decided the size of the sheaves and the length of the belts upon ordering.

ATTENTION!

Place the sheave and belt as close as possible to the motor body (it is advisable to make x as shown in Fig. 11 equal to 0) to reduce the bending moment and improve shaft life.

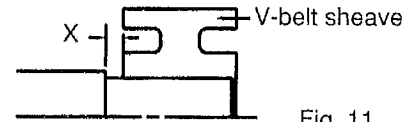


Fig. 11

3.4.2 Table of belt-sheave application for general electric motors

Output (KW/HP)			V-Belt Sheave							
4P	6P	8P	Conventional V-Belts				Narrow V-Belts			
			V-Belt Type	Number Of Belts	Min. PCD (mm)	Max Width (mm)	V-Belt Type	Number Of Belts	Min. PCD (mm)	Max Width (mm)
11/15	-	-	B	4	160	82	3V	4	125	48
-	11/15	-	B	5	170	101	3V	5	140	59
-	-	11/15	B	5	190	101	3V	6	160	69
15/20	-	-	B	5	170	101	3V	6	125	69
-	15/20	-	B	5	224	101	3V	6	160	69
-	-	15/20	C	4	224	111	5V	3	180	60
18.5/25	-	-	B	5	200	101	3V	6	140	69
-	18.5/25	-	C	4	224	111	5V	3	180	60
-	-	18.5/25	C	5	224	136	5V	4	180	78
22/30	-	-	B	5	224	101	5V	6	160	69
-	22/30	-	C	5	224	136	3V	4	180	78
-	-	22/30	C	5	250	136	5V	4	200	78
30/40	-	-	C	5	224	136	5V	4	180	78
-	30/40	-	C	5	265	136	5V	4	224	78
-	-	30/40	C	6	265	162	5V	5	224	95
37/50	-	-	C	6	224	162	5V	4	200	78
-	37/50	-	C	6	265	162	5V	4	224	78
-	-	37/50	C	7	280	187	5V	5	250	95
45/60	-	-	C	6	265	162	5V	4	224	78
-	45/60	-	C	7	280	187	5V	5	224	95
-	-	45/60	C	7	315	187	5V	6	250	113
55/75	-	-	C	7	265	187	5V	5	224	95
-	55/75	-	C	8	300	213	5V	6	250	113
-	-	55/75	D	5	355	196	5V	6	280	113
75/100	-	-	C	8	315	213	5V	6	250	113
-	75/100	-	D	6	355	233	5V	6	315	113
-	-	75/100	D	6	400	233	5V	6	355	113
-	90/120	-	D	6	400	233	5V	6	355	113
-	-	90/120	D	6	425	233	8V	4	355	124
-	110/150	-	D	7	400	270	8V	4	355	124
-	132/175	110/150	D	7	450	270	8V	4	400	124
-	160/200	132/175	D	9	450	344	8V	4	450	124

3.5 Conveyance with chain or gear**3.5.1**

Make sure the loading capacity of shaft and bearings is appropriate for the size and installation position (overhung) of chain and gear. If necessary, please contact us to ensure the shaft and bearings will meet your requirements.

3.5.2

Pay close attention to ensure the parallelism of shafts.

3.5.3

The teeth of couplings should be correctly and precisely matched; the force conveyance centers should lie on the same line.

3.5.4

There should be no skip, jumping, vibration or unusual noises.

ATTENTION!

Do not hammer the conveyance devices such as couplings, belt sheaves, chain wheels, gears etc. onto the shaft. Those shaft fitments should be fitted and removed only by means of suitable devices. Heat shrinking may be a better alternative to avoid damaging bearings and components.



The exposed rotating parts should be covered to prevent accidents.

3.6 Electrical connections

All interconnecting wiring for controls and grounding should be in strict accordance with local requirements such as the USA National Electrical Code and UK IEE wiring regulations. Wiring of motor and control, overload protection and grounding should follow the instructions of connection diagrams attached to the motor.

3.6.1 Power

The rated conditions of operation for the motor are as shown on the nameplate. Within the limits, given below, of voltage and frequency variation from the nameplate values, the motor will continue to operate but with performance characteristics that may differ from those at rated conditions:

±10% of rated voltage

±5% of rated frequency

±10% combined voltage and frequency variation so long as frequency variation is no more than ±5% of rated.

Operating the motor at voltages and frequencies outside of the above limits can result in both unsatisfactory motor performance and damage to or failure of the motor.

3.6.2

The main lead box furnished with the motor has been sized to provide adequate space for the make-up of the connections between the motor lead cables and the incoming power cables.



The bolted joints between the motor lead and the power cables must be made and insulated in a workman-like manner following the best trade practices.

3.6.3

Either fabricated motors or fan cooled cast frame, motors are all provided with grounding pads or bolts.



The motor must be grounded by proper connection to the electrical system ground.

3.6.4

The rotation direction of the motor will be as shown by either a nameplate on the motor or the outline drawing. The required phase rotation of the incoming power for this motor rotation may also be stated. If either is unknown, the correct sequence can be determined in the following manner: While the motor is uncoupled from the load, start the motor and observe the direction of rotation. Allow the motor to achieve full speed before disconnecting it from the power source. Refer to the operation section of these instructions for information concerning initial start-up. If resulting rotation is incorrect, it can be reversed by interchanging any two (2) incoming cables.

3.6.5 Auxiliary devices

Auxiliary devices such as resistance temperature detectors, thermocouples, thermoguards, etc., will generally terminate on terminal blocks located in the auxiliary terminal box on the motor. Other devices may terminate in their own enclosures elsewhere on the motor. Such information can be obtained by referring to the outline drawing. Information regarding terminal designation and the connection of auxiliary devices can be obtained from auxiliary drawings or attached nameplates.

If the motor is provided with internal space heaters, the incoming voltage supplied to them must be exactly as shown by either a nameplate on the motor or the outline drawing for proper heater operation.



Caution must be exercised anytime contact is made with the incoming space heater circuit as space heater voltage is often automatically applied when the motor is shutdown.

4. OPERATION

4.1 Examination before start

4.1.1

When motors are installed in good manner, ensure the wiring is according to the diagram. Also, the following points should be noted:

- (a) Make sure all wiring is correct.
- (b) Ensure the sizes of cable wires are appropriate and all connections are well made for the currents they will carry.
- (c) Ensure all connections are properly insulated for the voltage and temperature they will experience.
- (d) Ensure the capacity of fuses, switches, magnetic switches and thermo relays etc. are appropriate and the contactors are in good condition.
- (e) Make sure the frame and terminal box are grounded.
- (f) Make sure that the starting method is correct.
- (g) Make sure switches and starters are set at their right positions.
- (h) Motor heaters must be switched off when the motor is running.

4.1.2 Measurement of insulation resistance



During and immediately after measuring, the terminals must not be touched as they may carry residual dangerous voltages. Furthermore, if power cables are connected, make sure that the power supplies are clearly disconnected and there are no moving parts.

- (a) For rated voltage below 1000V, measured with a 500VDC megger.
- (b) For rated voltage above 1000V, measured with a 1000VDC megger.
- (c) In accordance with IEEE 43, clause 9.3, the following formula should be applied:

$$R \geq \left(\frac{\text{Rated voltage (v)}}{1000} + 1 \right) \times 10(\text{M}\Omega)$$

- (d) On a new winding, where the contaminant causing low insulation resistance is generally moisture, drying the winding through the proper application of heat will normally increase the insulation resistance to an acceptable level. The following are several accepted methods for applying heat to the winding:
 - (1) If the motor is equipped with space heaters, they can be energized to heat the winding.
 - (2) Direct current (as from a welder) can be passed through the winding. The total current should not exceed approximately 50% of rated full load current. If the motor has only three leads, two must be connected together to form one circuit through the winding. In this case, one phase will carry the fully applied current and each of the others, one-half each. If the motor has six leads (3 mains and 3 neutrals), the three phases should be connected into one series circuit.



Ensure there is adequate guarding so live parts cannot be touched.

- (3) Heated air can either be blown directly into the motor or into a temporary enclosure surrounding the motor. The source of heated air should preferably be electrical as opposed to fueled (such as kerosene) where a malfunction of the fuel burner could result in carbon entering the motor.

ATTENTION!

Caution must be exercised, when heating the motor with any source of heat other than self contained space heaters, to raise the winding temperature at a gradual rate to allow any entrapped moisture to vaporize and escape without rupturing the insulation. The entire heating cycle should extend over 15-20 hours.

Insulation resistance measurements can be made while the winding is being heated. However, they must be corrected to 40°C for evaluation since the actual insulation resistance will decrease with increasing temperature. As an approximation for a new winding, the insulation resistance will approximately halve for each 10°C increase in insulation temperature above the dew point temperature.

- (e) Should the resistance fail to attain the specified value even after drying, careful examination should be undertaken to eliminate all other possible causes, if any.

4.1.3 Power Source

- (a) Ensure the capacity of the power source is sufficient.
- (b) Ensure the supply voltage and frequency ratings are identical to those on the nameplate.
- (c) Voltage variation should be confined to within ±10% of the rated value and the phase to phase voltages should be balanced.

4.1.4 Bearing lubrication

- (a) For sleeve bearing motors, the oil reservoir must be filled with oil to the correct level. On self-lubricated bearings, the standstill oil level will be at the center of the oil gauge. The proper oil is a rust and oxidation inhibited, turbine grade oil. Refer to the lubrication nameplate for the recommended viscosity.
- (b) Motors, which are supplied with provision for flood lubrication, have an inlet orifice to meter the oil flow to the bearing. Refer to the outline drawing for these values. If the supply pressure does not match that stated on the outline, the orifice size must be adjusted to produce the specified flow rate. The drain adapter (also provided) has a weir plate fixed to the inside of the pipe to permit the establishment of the proper oil level. This weir plate must be located at the bottom of the pipe and must be parallel to the plane of the motor feet. To ensure optimum flow, the drain line should be vented to the atmosphere.

Oil inlet temperature: Normal below 50°C
 Alarm 60°C
 Trip 65°C

- (c) If the motor is in storage for over three (3) months, refilling of some new oil should be undertaken before operation to prevent bearing damage due to dry friction. The oil level should be kept at the center of the oil gauge. If necessary, drain some oil after refilling.
- (d) Motors that have been designed with anti-friction bearings for use with an oil mist lubrication system have been packed at the factory with a small amount of grease for short test runs. Continuous running should not be considered unless the oil mist system is installed and operating.
- (e) Grease lubricant type
 - (1) The bearings have been well greased at the factory before delivery. However, regreasing is required if a significant period has elapsed between manufacture and use or in storage
 - (2) All motors with ZZ bearings will have SHELL Alvania R3 (*Lithium base grease*). All motors with open bearings will have Polyrex EM (*polyurea base grease*).

4.1.5 Cooling water for the cooler on water-cooled motors

Make sure the quality, volume and inlet temperature of cooling water for the motors are normal before the machine is in operation.

Water: General tower water or industrial water.

Volume: Please see outline drawing

Inlet temperature: Normal below 30°C
 Alarm 35°C
 Trip 40°C

ATTENTION!

Make sure all locks, which fasten the movable parts of the motors during transportation, are dismantled and the shaft can rotate freely.

ATTENTION!

Ensure there is no foreign matter or tools inside the motors before starting motors.

4.1.6

Make sure the transmission system, including belts, screws, bolts, nuts and set pins are in good condition.



The keys fitted to the shaft extensions are held by plastic tape only to prevent them from falling out during transportation or handling. The shaft key shall be removed to avoid flying out, when the motor is operated prior to the couplings etc. being fitted to the shaft extension.

4.1.7

Make sure the items above are examined. Test the motor running with or without load. Record and check according to "Maintenance" at 15-minute intervals during the first three hours of operation. Then regular examinations should take place at longer intervals. If all goes well the motor can be classified as "in good order".

4.2 Starting operation

4.2.1 Starting load

Initially run the motor unloaded prior to coupling to other machines. Unless otherwise specified, a motor usually starts with light load, which is then gradually increased, proportional to the square of the speed and at last reaches 100% load at full load speed.

4.2.2 Starting

Too frequent starts can be harmful to the motors. The following restrictions should be observed:

- (a) Motor can be restarted should the initial start fail. Two starts are generally permissible when the motor is cold.
- (b) Motor can be started only once when it is at normal running temperature.
- (c) Should additional starts be necessary beyond the conditions stated above, the following restrictions should be noted:
 - (1) Let the motor cool down for 60 minutes before restarting, fully loaded.
 - (2) Let the motor cool down for 30 minutes before restarting, unloaded.
 - (3) Two inching starts can be regarded as one normal start.

ATTENTION!

If the motor rotor fails to start turning within one or two seconds, shut off the power supply immediately.

Investigate thoroughly and take corrective action before attempting a restart.

Possible reasons for not starting are:

- (1) Too low a voltage at the motor terminals.
- (2) The load is too much for the rotor to accelerate.
- (3) The load is frozen up mechanically.
- (4) All electrical connections have not been made.
- (5) Single-phase power has been applied.
- (6) Any combination of the above.

4.2.3 Rotating direction

- (a) Most TWMC motors are bi-directional. However, when some special types, such as high speed 2-Pole, certain large capacity motors, those with a non-reversing ratchet etc., should rotate in one direction, please ensure the rotation is in conformity with the directional arrow-mark shown on the attached nameplate.
- (b) To reverse a bi-directional motor, cut the power and wait until the motor stops. Then interchange any two of the three phases.

4.2.4 Power source, Voltage, Current

- (a) Ensure the voltage and frequency of the power source are identical to the ratings shown on the nameplate.
- (b) Voltage variation should be confined to within $\pm 10\%$ of the rating and the three phase voltages should be in full balance
- (c) Ensure the motor phase currents, when without load, are within $\pm 5\%$ of the average values.

4.2.5

Frequency variation should be confined to within $\pm 5\%$ of the rating. The aggregate variation of voltage and frequency should be confined to within $\pm 10\%$ of the absolute value of the ratings.

Starting time and unusual noises

ATTENTION!

Starting time is longer for the motors with large inertia. However, if starting time is longer than usual or if there is difficulty in starting, or there is abnormal noise, do not run the motor and refer to TWMC Service representative.

4.2.6 Sleeve bearing oil rings (sleeve bearing types only)

As the oil ring is used to carry lubricant to sleeve bearings, frequently check to ensure the oil ring is in motion.

4.2.7 Bearing temperature rise

Following the initial start-up, the bearing temperatures should be closely monitored. The rate of rise in bearing temperature is more indicative of impending trouble than is the actual temperature.

ATTENTION!

If the rate of rise in temperature is excessive or if the motor exhibits excessive vibration or noise, it should be shut down immediately and a thorough investigation made as to the cause before it is operated again.

If the bearing temperature rise and motor operation appear to be normal, operation should continue until the bearing temperature stabilizes.

Recommended limits on bearing temperature are as follows:

Sleeve Bearings	Total measured temperature
• By permanently installed detector	90°C
• By temporary detector on top of the bearing sleeve near the oil ring	85°C

Anti-Friction Bearings

- By permanently installed detector
- By temporary detector measuring the outside of the bearing housing

Total measured temperature

100°C
95°C

ATTENTION! (For sleeve bearing)

- (1) It must be noted that when operating flood lubricated sleeve bearings without outside lubrication supplied, the bearing temperature must not be allowed to exceed 85°C total temperature
- (2) Under normal condition, for the self-lube bearing, the rate of temperature rise should be from 11 to 14°C for the first ten (10) minutes after starting up and approximately 22°C at thirty (30) minutes. The rate of bearing temperature rise is a function of the natural ventilation and operating conditions.
- (3) When the rate of bearing temperature rise is less than 1°C per half-hour, the bearing temperature is considered to be stabilized.
- (4) If the total bearing temperature exceeds 95°C, the motor should be shut down immediately.

Noise and Vibration

ATTENTION!

Any abnormal noise or vibration should be immediately investigated and corrected. Increased vibration can be indicative of a change in balance due to mechanical failure of a rotor part, a stator winding problem or a change in motor alignment.

5. MAINTENANCE

5.1 Major points in regular inspections and maintenance.



For safety, maintenance and repairs must only be carried out by properly trained personnel.



Some testing, such as insulation resistance, usually requires the motor to be stopped and isolated from power supply(ies).

Routine inspection and maintenance are usually performed by looking, listening, smelling and simple meters.



High temperature may arise under operating conditions on the motor surfaces, so that touching should be prevented or avoided. Keep away from moving and live parts. Unless deemed necessary, do not remove guards whilst assessing the motor.

Timely replacement of worn parts can assure longevity and prevent breakdown.

Routine inspection and regular inspection and maintenance are important in preventing breakdown and lengthening service life.

Owing to the varied time and circumstances, motors are used, it is difficult to set the items and periods for regular inspection and maintenance. However, as a guide it is recommended to be performed periodically according to factory maintenance program. Generally, the inspection scope determined by the following factors:

- (a) Ambient temperature.
- (b) Starting and stopping frequency.
- (c) Troublesome parts usually affecting motor functions.
- (d) Easily abraded parts.
- (e) The important position of motor in the operational system of a factory should be duly recognized. Therefore, its health and wellbeing should be fully protected especially when it is operating in severe conditions.

5.2 Motor windings:

- (a) Measurement of insulation resistance and standards to determine quality of insulation resistance, please refer to measures stated in 3.1.2 "Measurement of insulation resistance".
- (b) Inspection of coil-ends:
 - (1) Grease and dust accumulated on coils may cause insulation deterioration and poor cooling effect.
 - (2) Moisture must not accumulate. Keep coils warm when motor is not in use if moisture can be seen.
 - (3) Discoloring. This is mainly caused by overheating.
- (c) Ensure no untoward change of wedges from original position.
- (d) Ensure the binding at the coil end is in its normal position.

5.3 Clean the interior of the motor:

- (a) After a motor is in operation for some time, accumulation of dust, carbon powder and grease etc., on the inside is unavoidable, and may cause damage. Regular cleaning and examination is necessary to assure top performance.
- (b) Points to note during cleaning:
 - (1) If using compressed air or blower:
 - (a) Compressed air should be free of moisture.
 - (b) Maintain air pressure at 4 kg/cm², since high pressure can cause damage to coils.
 - (2) Vacuum
Vacuum cleaning can be used, both before and after other methods of cleaning, to remove loose dirt and debris. It is a very effective way to remove loose surface contamination from the winding without scattering. Vacuum cleaning tools should be non-metallic to avoid any damage to the winding insulation
 - (3) Wiping
Surface contamination on the winding can be removed by wiping using a soft, lint-free wiping material. If the contamination is oily, the wiping material can be moistened (not dripping wet) with a safety type petroleum solvent. In hazardous locations, a solvent such as inhibited methyl chloroform may be used, but must be used sparingly and immediately removed. While this solvent is non-flammable under ordinary conditions, it is toxic and proper health and safety precautions should be followed while using it.

ATTENTION!

Solvents of any type should never be used on windings provided with abrasion protection. Abrasion protection is a gray, rubber-like coating applied to the winding end-turns.



Adequate ventilation must always be provided in any area where solvents are being used to avoid the danger of fire, explosion or health hazards. In confined areas (such as pits) each operator should be provided with an airline respirator, a hose mask or a self-contained breathing apparatus. Operators should wear goggles, aprons and suitable gloves. Solvents and their vapors should never be exposed to open flames or sparks and should always be stored in approved safety containers.

- (4) Keep core ducts completely clean. The difference in temperature rise could be around 10°C before and after cleaning

5.4 Clean the exterior of the motor:

- (a) On open ventilated motors, screens and louvers over the inlet air openings should not be allowed to accumulate any build-up of dirt, lint, etc. that could restrict free air movement.

ATTENTION!

Screens and louvers should never be cleaned or disturbed while the motor is in operation because any dislodged dirt or debris can be drawn directly into the motor.

- (b) If the motor is equipped with air filters, they should be replaced (disposable type) or cleaned and reconditioned (permanent type) at a frequency that is dictated by conditions. It is better to replace or recondition filters too often than not often enough.
- (c) Totally enclosed air to air cooled and totally enclosed fan cooled motors require special cleaning considerations. The external fan must be cleaned thoroughly since any dirt build-up not removed can lead to unbalance and vibration. All of the tubes of the air-to-air heat exchanger should be cleaned using a suitable tube brush having synthetic fiber bristles (not wire of any type).

5.5 Maintenance of anti-friction bearings**5.5.1 Frequency of re-lubrication:**

The life of grease varies greatly as a result of types of model, revolution speed, temperature, operational conditions etc. It is, therefore, impossible to be precise about replenishment intervals. However, for normal direct coupling transmission, the periods shown as Table 1 may be used as a guide.

Remarks:

- (a) The periods shown in Table 1 should be halved where bearings are used for belt drive and/or in dirty or high ambient temperature or high humidity environments.
- (b) Please refer to the lubrication nameplate, if attached to the motor.
- (c) For bearing numbers outside the range of Table 1, please contact TWMC

- (d) If the periods referred to in Table 1 for drive-end bearing and opposite drive-end are different, for the convenience of maintenance operation, please take the shorter one the required grease replenishment period of these bearings.

5.5.1 Kinds of grease:

All motors with ZZ bearings will have SHELL Alvania R3 (lithium base grease). All motors with open bearings will have Polyrex EM (polyurea base grease).

Certain T-frame models will utilize special grease and will be noted on the lubrication nameplate. Please use identical grease or its equivalents when maintaining lubrication schedule.

ATTENTION!

Do not mix different kinds of grease.

Mixing grease with different type of thickeners may destroy its composition and physical properties. Even if the thickeners are of the same type, possible differences in the additive may cause detrimental effects.

5.5.2 Grease quantity

The amount of grease per replenishment depends on the type, size and construction of the bearings. The maximum amount of one replenishment for each bearing is shown in Table 2.

5.5.3 Re-greasing



If re-lubrication is to be performed when the motor is running, stay clear of rotating parts.

It is advisable to re-grease when the motor is running to allow the new grease to be evenly distributed inside the bearing.

Before re-greasing, the inlet fitting should be thoroughly cleaned to prevent any accumulated dirt from being carried into the bearing with the new grease. The outlet of grease drainage should be opened to allow the proper venting of old grease.

Use a grease gun to pump grease through grease nipple into the bearings. After re-greasing, operate the motor for 10-30 minutes to allow any excess grease to vent out.

TABLE 1.

Bearing Number	600 RPM	720 RPM	750 RPM	900 RPM	1000 RPM	1200 RPM	1500 RPM	1800 RPM	3000 RPM	3600 RPM
62XX 63XX 72XX 73XX	6210									
	12								2000 Hrs.	
	13									
	14								1000 Hrs.	
	15									
	16								720 Hrs.	
	17							2000 Hrs.		
	18			3000 Hrs.						
	20									
	22									
	24							1500 Hrs.		
	26									
	28					2000 Hrs.		1000 Hrs.		
	30									
	32							500 Hrs.		
	34					1500 Hrs.				
36										
38			2000 Hrs.		1000 Hrs.					

Bearing Number	600 RPM	720 RPM	750 RPM	900 RPM	1000 RPM	1200 RPM	1500 RPM	1800 RPM
NU2XX NU3XX	NU214							
	15						2000 Hrs.	
	16							
	17							
	18			3000 Hrs.				1500 Hrs.
	20							
	22						1000 Hrs.	
	24							
	26					2000 Hrs.		
	28							500 Hrs.
	30							
	32							
	34			2000 Hrs.		1000 Hrs.		
	36							
	38	2000 Hrs.						
	40							
44			1000 Hrs.					
48	1000 Hrs.							

Bearing Number	600 RPM	720 RPM	750 RPM	900 RPM	1000 RPM	1200 RPM	1500 RPM	1800 RPM
222XX 223XX	22220						300 Hrs.	
	22							
	24			1000 Hrs.		500 Hrs.		
	26							
	28							
	30					300 Hrs.		
	32			500 Hrs.				
	34							
	36							
	38	500 Hrs.						
	40			300 Hrs.				
44								
48	300 Hrs.							

TABLE 2.

Bearing No.	Amount of replenishment
6210	30 g
6212	40
6213	50
6214	50
6215	60
6216	60
6217	80
6218	80
6220	100
6222	120
6224	120
6226	140
6228	160
6230	180
6232	200
6234	250
6236	300
6238	350
6240	400
6244	450
6248	500

Bearing No.	Amount of replenishment
6310	40 g
6312	60
6313	80
6314	80
6315	100
6316	100
6317	120
6318	120
6320	160
6322	220
6324	270
6326	300
6328	400
6330	450
6332	500
6334	600
6336	700
6338	800
6340	900
6344	900
6348	900

*Fill new grease until it overflows and the old grease is entirely replaced.

5.5.4 Oil re-lubrication (For oil lubrication types only)

Maintain proper lubrication by checking the oil level periodically and adding oil when necessary. Because of the initial clearing action of the bearing and the expansion of the oil as it comes up to operating temperature, the oil level will be higher after the motor has been in operation for a while than it is with the motor at standstill.

Overfilling should be avoided not only because of the possibility that expansion may force the oil over the oil sleeve and on to the rotor, but also because too high an operating oil level prevents the bearing from clearing itself of excess oil. The resultant churning can cause extra loss, high temperatures, and oxidized oil. If, during operation, the oil level goes above the maximum shown on the sight gauge, drain enough oil to bring the level back within the recommended operating range. **Do not permit the operating level to fall below the minimum shown on the gauge.**

ATTENTION!

Should it ever become necessary to add excessive amount of make-up oil, investigate immediately for oil leaks.

Change the oil at regular intervals. The time between oil changes depends upon the severity of operating conditions and, hence, must be determined by the motor user. Two or three changes a year is typical, but special conditions, such as high ambient temperature, may require more frequent changes. Avoid operating the motor with oxidized oil.

Use only good grade, oxidation-corrosion-inhibited turbine oils produced by reputable oil companies.

The viscosity of the oil to be used depends upon the type and size of the bearings, its load and speed, the ambient temperature, and the amount and temperature of the cooling water (if used)). The lubrication nameplate or instructions with each motor specifies the viscosity range of oil suitable for average conditions. The usual oil viscosity range of oil suitable for average conditions. The usual oil viscosity recommendations are summarized in Table 3. Operation in ambient temperatures that are near or below freezing may require preheating the oil or the use of special oil. Whenever the motor is disassembled for general cleaning and reconditioning, the bearing housing may be washed out with a suitable cleaning solvent. Be sure that the oil-metering hole is clear, and then dry the housing thoroughly before re-assembly, and ensure all traces of cleaning solvent have been removed.

TABLE 3 Oil Viscosity**

Bearing function and location	Bearing Type	Oil Viscosity - SSU	
		@ 100°F	@ 200°F
Thrust Bearing	72XX, 73XX Angular contact ball And/or (62XX, 63XX)	150	45
	Spherical roller	300	53
	Plate (Kingsbury Type)	300	53

**Remark: When a lubrication nameplate attached to the motor, use lubrication oil it stipulates.

5.5.5 Cleaning and installation of bearings

- (a) Apply the proper amount of grease to the disassembled parts of the bearing after they have been thoroughly cleaned with high quality cleaning oil. Then protect them from contamination before and during assembly.
- (b) Bearing installation

ATTENTION!

Before installing the bearings, make sure that the shaft mounted parts inside the bearings are in place before installation.

Since the bearing is a high precision component, it is important to avoid ingression of dust and foreign matter, and hammering during cleaning and installation. Use extreme care and insure clean conditions during installation and assembly.

ATTENTION!

The best way for bearing installation is heat shrinking. Knocking and hammering during installation should be avoided absolutely.

The bearing should be heated in a bath of clean oil at a temperature of approximately 80°C. After warming, slide the bearings in place quickly and nimbly so that it has not shrunk before being fully in position. Grease the bearing after the temperature returns to normal, and then reassemble the motor.

5.6 Maintenance of sleeve bearings

5.6.1 Daily inspections

- (a) Ensure the volume and quality of lubrication oil are in compliance with specifications.

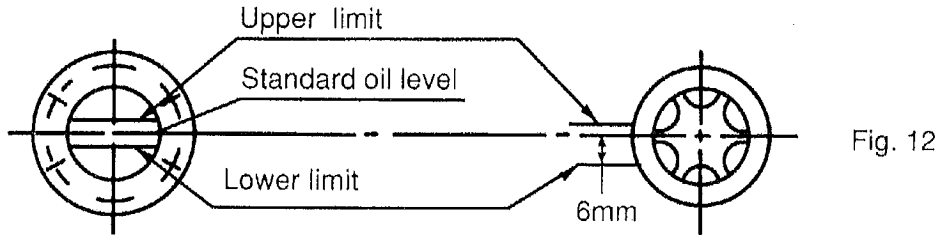


Fig. 12

- (b) Ensure there is motion of the oil ring and it is not clamped.
 (c) The indicator of the shaft endplay should be restricted within the specified range of the red groove of the shaft or the $\pm 3\text{mm}$ (.118 in.) range of the drive-end shaft shoulder, or the bearing may be damaged.

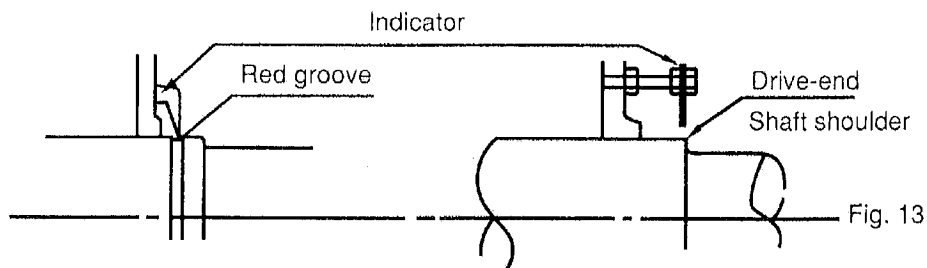


Fig. 13

5.6.2 Regular examination

- (a) Periodical change of oil

The oil reservoirs of self (not flood) lubricated bearings should be drained and refilled about every six (6) months. More frequent changes may be needed on high speed (3600 rpm) motors or if severe oil discoloration or contamination occurs. In conditions where contamination does occur, it may be advisable to flush the reservoir with kerosene to remove any sediment before new oil is added. Proper care must be taken to thoroughly drain the reservoir of the flushing material before refilling with the new oil.

Refill the reservoir to the center of oil sight glass with a rust and oxidation inhibited turbine grade oil. Refer to the outline and lubrication nameplate for the correct viscosity.

- (b) Quantity of lubrication oil

Please refer to the lubrication nameplate for oil quantity.

- (c) Oil viscosity

- (d)

ISO	Equivalents	Viscosity (SUS/100°F)
VG32	Esso Teresso 32	150
VG46	Esso Teresso 46	200
VG68	Esso Teresso 68	300

5.6.3 Disassembly



Prior to disassembling, ensure the power supplies are disconnected and there are no moving parts.

The bearing sleeve is of the spherically seated, self-aligning type. The opposite drive end bearing is normally insulated for larger motors (or when specified). On some motors, the insulation is bonded to the spherical seat of the bearing housing.

ATTENTION!

Extreme care must be exercised in removing the bearing sleeve from the insulated support to avoid damaging this insulation.

The following is the recommended procedure for removing the bearing sleeve:

- (a) Remove the oil drain plug in the housing bottom and drain the oil sump.
- (b) Remove all instrumentation sensors that are in contact with the bearing sleeve. These would include resistance temperature detectors, thermocouples, thermometers, etc..
- (c) Remove the socket head bolts holding the bearing cap and the inner air seal. The end cover plate must also be removed if the non-drive end bearing is being disassembled. Remove the bearing cap and top half of the inner air seal. Place them on a clean, dry surface to avoid damage to the parting surfaces.
- (d) Remove the top half of the bearing sleeve using suitable eyebolts in the tapped holes provided. Lift the bearing top straight up and avoid any contact with the shoulders of the shaft journals that might damage the thrust faces of the bearing. Place on a clean, dry surface taking care to prevent damage to either the parting surfaces or the locating pins that are captive in the top bearing half.
- (e) Remove the screws at the partings in the oil ring and dismantle the ring by gently tapping the dowel pin ends with a soft face mallet. Remove the ring halves and immediately reassemble them to avoid any mix up of parts or damage to the surfaces at the partings.
- (f) Pull up on the garter spring surrounding the floating labyrinth seal and carefully slip out the top half. Rotate the garter spring until the lock is visible. Twist counter-clockwise to disengage the lock, remove the garter spring then rotate the lower half of the seal out of the groove in the bearing housing. Note the condition of these floating labyrinth seals. If they are cracked or chipped, they must be replaced. Do not attempt to reuse a damaged seal.
- (g) To remove the bottom bearing half, the shaft must be raised a slight amount to relieve pressure on the bearing. On the drive end, this can be done by jacking or lifting on the shaft extension. Protect the shaft. On the non-drive, jacking or lifting can be done using bolts threaded into the tapped holes provided in the shaft end.

- (h) Roll the bottom bearing half to the top of the shaft journal and then lift it using suitable eyebolts threaded into the holes provided. Again avoid any contact with the shaft shoulders that could damage the bearing thrust faces. Place the lower bearing half on a clean, dry surface to protect the parting surfaces.



Use extreme care when rolling out the lower bearing half. Keep the hands and fingers well clear of any position where they might be caught by the bearing half if it were accidentally released and rotated back to its bottom position. Serious personal injury could result.

- (i) Protect the shaft journal by wrapping it with clean, heavy paper or cardboard.

5.6.4 Re-assembly

Bearing re-assembly is basically a reverse of the disassembly procedures outlined above, with the following suggestions:

- (a) The interior of the bearing housing should be cleaned and then flushed with clean oil or kerosene.
- (b) The bearing halves and the shaft journal should be wiped clean using lint-free cloth soaked with clean oil.
- (c) All parts should be carefully inspected for nicks, scratches, etc., in any contact surfaces. Such imperfections should be removed by an appropriate method such as stoning, scraping, filling, etc., followed by thorough cleaning.
- (d) Before installing the floating labyrinth seal halves, observe their condition. Do not attempt to use a cracked or chipped seal. The bottom half seal has a set of drilled holes in its side face. These must be placed at the bottom toward the inside of the bearing so that accumulating oil may drain back into the housing.
- (e) Put a bead of Curil-T around the seal half O.D.'s on both sides adjacent to the garter spring groove. This will prevent oil by-passing the seal around its outside.
- (f) Place the bottom seal half on top of the shaft and roll it into position. Install the top half and insert the garter spring pulling up on both ends to permit engaging the lock. Run a bead of Curil-T around the O.D.'s on both sides adjacent to the garter spring groove on this half also.
- (g) Carefully reassemble the two oil ring halves. Inspect the dowel pins for burrs and straightness and make any corrections required. Do not force the ring halves together. Excessive force may alter the roundness or flatness of the oil ring which can change its oil delivery performance.
- (h) Some of the pipe plugs in the housing are metric thread type. These are identified as those, which have a copper, lead, or similar material washer. If these plugs are removed,

be careful not to lose the washers. Before re-assembly, inspect the washers and replace them as required.

- (i) Before installing the bearing cap, observe the position of the floating labyrinth seal. The "tab" must be on top to engage the pocket. Failure to position the seal properly will result in damage when the cap is assembled.

ATTENTION!

- (1) Curil-T is the only approved compound for use in the assembly of the bearings on this motor. Other products may harden and impede the operation.
- (2) During the re-assembly of the bearing parts, a thin layer of Curil-T should be applied to all gaskets and machined interface surfaces. This suggestion does not apply to the machined surfaces of the bearing liner halves.
- (3) When seating the bearing shell, apply a thin layer of lube oil at the spherical surface of the liner. Slowly roll the lower bearing liner into the bearing housing making sure that the splined surface of the liner and the housing are flush. Gradually lower the shaft onto the bearing. The weight of the shaft will help rotate the bearing liner so that the babbitt surface of the liner will match the slope of the journal. Sometimes it is required to use a rubber mallet to tap lightly on the bearing housing while slowly rolling the shaft to help this seating operation.

5.7 Maintenance of slip ring (For Wound Rotor Motors only)



Ensure motor is disconnected from power supplies and there are no accessible moving parts before maintenance operation.

5.7.1 Adjustment of carbon brush

- (a) Brush pressure for normal operation:
 - Electro-graphite brush.....0.2~0.25 kg/cm²
When frequent vibrations are evident or the brush is small (area below 0.5 cm²), the pressure should be greater than as shown.
- (b) Adjustment of brush pressure:
The brush pressure should be adjusted to keep normal operation as it wears.
 - The brush pressure may be reduced after use, so it is necessary to re-adjust. For adjustment, please turn adjusting screw, pressure adjusting pin or pressure adjusting plate as shown in Fig. 14 to obtain the correct tension (=0.23 x brush cross sectional area in cm²) ±10% kg.
- (c) Brush pressure need not be adjusted if constant force spring is used as shown in Fig. 15 and Fig. 16.

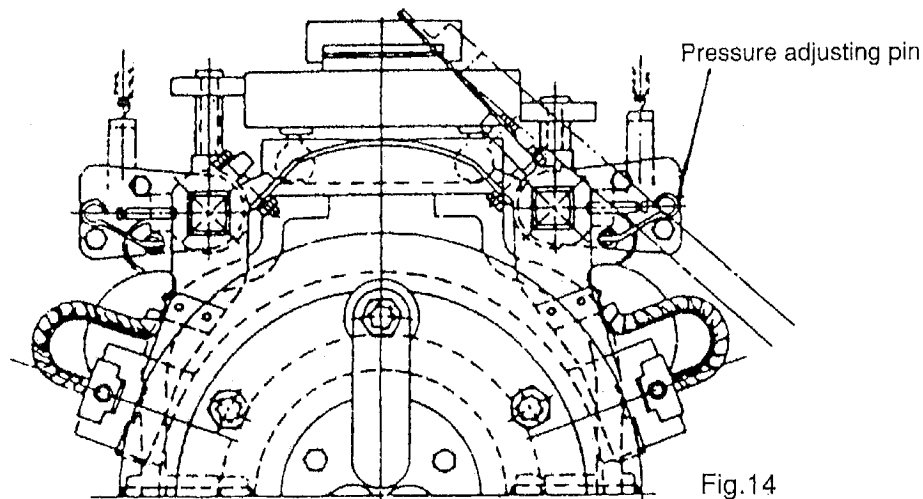


Fig.14

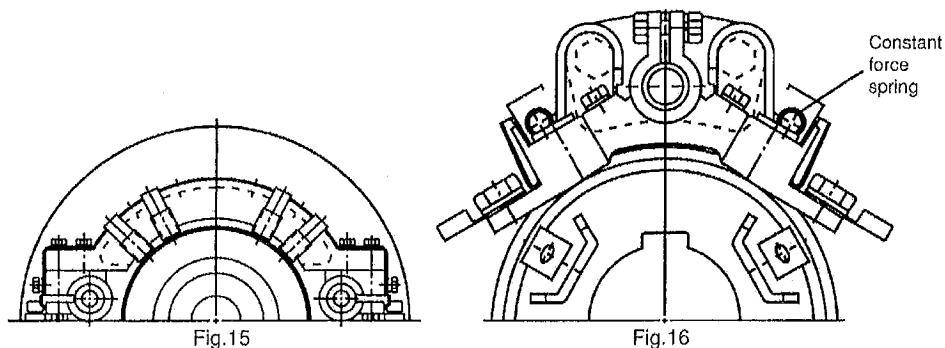


Fig.15

Fig.16

5.7.2 Brush replacement

The carbon brush is a part of the equipment which is easily worn away, replace it after it is worn to $\frac{1}{2} \sim \frac{3}{4}$ of original size.

(a) Brush material

The brush material is important to the performance of the motor. Only the most appropriate materials are chosen by TWMC, and are listed on the nameplate of the motor. It is important to know this when you replace the brush, so a recommended type is used.

(b) Dimensions

Brush, holder and gap between them, please refer to CNS 2322 C4051 or JIS C2802.

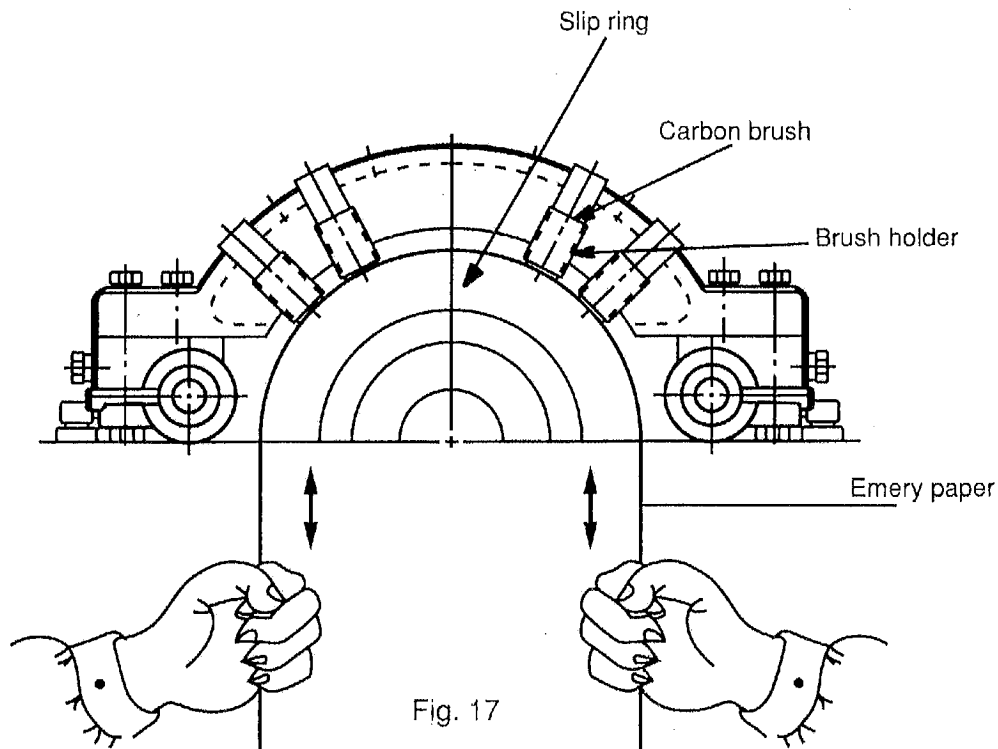
ATTENTION!

The gap between a brush and it holder is important for good performance and safety of the motor.

(c) Adjustment of new brushes (Shown in Fig. 17)

- (1) Polish the new brush with a file until it assumes the appropriate contour of the slip ring which it touches.

- (2) Place sand-paper (JIS R6252 No. 40...50) on the slip ring with the abrasive face of the paper against the brush to induce a closer contact by rubbing against each other.
- (3) Repeat item 2 with fine sand -paper (JIS R6252 No. 100 to 200) until the contact surface between brush and slip ring exceeds 80%.
- (4) Finally, clean the contaminated slip ring and brush with clean cloth or compressed air.



5.8 Maintenance of non-reverse ratchet mechanism (For Vertical high Thrust Motor only)

5.8.1

In the pump piping system, a check valve and a stop valve should be installed in the discharge line. The check valve, placed between the pump and the stop valve, is to protect the pump from reverse flow and excessive backpressure. The stop valve is used in priming, starting and when shutting down the pump. It is advisable to close the stop valve before stopping the pump. This is especially important when the pump is operated against a high static head.

TWMC vertical high thrust motors are equipped with non-reverse ratchet (N.R.R.) mechanism only when requested by the pump manufacturer. Typical construction of the N.R.R. mechanism is shown as Fig 18 below.

The N.R.R. mechanism keeps the pump and motor from rotating in the reverse direction. Thus prevents damage from over-speeding and damage to water-lubricated pump shaft bearings

when, on shutdown, the falling water column tends to drive the pump in the reverse direction. In normal operation, the ratchet pins are lifted by the ratchet teeth and are held clear by centrifugal force and friction as the motor comes up to speed. When power is removed, the speed decreases and the pins fall. At the instant of reversal, a pin will catch in a ratchet tooth and prevent backward rotation.

5.8.2

The service life of ratchet pins depends not only on the reverse shock load between the pin and ratchet tooth when pump stopped but also the frequency of pump starting and stopping while in service. Provided that the pins are deformed due to this reverse shock load, then the up and down motion of the ratchet pins could be sluggish or jammed and that unusual noises shall arise.

The recommended replacement period for these ratchet pins is every three (3) years. If the reverse shock load is greater than 30% of motor rated torque or the starting frequency is more than twice per day, then the replacement period should be halved.

ATTENTION!
The check valve and stop valve in the discharge line should be regularly inspected and maintained to assure the normal function of these valves. This is important to protect the pump and motor from damage and increase the service life of the N.R.R. mechanism.

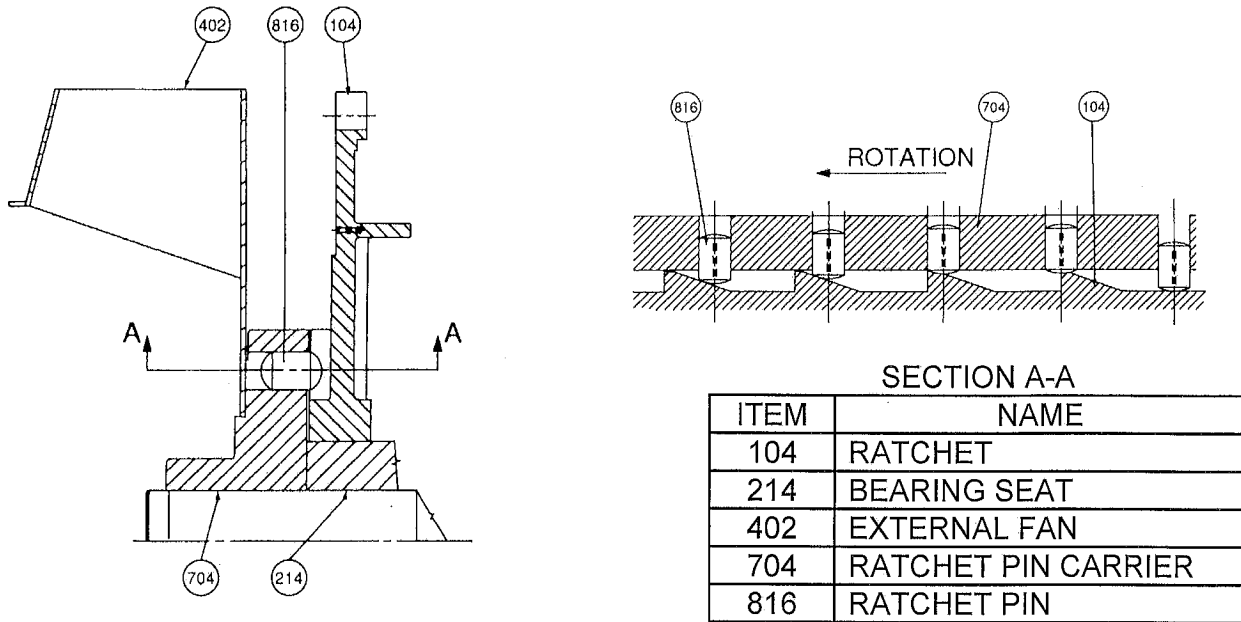


Fig. 18

6. FAULT FINDING AND RECOGNITION

Kinds of Breakdown	Symptoms	Possible Causes	Remedies
Fail to start without load	Motionless and soundless	Power-off	Consult power company
		Switch-off	Switch-on
		No fuse	Install fuse
		Broken wiring	Check wiring and repair
		Broken lead	Check wiring and repair
		Broken windings	Check windings and repair
	Fuse blowing. (Automatic switch trips off, slow start with electromagnetic noise)	Short circuit of circuit switches	Check circuit switches and replace
		Incorrect wiring	Check wiring according to nameplate
		Poor contact at terminal	Lock tightly
		Windings grounded	Factory repair
		Broken windings	Factory repair
		Poor contact of circuit switches	Check and repair
		Broken wiring	Check and repair
		Poor contact of starting switches	Check and repair
Short circuit of starting switches	Check and repair		
Incorrect connections of starting switches	Connect according to nameplate		
Loading after start	Fuse blowing. Fail to restart due to trip-off of automatic switch	Insufficient capacity of fuse	Replace fuse if wiring permits
		Overload	Lighten load
		High load at low voltage	Check circuit capacity and reduce load
	Overheating motor	Overload or intermittent overload	Lighten load
		Under-voltage	Check circuit capacity and power source
		Over-voltage	Check power source
		Ventilation duct clogged	Remove the foreign matter in the duct
		Ambient temperature exceeds 40°C	Correct insulation class to B or F, or lower ambient temperature
		Friction between rotor and stator	Factory repair
		Fuse blown (Single-phase rotating)	Install the specified fuse
		Poor contact of circuit switches	Check and repair
		Poor contact of circuit starting switches	Check and repair
		Unbalance three-phase voltage	Check circuit or consult power company

Kinds of Breakdown	Symptoms	Possible Causes	Remedies
Loading after start	Speed falls sharply	Voltage drop	Check circuit and powers source
		Sudden overload	Check machine
		Single-phase rotating	Check circuit and repair
	Switch overheat	Insufficient capacity of switch	Replace switch
		High load	Lighten load
	Bearing over-heating	High belt tension	Adjust belt tension
		Slack belt tension	Adjust belt tension
		Misalignment between motor and machine shafts	Re-align
Over speed of bearing outer-ring		Adjust bracket	
High bearing noise		Replace the damaged bearing	
Noise	Electromagnetic noise induced by electricity	Occurrence from its first operation	May be normal
		Sudden sharp noise and smoking	Short circuit of windings should be repaired at the factory
	Bearing noise	Noise of low shishi or Thru-Thru	May be normal
		Kala-Kala as a result of poor lubrication	Grease
		Kulo-Kulo as a result of poor lubrication	Clean bearing and grease
		Sa-Sa or larger noise	Replace the damaged bearing
	Mechanical noise caused by machinery	Loose belt sheave	Adjust key and lock the screw
		Loose coupling or skip	Adjust the position of couplings, lock key and screw
		Loose screw on fan cover	Lock fan cover screw tightly
		Fan rubbing	Adjust fan position
		Rubbing as a result of ingress of foreign matter	Clean motor interior and ventilation ducts
		Wind noise	Noise induced by air flowing through ventilation ducts
		Induced by conveyance machine	Repair machine
Vibration	Electromagnetic vibration	Short circuit of winding	Factory repair
		Open circuit of rotor	Factory repair
	Mechanical vibration	Unbalanced rotor	Factory repair
		Unbalanced fan	Factory repair
		Broken fan blade	Replace fan
		Unsymmetric centers between belt sheaves	Align central points
		Central points of couplings do not lie on the same level	Adjust the central points of couplings to the same level
		Improper mounting installation	Lock the mounting screws
		Motor mounting bed is not strong enough	Reinforce mounting bed
Remarks:			
(1) Circuit switches: These include knife switches, electromagnetic switches, fuse and other connection switches etc.			
(2) Starting switches: These include Delta-Star starters, compensate starters, reactance starters, resistor starters, starting controller's etc.			

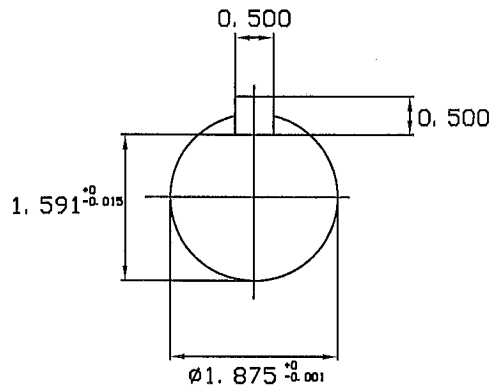
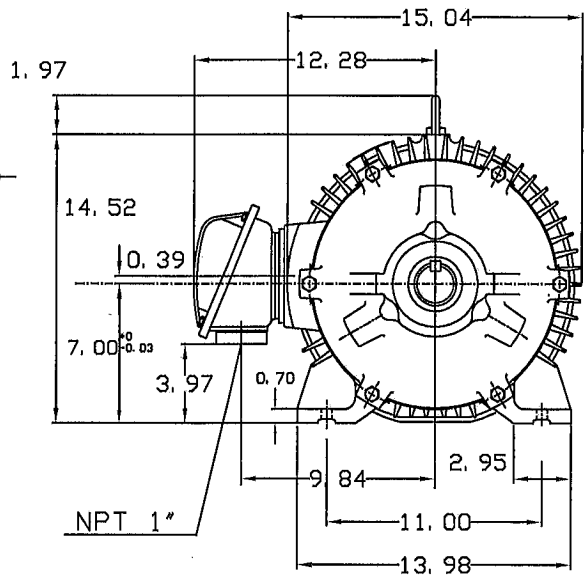
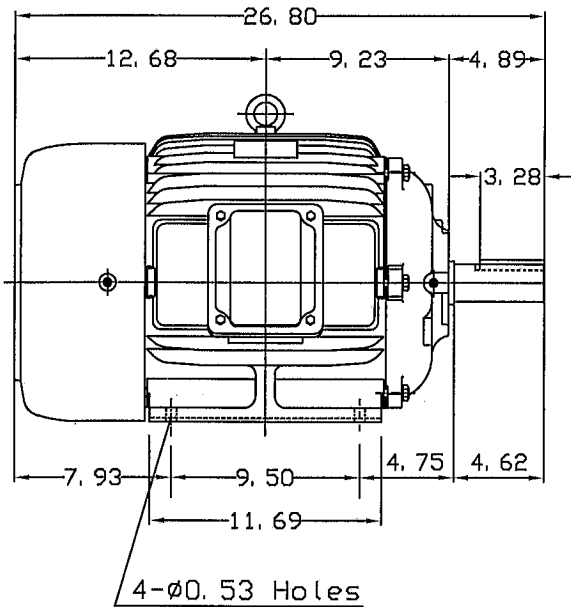
DATE
JUNE 21, 2005
CATALOG NO.
EPO254

OUTLINE DIMENSIONS
3-PHASE INDUCTION MOTOR

MOTOR TYPE:
AEHH8N
FRAME NO. 284T

Pole	HP	KW	Hz	VOLT	Syn. Speed RPM
4	25	18.5	60	230/460	1800
Ins	Rating	Dimension in	Approx Weight	Bearings	
F	CONT.	inches	429 lbs.	DE: 6311ZZ	NDE: 6310ZZ

Totally Enclosed Fan Cooled Type. Squirrel-cage Rotor.



DWN.	J. H. LIANG	11-30-98
CHKD.	C. H. KAD	12-26-98
APPD.	Y. B. HUANG	12-26-98

TECO Westinghouse

DWG NO.
31057H360000

TECO Westinghouse

ISSUED 5/5/2006	PERFORMANCE DATA 3-PHASE INDUCTION MOTOR	ENCLOSURE TEFC
TYPE AEHH8N		CATALOG# EP0254

NAMEPLATE INFORMATION

OUTPUT		POLE	FRAME SIZE	VOLTAGE	HZ	RATED AMBIENT	INS. CLASS	NEMA DESIGN	TIME RATING	SERVICE FACTOR
HP	KW									
25	18.7	4	284T	230/460	60	40°C	F	C	CONT.	1.15

VARIABLE FREQUENCY DRIVE SERVICE

VARIABLE TORQUE				OHMS/PHASE EQUIVALENT WYE CIRCUIT (AT RATED OPERATING TEMPERATURE 25°C)				
HZ	HP	RPM	TORQUE (lb-ft)	R1	R2	X1	X2	X _m
3~60	0.0032~25	90~1800	0.187~74.37	0.1408	0.271	0.8469	1.3283	43.804

CONSTANT TORQUE				CONSTANT HORSEPOWER			
HZ	HP	RPM	TORQUE (lb-ft)	HZ	HP	RPM	TORQUE (lb-ft)
6~60	2.5~25	180~1800	74.37	60~90	25	1800~2700	74.37~49.58

TYPICAL PERFORMANCE

FULL LOAD RPM	EFFICIENCY				POWER FACTOR			SOUND PRESSURE LEVEL @ 3 FT Db(A)
	FULL LOAD		3/4 LOAD %	1/2 LOAD %	FULL LOAD %	3/4 LOAD %	1/2 LOAD %	
	MIN.%	NOM.%						
1765	92.4	93.6	93.6	93.6	86	83	77	68

CURRENTS									NEMA KVA CODE LETTER	SAFE STALL TIME IN SECONDS	
NO LOAD			FULL LOAD			LOCKED ROTOR				COLD	HOT
AT 208 VOLT	AT 230 VOLT	AT 460 VOLT	AT 208 VOLT	AT 230 VOLT	AT 460 VOLT	AT 208 VOLT	AT 230 VOLT	AT 460 VOLT			
15.70	14.28	7.14	64.30	58.20	29.1	404.0	366.0	183	G	28	20

TORQUE				INERTIA			ACCEL TIME (DOL)		ALLOWABLE STARTS PER HOUR	
FULL LOAD (lb-ft)	LOCKED ROTOR %FLT	PULL UP %FLT	BREAK DOWN %FLT	ROTOR WR ² (lb-ft ²)	NEMA LOAD WK ² (lb-ft ²)	MAX ALLOWABLE WK ² (lb-ft ²)	NEMA LOAD WK ² Sec	MAX ALLOWABLE WK ² Sec	COLD	HOT
74.37	205	165	240	4.586	122	255	4.76	9.76	2	1

APPROVED:	M. PRATER	DRAWING NO.	31057EP0254	REVISION:	0
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Shock/Vibration Control Switches Installation Instructions

Models: VS2, VS2C, VS2N, VS2EX, VS2EXR, VS2EXRB and VS94

VS-7037N
Revised 06-96
Replaces VS-7037NS and VIB-95108N
Section 20
(00-02-0185)



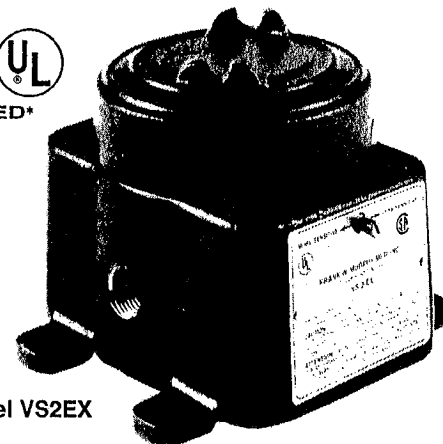
Please read the following instructions before installing. A visual inspection of this product for damage during shipping is recommended before mounting. It is your responsibility to have a qualified person install the unit, and make sure installation conforms with NEC and local codes.

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.

VS2N: Pneumatic signal—no electrical contacts.

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

* See *Specifications* section, on page 3, for listed models.

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

-H23: Space heater for 230 VAC

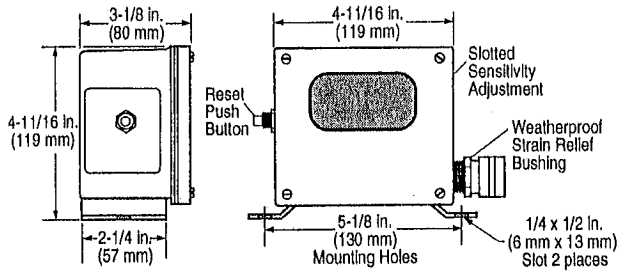
-H24: Space heater for 24 VDC

Warranty

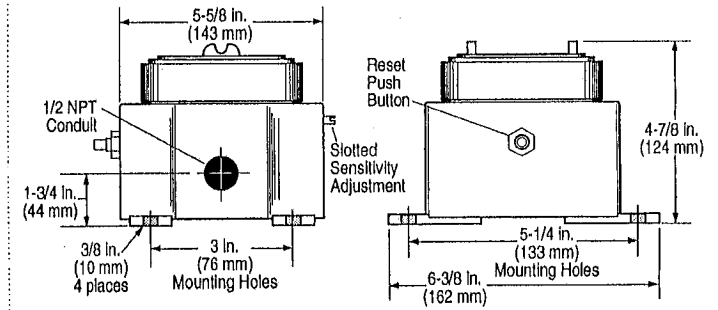
A two-year limited warranty on materials and workmanship is provided with this Murphy product. Details are available on request and are packed with each unit.

DIMENSIONS

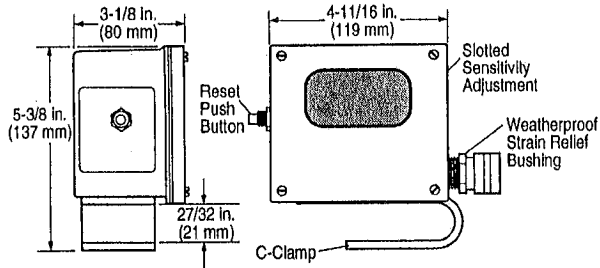
VS2



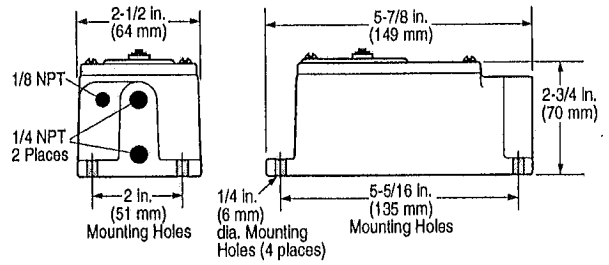
VS2EX and VS2EXR



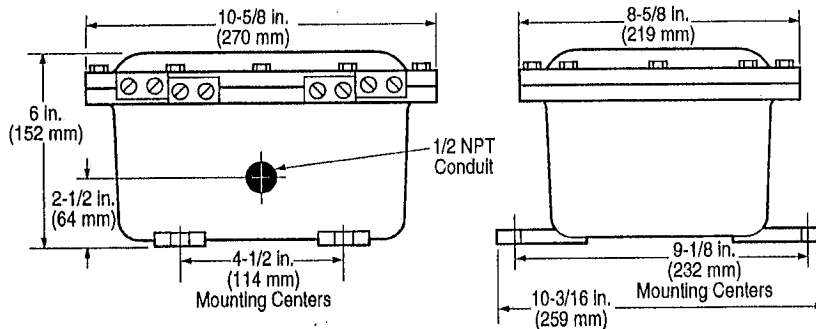
VS2C



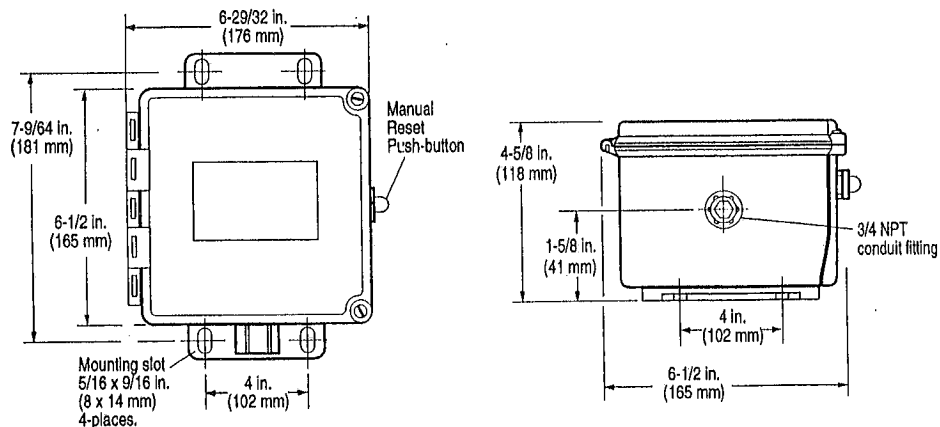
VS2N



VS2EXRB



VS94



SPECIFICATIONS

VS2 and VS2C

- **Case:** Weatherproof (equal to NEMA 3R) housing suitable for open mounting. Rated 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.

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.

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 :** 115 VAC or 24 VDC (specify).

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:** 115 VAC or 24 VDC (specify).

*CSA and UL listed with 480 VAC rating.

VS2N (Pneumatic Model)

- **Case:** Aluminum alloy housing.
- **Operating Pressure:** 20 to 80 psi (138 to 552 kPa) [1.38 to 5.52 bar]. 60 psi (414 kPa) [4.14 bar] recommended.

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):

Option	Operating Current
H15	.023 A @ 115 VAC
H23	.011 A @ 230 VAC
H24	.12 A @ 24 VDC

Remote Reset (optional):

Option	Operating Current
R15	.17 A @ 115 VAC
R24	.36 A @ 24 VDC

Time Delay (optional):

Option	Operating Current	Standby Current
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).

INSTALLATION

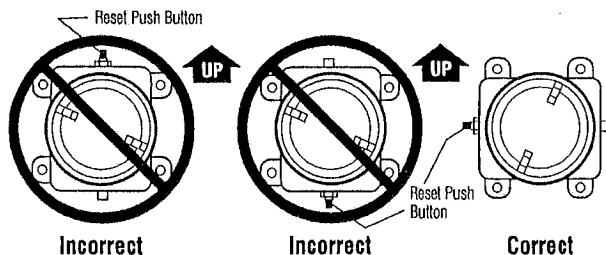


WARNING: STOP THE MACHINE AND DISCONNECT ALL ELECTRICAL POWER BEFORE BEGINNING INSTALLATION.

The VS2 and VS94 Series are sensitive to shock and vibration in all three planes of motion—up/down, front/back and side/side. Front/back is most sensitive. (See Dimensions on page 2 for sensitivity adjustment location.)



CAUTION: Mounting for all VS2 and VS94 Series shock and vibration switches must be with the reset push button on a horizontal plane. DO NOT MOUNT with reset push-button UP or DOWN.



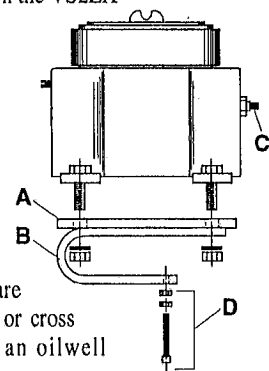
The VS2 and VS94 Series must be firmly attached/mounted to the machine so that all mounting surfaces are in rigid contact with the mounting surface of the machine. For best results, mount the instrument in-line with the direction of rotating shafts and near bearings, in other words, the reset push

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 and VS94 Series. Typically 1/2 in. (13 mm) thick plate is sufficient. See illustrations on page 5 for typical mounting locations.

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.

Electric 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 Installation* 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.

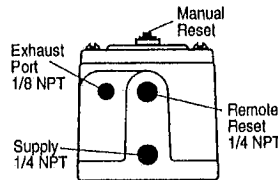
If conduit is not used for the entire length of wiring, conduit should be used from the electrical supply box to a height above ground level that prevents damage to the exposed cable from the elements, rodents, etc. or as otherwise required by applicable electrical codes. If conduit is not attached directly 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.

Pneumatic Models (VS2N)



WARNING: IF USED IN A HAZARDOUS AREA, EXPLOSIVE GASES MUST NOT BE VENTED INTO THE AREA.

1. Mount the VS2N according to the same instructions as the electric models. However, note that although the VS2N is sensitive to shock/vibration in all three planes of motion, its most sensitive plane is perpendicular to its base.
2. Attach a pressure source of 20-80 psi (138-552 kPa) [1.37-5.51 bar] to the "Supply" port. Best operation is obtained with 60 psi (414 kPa) [4.13 bar]. Pressure medium must be clean, dry air or gas. Use a filter and pressure regulator as necessary.
3. Connect an exhaust line to the "Exhaust" port and to the equipment shutdown device to be operated.



Sensitivity Adjustment

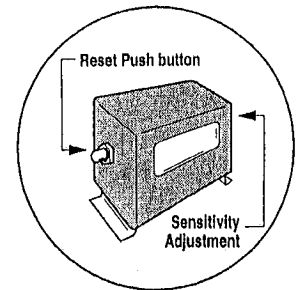


WARNING: REMOVE ALL POWER BEFORE OPENING THE ENCLOSURE. IT IS YOUR RESPONSIBILITY TO HAVE A QUALIFIED PERSON PERFORM ADJUSTMENTS, AND MAKE SURE IT CONFORMS WITH NEC AND LOCAL CODES. DO NOT ADJUST SENSITIVITY WHILE THE MACHINE IS RUNNING. STAND CLEAR OF THE MACHINE AT ALL TIMES WHEN IT IS OPERATING.

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, VS2N, 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, 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").

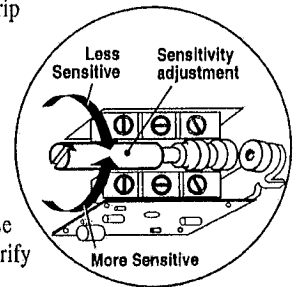
DETAIL "A"



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.

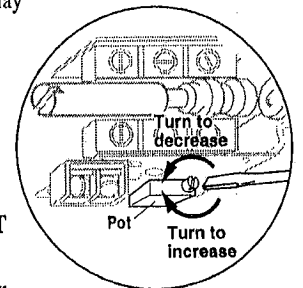
1. Apply power to the time delay circuit. (see page 7 for time delay circuit). The time delay function will be initiated.
2. Time the length of the delay with a watch. Let time delay expire. After it expires, the override circuit will de-energize the solenoid, allowing the latch arm to trip. A clicking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

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.

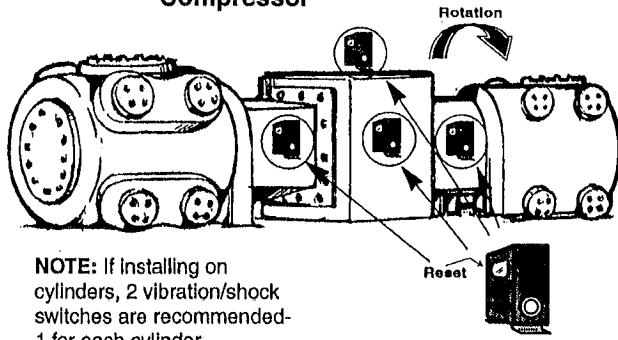
NOTE: An external time delay can be used with the remote reset feature of the VS2EXR series to provide a remote reset and override of the trip operation on start-up. Time delay must automatically disconnect after equipment start-up.

DETAIL "C"



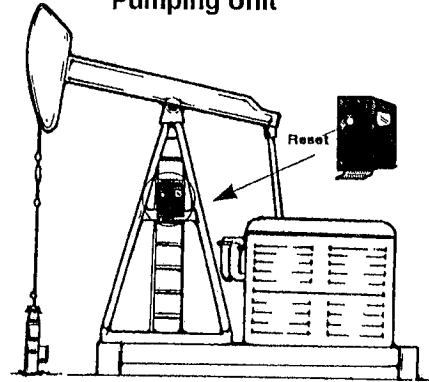
TYPICAL MOUNTING LOCATIONS

2-Throw Balance-Opposed Compressor

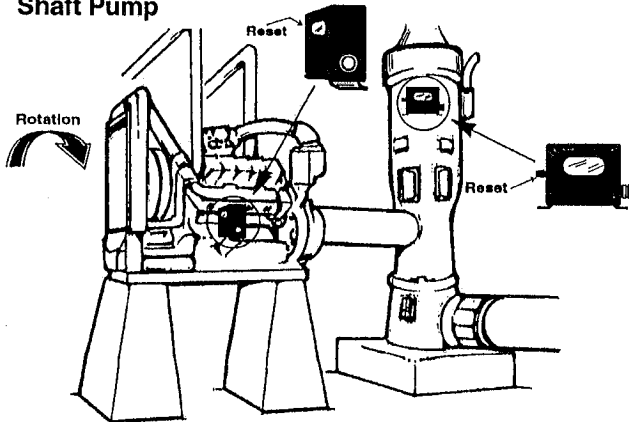


NOTE: If installing on cylinders, 2 vibration/shock switches are recommended- 1 for each cylinder.

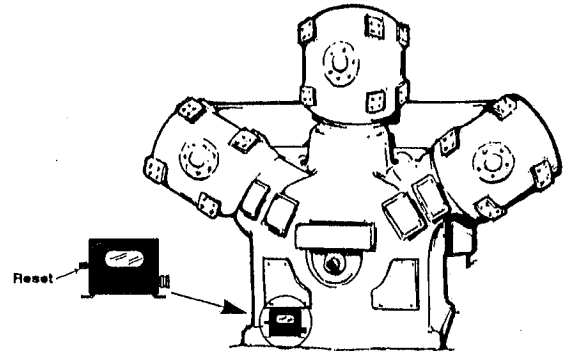
Pumping Unit



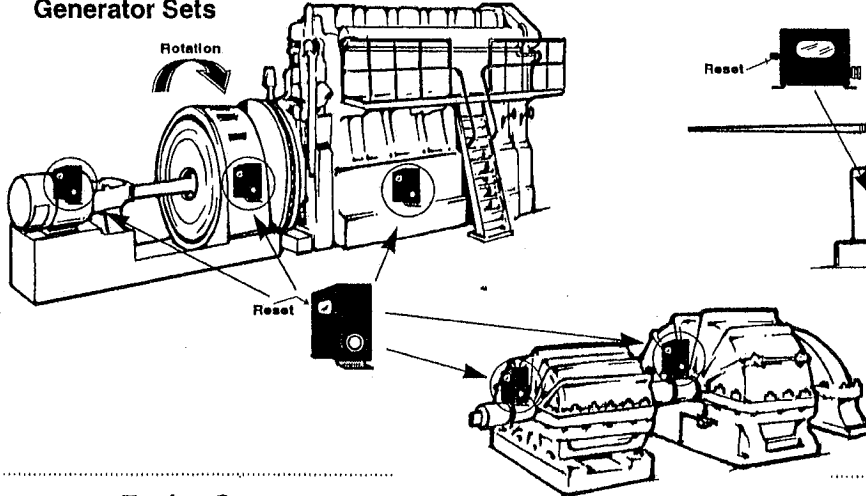
Engine and Vertical Shaft Pump



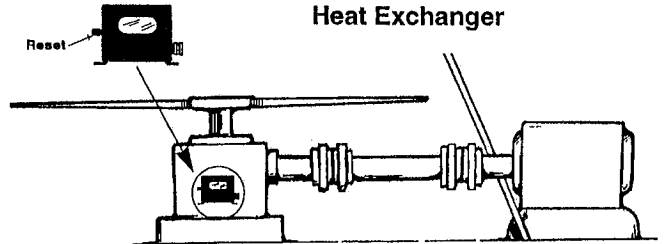
"Y" Type Reciprocating Compressor



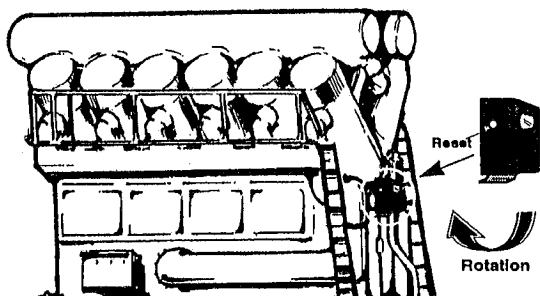
Generator Sets



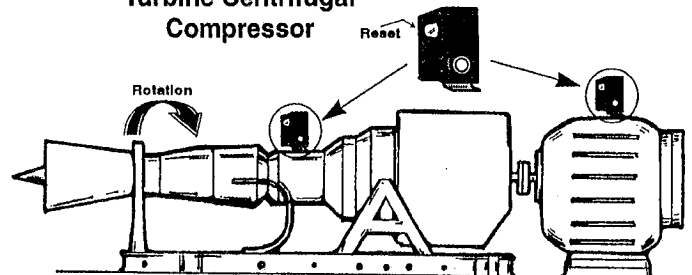
Cooling Tower Fan or Heat Exchanger



Engine Compressor

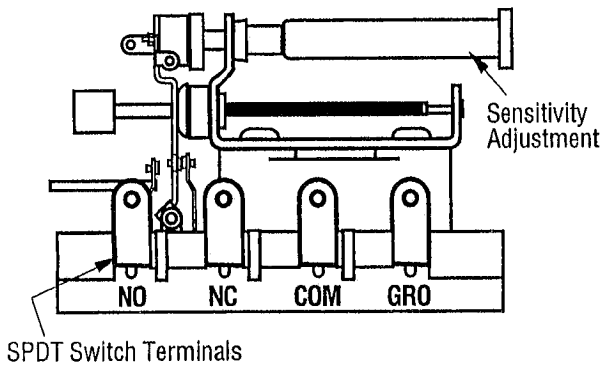


Turbine Centrifugal Compressor

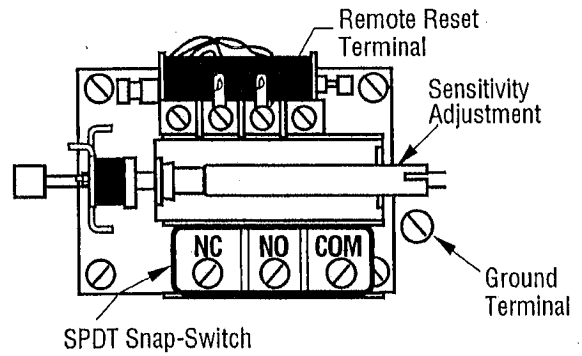


INTERNAL SWITCHES

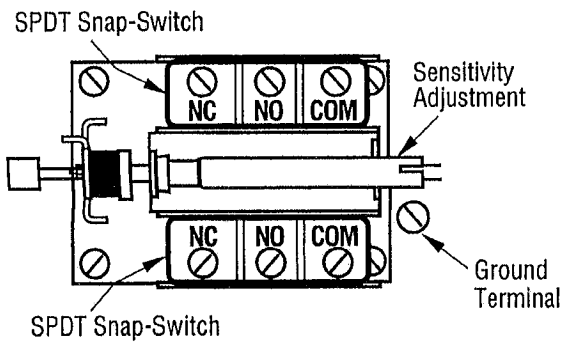
VS2 and VS2C



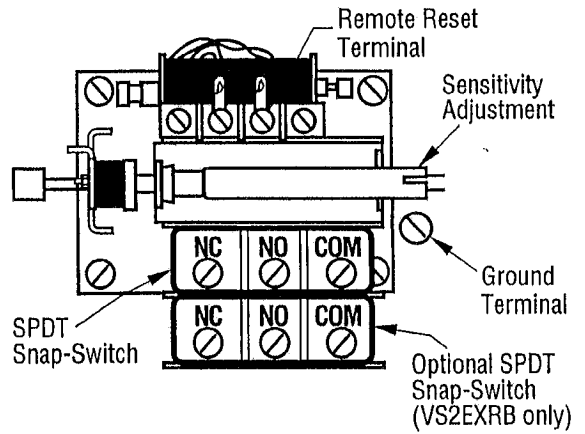
VS2EXR



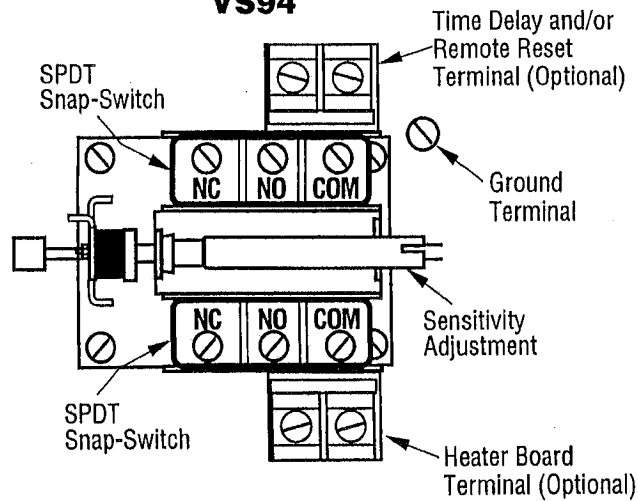
VS2EX



VS2EXB and VS2EXRB



VS94

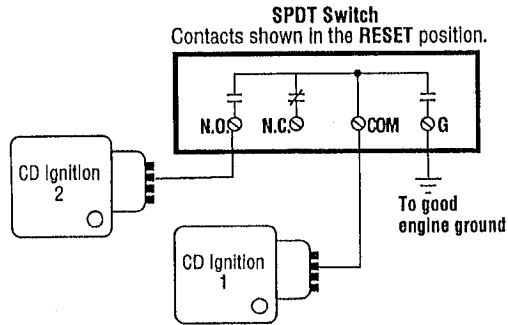


ELECTRICAL

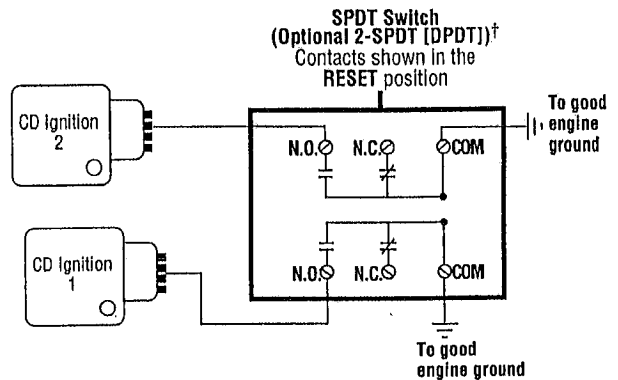


WARNING: REMOVE POWER BEFORE OPENING THE UNIT (ACCESS DOOR). STOP THE MACHINE AND DISCONNECT ALL ELECTRICAL POWER BEFORE BEGINNING THE WIRING OPERATION. IT IS YOUR RESPONSIBILITY TO HAVE A QUALIFIED PERSON INSTALL AND WIRE THE UNIT, AND MAKE SURE IT CONFORMS WITH NEC AND APPLICABLE CODES.

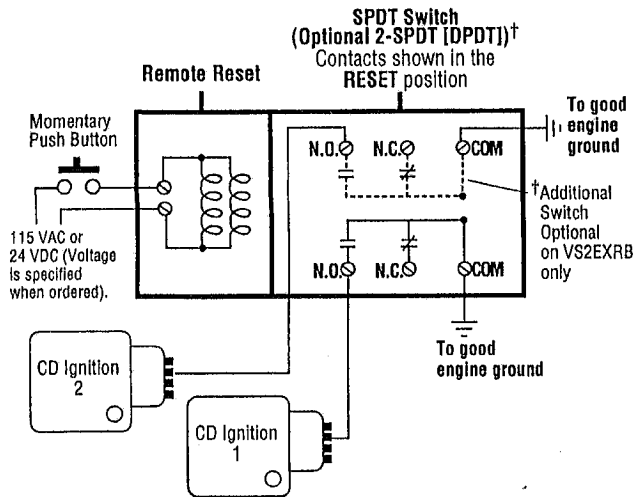
VS2 and VS2C
Typical Wiring Diagram for Single or Dual CD Ignition



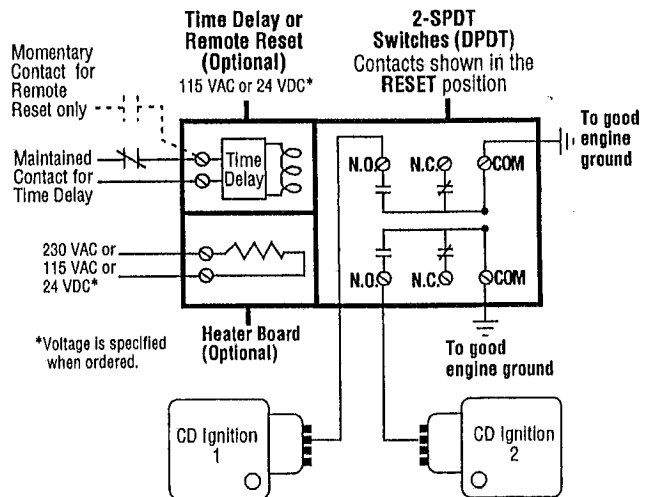
VS2EX
Typical Wiring Diagram for Single or Dual CD Ignitions



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

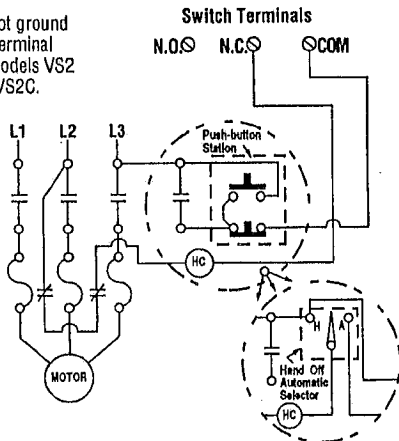


VS94
Typical Wiring Diagram for Single or Dual CD Ignitions



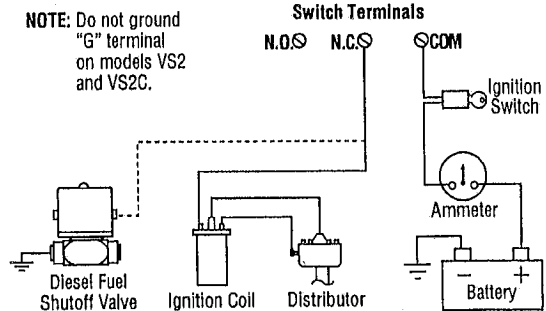
VS2, VS2C, VS2EX, VS2EXR, VS2EXRB and VS94
Typical Wiring Diagram for Electric Motors

NOTE: Do not ground "G" terminal on models VS2 and VS2C.



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

NOTE: Do not ground "G" terminal on models VS2 and VS2C.



SERVICE PARTS

PART NO. DESCRIPTION

VS2 and VS2C

20-00-0030 Movement assembly
 20-00-0031 Glass and gasket assembly
 20-00-0032 Reset push button assembly
 20-05-0021 Mounting clamp
 00-00-3292 Cable clamp assembly (1 each)
 20-00-0465 2-Conductor electrical cable, 45 feet (13.7 meters)
 20-00-0137 5 clamps and 45 feet (13.7 meters) of cable

VS2EX

20-01-0091 Movement assembly
 20-05-0087 Cover
 00-00-0309 Cover gasket
 20-01-0090 Snap-switch and insulator kit (1 switch per kit)
prior to September 1, 1995.*
 20-00-0288 Snap-switch and insulator kit (1 switch per kit) for models
manufactured on September 1, 1995 or later.*
 20-00-0289 C-clamp conversion mounting kit

VS2EXR

20-00-0046 Movement assembly
 20-05-0087 Cover
 00-00-0309 Cover gasket
 20-01-0090 Snap-switch and insulator kit (1 switch per kit)
prior to September 1, 1995.*
 20-00-0288 Snap-switch and insulator kit (1 switch per kit) for models
manufactured on September 1, 1995 or later.*
 20-00-0049 Reset solenoid assembly (115 VAC)
 20-00-0234 Reset solenoid assembly (24 VDC)
 20-00-0289 C-clamp conversion mounting kit

PART NO. DESCRIPTION

VS2EXRB

20-01-0090 Snap-switch and insulator kit (1 switch per kit)
prior to September 1, 1995.*
 20-00-0288 Snap-switch and insulator kit (1 switch per kit) for models
manufactured on September 1, 1995 or later.*
 20-00-0057 *Inside* snap-switch and insulator kit (1 switch per kit) for
 model VS2EXRB-D **prior to September 1, 1995.***
 20-00-0058 *Outside* snap-switch and insulator kit (1 switch per kit) for
 model VS2EXRB-D **prior to September 1, 1995.***
 20-00-0287 *Inside* snap-switch and insulator kit (1 switch per kit) for model
VS2EXRB-D manufactured on September 1, 1995 or later.*
 20-00-0290 *Outside* snap-switch and insulator kit (1 switch per kit) for model
VS2EXRB-D manufactured on September 1, 1995 or later.*
 20-05-0077 Adjustment shaft
 20-00-0046 Movement assembly
 20-00-0049 Reset solenoid assembly (115 VAC)
 20-00-0234 Reset solenoid assembly (24 VDC)

* Models with date 0895 and before use old switch. Dated 0995 after, use straight snap-switch arm, no rollers.

In order to consistently bring you the highest quality, full featured products, we reserve the right to change our specifications and designs at any time.



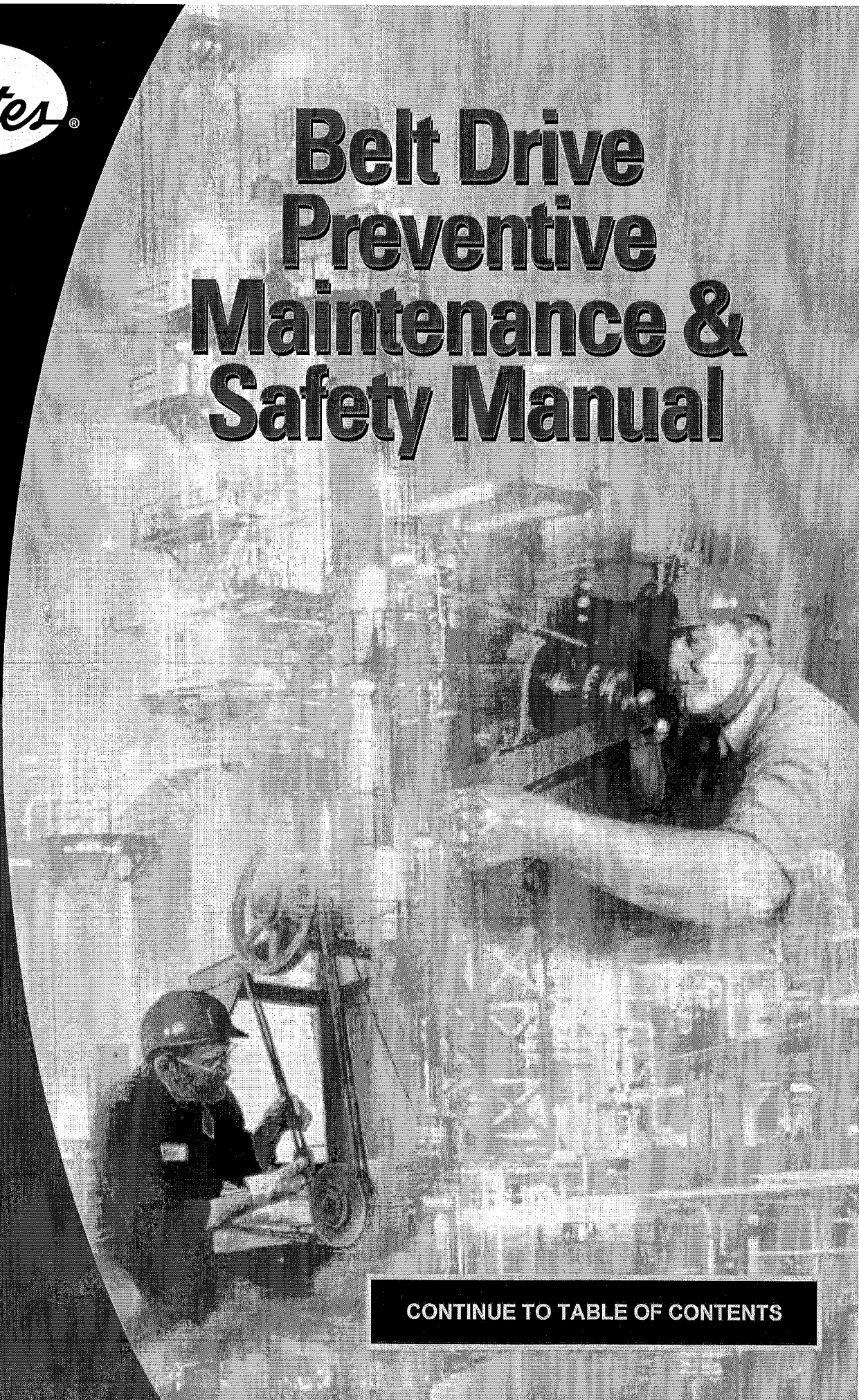
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Belt Drive Preventive Maintenance & Safety Manual



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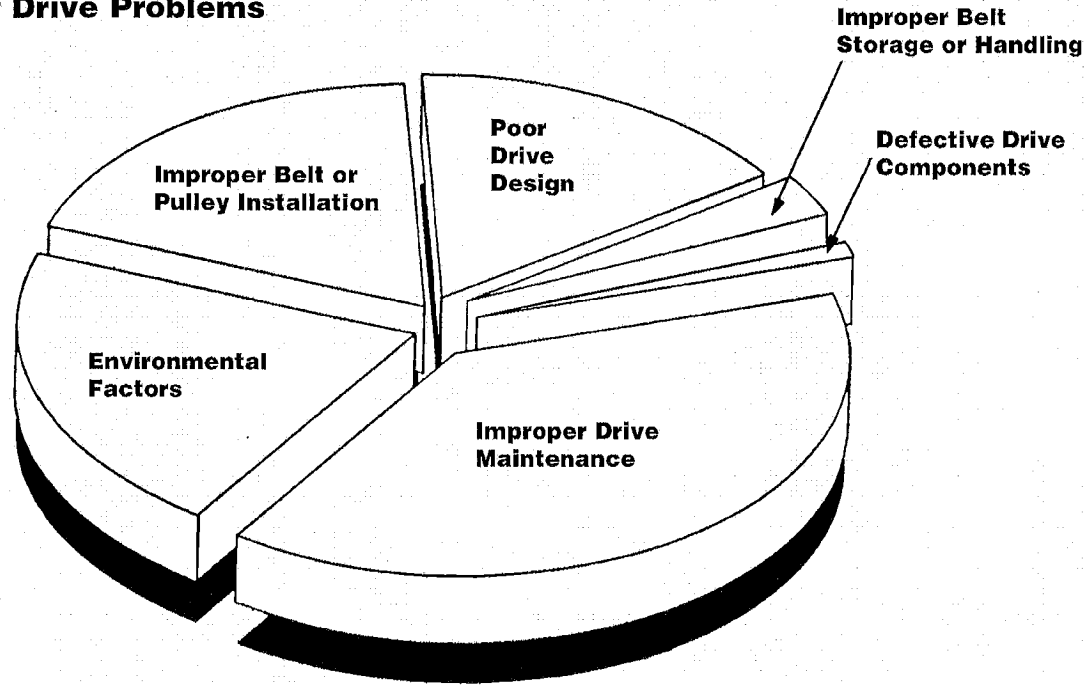
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Sources of Drive Problems

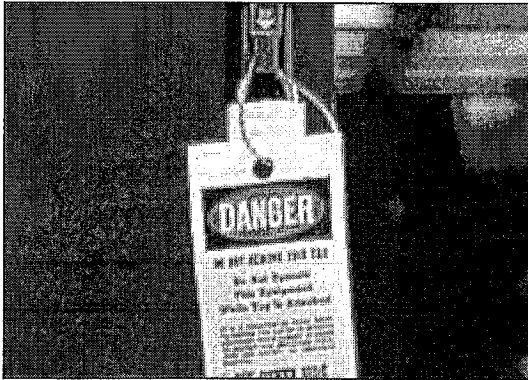


FOREWARD

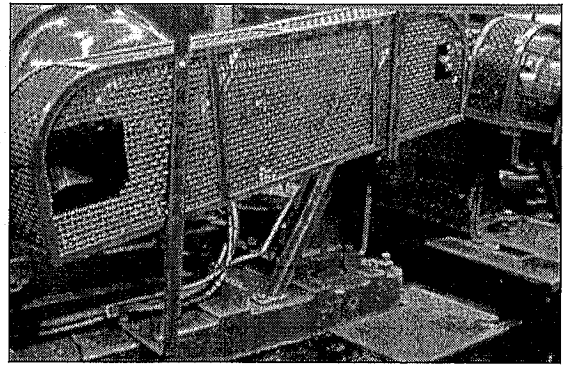
Why Have A Preventive Maintenance Program?

When compared to the constant lubrication problems associated with chain drives, or the mechanical problems and high costs associated with gear drives, belts are the most cost-effective, reliable means of power transmission.

However, optimum belt drive performance requires proper maintenance. The potential for long service life is built into every Gates belt. When coupled with a regularly scheduled maintenance program, your belts and belt drives will run relatively trouble-free for a long time.



Power should be shut off and controls locked before inspecting



Belt drive should have adequate guard

*** Note** Section cut-outs for demo



Carefully inspect all belts

Important to your business

An effective preventive maintenance program saves your firm time and money. When you inspect and replace belts and faulty drive components before they fail, you reduce costly downtime and production delays.

What is a good belt maintenance program?

A comprehensive, effective program of preventive maintenance consists of several elements:

- Maintaining a safe working environment
- Belt product knowledge
- Regularly scheduled belt drive inspections
- Belt storage and handling
- Proper belt installation procedures
- Belt drive performance evaluations
- Troubleshooting

FOREWARD

Maintaining A Safe Working Environment

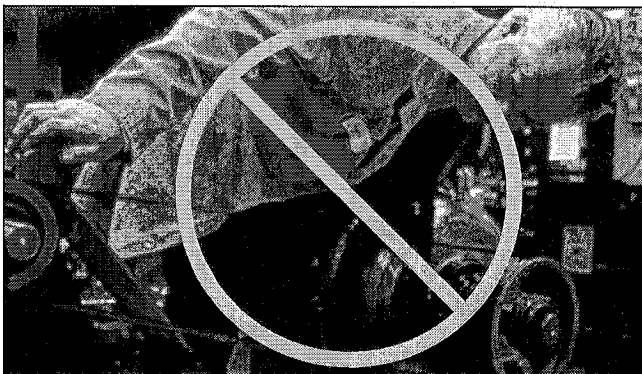
It is common sense to establish a safe working environment in and around your belt drives. The following precautions will make belt drive inspection and maintenance easier and safer.

Checklist

- ✓ Always shut off power, lock and tag control box.
- ✓ Place all machine components in safe position.
- ✓ Remove guard, inspect and clean.
- ✓ Inspect belt for wear, damage. Replace as needed.
- ✓ Inspect sheaves or sprockets for wear, alignment. Replace if worn.
- ✓ Inspect other drive components such as bearings, shafts, motor mounts and takeup rails.
- ✓ Inspect static conductive grounding system (if used) and replace components as needed.
- ✓ Check belt tension and adjust as needed.
- ✓ Recheck pulley alignment.
- ✓ Reinstall belt guard.
- ✓ Restart drive. Look and listen for anything unusual.

Wear Proper Clothing

Never wear loose or bulky clothes, such as neckties, exposed shirttails, loose sleeves or lab coats around belt drives. Wear gloves while inspecting sheaves or sprockets to avoid being cut by nicks, burrs or sharply worn pulley edges.



No loose or bulky clothing

Maintain Safe Access to Drives

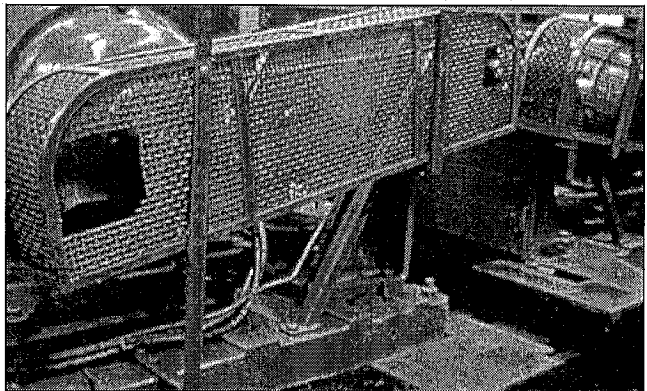
Always maintain a safe access to the belt drives. Keep area around drives free of clutter, debris and other obstructions. Floors should be clean and free of oil and debris to insure good footing and balance while working on machinery.



Don't clutter area around belt drive

Drive Guards

Always keep drives properly guarded. Every belt drive must be guarded when in operation. Guard must be designed and installed according to OSHA standards.



A properly guarded belt drive

A Properly Guarded Belt Drive

A properly designed guard has the following features:

- Completely encloses drive.
- Grills or vents for good ventilation.
- Accessible inspection door or panels.
- Can easily be removed and replaced if damaged
- Where necessary, should protect the drive from weather, debris and damage.

Follow these precautions to make your preventive maintenance easier.

DRIVE SHUTDOWN & THOROUGH INSPECTION

Simple Drive Inspection

Begin preventive maintenance with a periodic drive inspection as a normal part of your maintenance rounds. Look and listen for any unusual vibration or sound while observing the guarded drive in operation. A well designed and maintained drive will operate smoothly and quietly.

Inspect guard for looseness or damage. Keep it free of debris or dust and grime buildup on either the inside or the outside of the guard. Any accumulation of material on the guard acts as insulation, and could cause drives to run hotter.

The effect of temperature on belt life is important. For example, an internal temperature increase of 18°F (or approximately 36°F rise in ambient drive temperature) may cut belt life in half.

Also look for oil or grease dripping from guard. This may indicate over-lubricated bearings. If this material gets on rubber belts, they may swell and become distorted, leading to early belt failure.

It's a good idea to check motor mounts for proper tightness. Check take-up slots or rails to see that they are clean and lightly lubricated.

How Often To Inspect

The following factors influence how often you need to inspect a drive.

- Critical nature of equipment
- Drive operating cycle
- Accessibility of equipment
- Drive operating speed
- Environmental factors
- Temperature extremes in environment

Experience with your own equipment is your best guide to how often you need to inspect belt drives. Drives operating at high speeds, heavy loads, frequent stop/start conditions and at temperature extremes or operating on critical equipment require frequent inspection.

When To Perform Preventive Maintenance

To help establish a preventive maintenance schedule, keep the following in mind.

Critical Drives

A quick visual and hearing inspection may be needed every one to two weeks.

Normal Drives

With most drives, a quick visual and hearing inspection can be performed once a month.

Complete Inspection

A drive shutdown for a thorough inspection of belts, sheaves or sprockets and other drive components may be required every three to six months.

Remember, a well-designed industrial belt drive is capable of operating for several years when properly maintained and used under normal conditions.

Once the power is off, locked and tagged and the machine components are in safe positions, remove the guard and begin inspection.

DRIVE SHUTDOWN & THOROUGH INSPECTION

Preventive Maintenance Check List

By the following these steps, you can maintain a drive efficiently, safely and with very little effort.

1. Always turn off the power to the drive. Lock the control box and tag it with a warning sign "Down For Maintenance. Do Not Turn Power On."
Make sure you have power turned off for the correct drive.
2. Test to make sure correct circuit has been turned off.
3. Place all machine components in a safe (neutral) position.
4. Remove guard and inspect for damage. Check for signs of wear or rubbing against drive components. Clean and realign guard to prevent rubbing if necessary.
5. Inspect belt for wear or damage. Replace as needed. (See page 7 and 8 for belt replacement procedure.) See page 11 for synchronous belt procedure.
6. Inspect sheaves or sprockets for wear and misalignment. Replace if worn. (See page 9 and 10 for pulley installation procedure.)



Turn off power, lock controls and tag

7. Inspect other drive components such as bearing, shafts, motor mounts and take-up rails.
8. Inspect static conductive grounding system (if used) and replace components as needed.
9. Check belt tension and adjust as needed.
10. Recheck sheave or sprocket alignment.
11. Reinstall belt guard.
12. Turn power back on and restart drive. Look and listen for anything unusual.

These steps are covered in detail in the following section.

DRIVE SHUTDOWN & THOROUGH INSPECTION

Preventive Maintenance Procedure

Once the power is off, locked and tagged, and the machine components are in safe positions, remove the guard and begin inspection.

How to Inspect a Belt

Begin by inspecting the belt. Observing signs of unusual belt wear or damage can allow you to troubleshoot possible drive problems.

Mark or note a point on the belt, or one of the belts in a multiple V-belt drive. Work your way around the belt(s), checking for cracks, frayed spots, cuts or unusual wear patterns.

Check the belt for excessive heat. While belts do get hot during operations, if they are too hot to touch, then troubleshooting is in order. The maximum temperature at which a properly maintained V-belt should operate is 140° F (185° F for Gates synchronous belts).

Belts should be replaced if there are obvious signs of cracking, fraying, unusual wear or loss of teeth in a timing, or synchronous, belt.

How to Inspect a Sheave or Sprocket

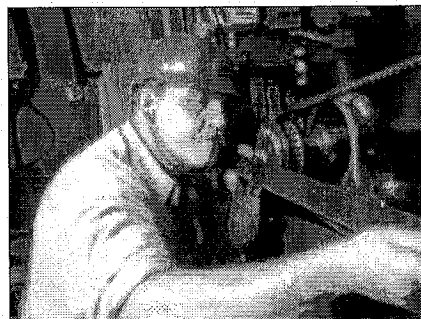
It's always a good idea to check sheaves and sprockets for proper alignment and mounting. If belts have been removed from the drive, then the pulleys should be checked for wear or damage.

To check alignment, all you need is a straight edge or, for drives with long centers, a steel tape. If these are unavailable, heavy string will work.

Line the straight edge (tape or string) along the outside face of both pulleys as shown in the illustration. Misalignment will show up as a gap between the outside face and the straight edge, tape



Begin by inspecting the belt



Use a straight edge to check pulley alignment

or string. Sheave or sprockets can be checked for tilting with a spirit level.

Three possible causes of sheave or sprocket misalignment are: (See Fig. 1, page 9)

1. Motor shafts and driven machine shafts are not parallel
2. Pulleys not properly located on the shafts
3. Pulleys are tilted due to improper mounting

Check Alignment Tolerances

As a general rule, sheave misalignment on V-belt drives should be less than 1/2° or 1/10" per foot of drive center distance. Misalignment for synchronous, Polyflex® and Micro-V® belts should be within 1/4° or 1/16" per foot of drive center distance.

The greater the misalignment, the greater the chance of belt instability, increased belt wear, noise, vibration and V-belt turnover.

Guard Inspection

Check guard for wear or possible damage. Don't overlook wear on the inside of guard. Clean the guard to prevent it from becoming insulated and closed to ventilation. Clean off any grease or oil that may have spilled onto the guard from over-lubricated bearings. Realign guard.

Check Other Drive Components

It's always a good idea to examine bearings for proper alignment and lubrication. Also check motor mounts for correct tightness. Be sure take-up rails are free of debris, obstructions, dirt or rust.

Check Belt Tension

Following the drive component inspection, the final step is to check belt tension and, if necessary, retension the belt. Then, make a final alignment check.

If too little tension is applied, the belts may slip. Too much tension can reduce belt and bearing life. Applying the proper tension is very important.

The correct tension is the lowest tension at which belts will run and not slip when the drive is under a full load. Experienced mechanics may claim to check belt tension with their thumb. But why take chances when there is a simple and more accurate method available?

Remember, belts with different construction will exhibit a different feel.

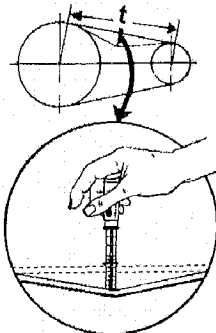
Following is an explanation on how to use the Gates Tension Tester.

DRIVE SHUTDOWN & THOROUGH INSPECTION

How to Tension Belt Drives With Your Gates Tension Testers

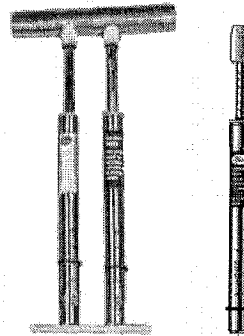
(Up to 30 lbs.)

1. Measure span length (t).
2. Position the lower of the two O-Rings using either of these methods:
 - a. On the scale reading "Deflection Inches", set O-Ring to show a deflection equal to 1/64" per inch of span length (t).
 - b. On the scale reading "Inches of Span Length", set O-Ring to show a deflection equal to the inches of measured span length (t).
3. At the center of span (t), apply force with Gates Tension Tester perpendicular to the span, large enough to deflect one belt of a multiple belt set on drive until the bottom edge of the lower O-Ring is even with tops of remaining belts. For drives with only one belt, a straightedge across pulleys will assure accuracy of positioning.
4. Find the amount of deflection force on upper scale of Tension Tester. The Sliding Rubber O-Ring slides up the scale as tool compresses—and stays up for accurate reading of pounds force. Read at the bottom edge of ring (slide ring down before reusing).

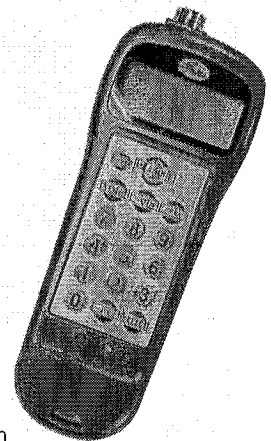


5. Compare deflection force with range of forces recommended. If less than minimum recommended deflection force, belts should be tightened. If more than maximum recommended deflection force, drive is tighter than necessary.

NOTE: There normally will be a rapid drop in tension during the "run-in period" for V-belt drives. Check tension frequently during the first day of operation.



Read the scales at the bottom edge of the O-Ring. Leave the upper O-Ring in maximum "down" position.



Belts, like string, vibrate at a particular natural frequency based on mass and span length. Gates unique Sonic Tension Meter simply converts this frequency into a measurement of tension. Here's how it works:

First, enter belt width, span length and unit weight into meter using built-in keypad. Next, hold meter sensor to belt span, then lightly strum belt to make it vibrate. Press "measure" button and that's it. Meter instantly converts vibrations into belt tension. Readings are displayed on a liquid-crystal screen. (detailed instructions accompany tester)

Recommended Deflection Force Per Belt For Super HC® V-Belts, Super HC PowerBand® Belts, Super HC Molded Notch V-Belts or Super HC Molded Notch PowerBand Belts*

V-Belt Cross Section	Small Sheave Diameter Range (in.)	Small Sheave RPM Range	Speed Ratio Range	Recommended Deflection Force (Lbs.)	
				Minimum	Maximum
3V	2.65 - 2.80	1200-3600	2.00	3.0	4.3
	3.00 - 3.15	1200-3600		3.3	4.8
	3.35 - 3.65	1200-3600	to	3.7	5.4
	4.12 - 5.00	900-3600	4.00	4.4	6.4
	5.30 - 6.90	900-3600		4.8	7.1
3VX	2.20	1200-3600	2.00	2.8	4.1
	2.35 - 2.50	1200-3600		3.2	4.7
	2.65 - 2.80	1200-3600	to	3.5	5.1
	3.00 - 3.15	1200-3600	4.00	3.8	5.5
	3.35 - 3.85	1200-3600		4.1	6.0
	4.12 - 5.00	900-3600		4.8	7.1
	5.30 - 6.90	900-3600		5.8	8.6
5VX	4.40 - 4.65	1200-3600	2.00	9.0	13.0
	4.90 - 5.50	1200-3600		10.0	15.0
	5.90 - 6.70	1200-3600	to	11.0	17.0
	7.10 - 8.00	600-1800	4.00	13.0	19.0
	8.50 - 10.90	600-1800		14.0	20.0
	11.80 - 16.00	400-1200		15.0	23.0
5V	7.10 - 8.00	600-1800	2.00	11.0	16.0
	8.50 - 10.90	600-1800	to	13.0	18.0
	11.80 - 16.00	400-1200	4.00	14.0	21.0
8V	12.50 - 17.00	600-1200	2.00	28.0	41.0
	18.00 - 24.00	400-900	4.00	32.0	48.0

Recommended Deflection Force Per Belt For Hi-Power II™ V-Belts, Hi Power II PowerBand Belts or Tri-Power® Molded Notch V-Belts*

V-Belt Cross Section	Small Sheave Diameter Range (in.)	Small Sheave RPM Range	Speed Ratio Range	Recommended Deflection Force (Lbs.)			
				Hi-Power II		Tri-Power Molded Notch	
				Minimum	Maximum	Minimum	Maximum
A AX	3.0	1750	2.00	2.7	3.8	3.8	5.4
	3.2			2.9	4.2	3.9	5.6
	3.4 - 3.6	to	to	3.3	4.8	4.1	5.9
	3.8 - 4.2	3600	4.00	3.8	5.5	4.3	6.3
	4.6 - 7.0			4.9	7.1	4.9	7.1
B BX	4.6	1160	2.00	5.1	7.4	7.1	10.0
	5.0 - 5.2			5.8	8.5	7.3	11.0
	5.4 - 5.6	to	to	6.2	9.1	7.4	11.0
	6.0 - 6.8	1800	4.00	7.1	10.0	7.7	11.0
	7.4 - 9.4			8.1	12.0	7.9	12.0
C CX	7.0	870	2.00	9.1	13.0	12.0	18.0
	7.5			9.7	14.0	12.0	18.0
	8.0 - 8.5	to	to	11.0	16.0	13.0	18.0
	9.0 - 10.5	1800	4.00	12.0	18.0	13.0	19.0
	11.0 - 16.0			14.0	21.0	13.0	19.0
D	12.0 - 13.0	690	2.00	19.0	27.0	19.0	28.0
	13.5 - 15.5			to	to	21.0	30.0
	16.0 - 22.0	1200	4.00	24.0	36.0	25.0	36.0

*Note: This information is for Horsepower Ratings which are mentioned in this manual only. Use with older drives could result in overtensioning.

PREVENTIVE MAINTENANCE

How To Install V-Belts

When the decision is made to install a belt, either as a replacement or on a new drive, the following steps are recommended:

1. After power has been turned off, and guard removed, loosen motor mounting bolts.



2. Move motor until belt is slack and can be removed without prying. Never pry off a belt!



3. Remove old belts. It is a good idea to check them for unusual wear. Excessive wear may indicate problems with drive design or maintenance procedures.



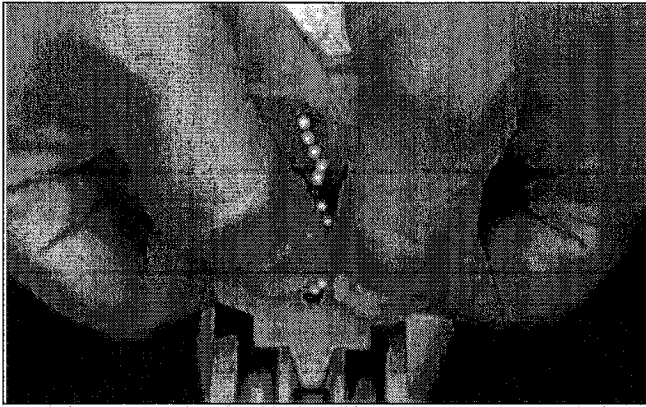
4. Select correct replacement belt.
5. Belts and sheaves may be cleaned by wiping with a rag slightly dampened with a light, non-volatile substance. Soaking or brushing solvent on the belt is not advisable. Obviously, sanding or scraping the belt with a sharp object to remove grease or debris is not recommended. Belts must be dry before using on a drive.



NOTE:

Worn sheaves are a major cause of shortened belt life.

PREVENTIVE MAINTENANCE



6. Inspect sheaves for wear and nicks. Gates Sheave Gauges make it easy to see if grooves are worn. If more than 1/32" of wear can be seen, the worn sheaves should be replaced.
7. Check alignment.
8. Inspect other drive components such as bearings and shafts for alignment, wear, lubrication, etc.
9. Install a new belt or belt set. Replace all belts on multiple belt drives. When a new belt replaces another belt in a multi-belt drive, the new one may be tensioned properly, but all of the old ones are undertensioned. The drive load may then be carried only by the new belt.
10. Take up the center distance on the drive, rotate the drive by hand for a few revolutions (this will help the belts seat properly) and check for proper tension, using a belt tension tester. Some long V80® belts may appear to hang unevenly when installed. It is normal for belts within RMA tolerances to create noticeable differences in deflection. This "catenary effect" is a curve made by a cord of uniform weight suspended between two points. This appearance will change with proper run-in and retensioning.
11. Secure motor mounting bolts to correct torque.
12. Replace guard.
13. A run-in procedure is recommended. This process consists of starting the drive, letting it run under full load and then stopping, checking and retensioning to recommended values. Running belts under full load allows them to seat themselves into the grooves.

If possible, let them run for about 24 hours. Even letting them run overnight, or over a lunch break, is better than nothing. This run-in procedure will reduce the future need for retensioning and extend belt life.
14. During startup, look and listen for unusual noise or vibration. It's a good idea to shut down the machine and check bearings and motor. If they feel hot, the belt tension may be too tight or bearing may be misaligned or not lubricated properly.

PREVENTIVE MAINTENANCE

How To Install and Align Pulleys

It is extremely important that new or replacement pulleys be installed and aligned properly. Any pulley types used in industry must be properly assembled, and bolts or setscrews tightened to the correct torque.

Most pulleys are attached to the shaft with a tapered bushing which fits a mating tapered bore in the pulley. This type of system consists of a bushing, a pulley, a key, and a setscrew, depending on bushing type. Bushings come in several bore size diameters. This allows for a reduction in the parts inventory required in your plant because one bushing can be used with a number of different size pulleys.

Type QD Pulleys

To install, slide the QD bushing on the shaft, flange end first. Assemble the key. Position the QD hub on the shaft. Tighten the setscrew over the key, hand-tight with a standard Allen wrench only. **Do not use excessive force.**

Slide the large end of the pulley taper bore into position over the cone, aligning pull-up bolt holes in the pulley and tapped holes in the flange of the bushing. Assemble pull-up bolts and lock washers. Align the pulleys.

Tighten pull-up bolts alternately and evenly. Do not use extensions on the wrench handle. There should be a gap between pulley hub face and bushing flange to assure a satisfactory cone grip and press fit. This gap must not be closed.

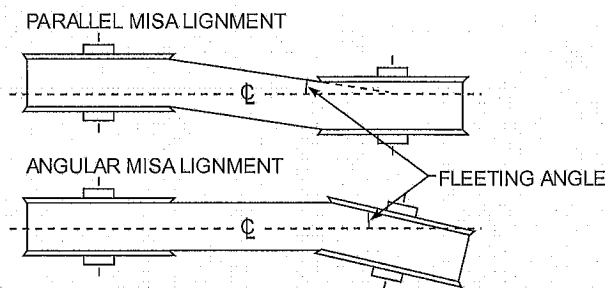
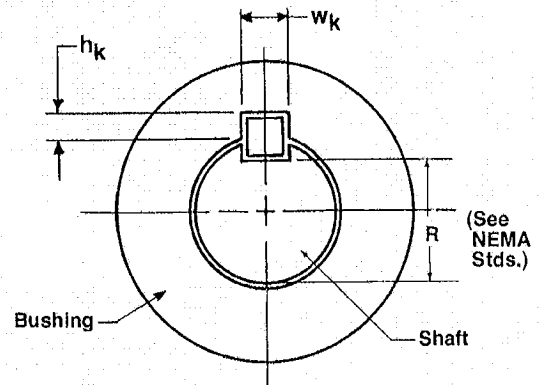


Fig. 1

Standard Shaft and Bushing Keyseat Dimensions



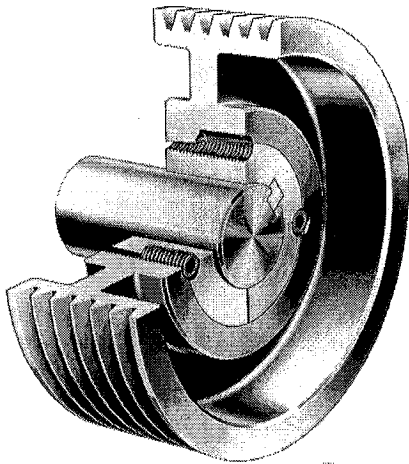
Shaft Diameter (Inches)	Width W_k (Inches)*	Depth h_k +0.015-0.000 (Inches)
Up Through 7/16 (0.44)	3/32 (0.094)	3/64 (0.047)
Over 7/16 (0.44) To and Incl. 9/16 (0.56)	1/8 (0.125)	1/16 (0.062)
Over 9/16 (0.56) To and Incl. 7/8 (0.88)	3/16 (0.188)	3/32 (0.094)
Over 7/8 (0.88) To and Incl. 1 1/4 (1.25)	1/4 (0.250)	1/8 (0.125)
Over 1 1/4 (1.25) To and Incl. 1 3/8 (1.38)	5/16 (0.312)	5/32 (0.156)
Over 1 3/8 (1.38) To and Incl. 1 3/4 (1.75)	3/8 (0.375)	3/16 (0.188)
Over 1 3/4 (1.75) To and Incl. 2 1/4 (2.25)	1/2 (0.500)	1/4 (0.250)
Over 2 1/4 (2.25) To and Incl. 2 3/4 (2.75)	5/8 (0.625)	5/16 (0.312)
Over 2 3/4 (2.75) To and Incl. 3 1/4 (3.25)	3/4 (0.750)	3/8 (0.375)
Over 3 1/4 (3.25) To and Incl. 3 3/4 (3.75)	7/8 (0.875)	7/16 (0.438)
Over 3 3/4 (3.75) To and Incl. 4 1/2 (4.50)	1 (1.000)	1/2 (0.500)
Over 4 1/2 (4.50) To and Incl. 5 1/2 (5.50)	1 1/4 (1.250)	5/8 (0.625)
Over 5 1/2 (5.50) To and Incl. 6 1/2 (6.50)	1 1/2 (1.500)	3/4 (0.750)
Over 6 1/2 (6.50) To and Incl. 7 1/2 (7.50)	1 3/4 (1.750)	3/4 (0.750)
Over 7 1/2 (7.50) To and Incl. 9 (9.00)	2 (2.000)	3/4 (0.750)
Over 9 (9.00) To and Incl. 11 (11.00)	2 1/2 (2.500)	7/8 (0.875)
Over 11 (11.00) To and Incl. 13 (13.00)	3 (3.000)	1 (1.000)

*Tolerance on Width, W_k for widths up through 1/2" (0.500) +0.002-0.000
 For widths over 1/2" (0.500) through 1" (1.000) +0.003-0.000
 For widths over 1" (1.000) +0.400-0.000

PREVENTIVE MAINTENANCE

Taper Lock Sheaves

To install, insert bushing into sheaves. Match holes (not threads) and slip the entire unit onto shaft. Put screws into holes that are threaded into the sheave only. Align sheaves and tighten the screws. As the bushing is wedged inward, it contacts and grips the shaft.



Sprocket Installation

Bushing Style	Bolts		Torque Wrench	
	Qty.	Size	lb-ft	lb-in
H	2	1/4 x 3/4	7.9	95
JA	3	10-24 x 1	4.5	54
SH & SDS	3	1/4-20 x 1 3/8	9.0	108
SD	3	1/4-20 x 1 7/8	9.0	108
SK	3	5/16-18 x 2	15.0	180
SF	3	3/8-16 x 2	30.0	360
E	3	1/2-13 x 2 3/4	60.0	720
F	3	9/16-12 x 3 5/8	75.0	900
J	3	5/8-11 x 4 1/2	135.0	1620
M	4	3/4-10 x 6 3/4	225.0	2700
N	4	7/8-9 x 8	300.0	3600
P	4	1-8 x 9 1/2	450.0	5400
W	4	1 1/8-7 x 11 1/2	600.0	7200
S	5	1 1/4-7 x 15 1/2	750.0	9000

Caution: Excessive bolt torque can cause sprocket and/or bushing breakage.

Note: To insure proper bushing/sprocket performance, full bushing contact on the shaft is recommended.

Sprocket Installation

Bushing Style	Bolts		Torque Wrench	
	Qty.	Size	lb-ft	lb-in
1008	2	1/4-20 x 1/2	4.6	55
1108	2	1/4-20 x 1/2	4.6	55
1210	2	3/8-16 x 5/8	14.6	175
1610	2	3/8-16 x 5/8	14.6	175
2012	2	7/16-14 x 7/8	23.3	280
2517	2	1/2-13 x 1	35.8	430
3020	2	5/8-11 x 1 1/4	66.7	800
3525	3	1/2-13 x 1 1/2	83.3	1000
4030	3	5/8-11 x 1 3/4	141.7	1700
4535	3	3/4-10 x 2	204.2	2450
5040	3	7/8-9 x 2 1/4	258.3	3100
6050	3	1 1/4-7 x 3 1/2	651.7	7820
7060	4	1 1/4-7 x 3 1/2	651.7	7820

Caution: Excessive bolt torque can cause sprocket and/or bushing breakage.

Note: To insure proper bushing/sprocket performance, full bushing contact on the shaft is recommended.

HOW TO INSTALL SYNCHRONOUS BELTS

Follow these steps to install synchronous belt drive systems:

1. **After power has been locked out and tagged,** loosen motor mounting bolts. Move motor until belt is slack and can be removed without prying. Never pry off a belt!
2. Remove old belt and check it for unusual wear. Excessive wear may indicate problems with the drive design or maintenance program. Refer to pages 26-33 for visual aids.
3. Select correct replacement belt. **Do not crimp belts during handling or installation.**
4. Sprockets may be cleaned by wiping with a rag slightly dampened with a light, non-volatile solvent. Soaking or brushing the solvent on the belt is not advisable. Obviously, sanding or scraping the belt or sprocket with a sharp object to remove grease or debris is not recommended. Belts must be dry before using on a drive.
5. Inspect sprockets for unusual or excessive wear. Check alignment. Proper alignment is very critical with synchronous belt drives. Check other drive components such as bearings and shafts for alignment, lubrication, wear, etc.
6. Install new belt over sprockets. Do not pry or use force.
7. Take up center distance on drive until proper tension is obtained on the tension tester. Rotate drive by hand for a few revolutions and re-check tension and alignment.
9. Secure motor mounting bolts to correct torque. Be sure all drive components are secure since any change in drive centers during operation will result in poor belt performance.
10. Although belts will not require further tensioning, we recommend starting up the drive and observing performance. Look and listen for unusual noise or vibration. It's a good idea to shut down the machine and check bearings and motor. If they feel hot, belt tension may be too tight or bearings may be misaligned or not lubricated correctly.

BELT IDENTIFICATION

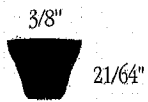
When preventive maintenance inspections indicate that belts need replacing, it's important that you install the correct belts.

Consequently, it is important that you be able to identify the various types and sizes of belts available, and then quickly be able to specify the correct replacement.

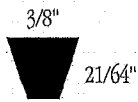
The information on the following pages will help you become familiar with the belt types used in the industry. You'll also discover that Gates makes a belt to fit nearly any application you can name.

V-Belts

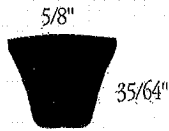
Super HC® V-Belts



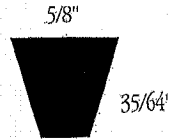
3V



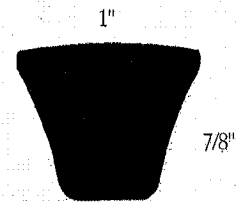
3VX



5V

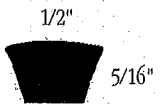


5VX

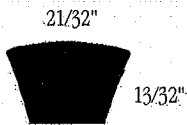


8V

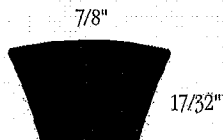
Hi-Power® II V-Belts



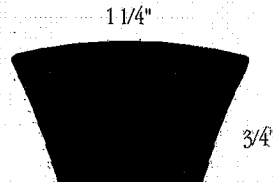
A



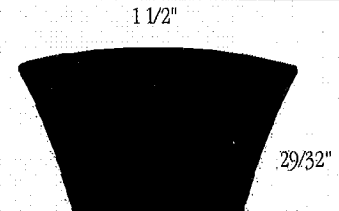
B



C

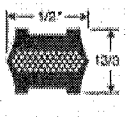


D

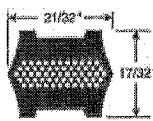


E

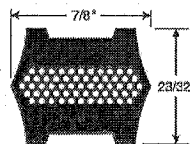
Dubl V-Belts



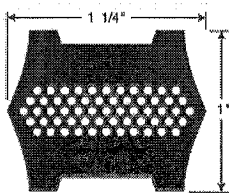
AA



BB

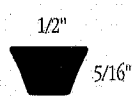


CC

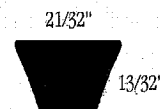


DD

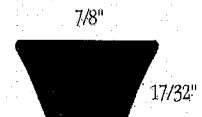
Tri-Power® V-Belts



AX

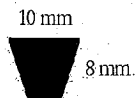


BX

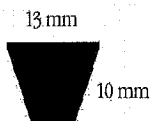


CX

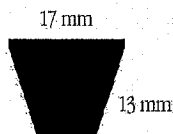
Metric Power™ V-Belts



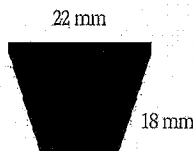
SPZ/XPZ



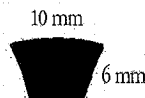
SPA/XPA



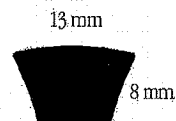
SPB/XPB



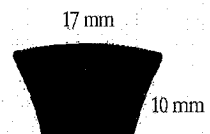
SPC/XPC



10mm



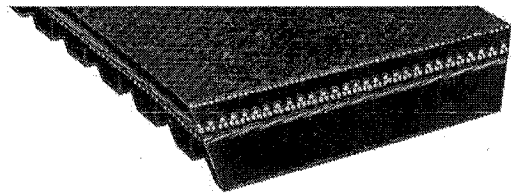
13mm



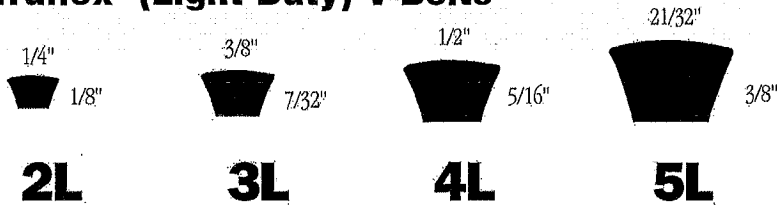
17mm

BELT IDENTIFICATION

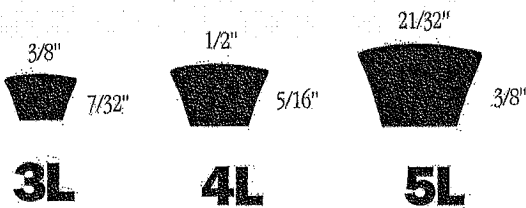
Multi-Speed Belts Top Width-Sheave Angle



Truflex® (Light Duty) V-Belts



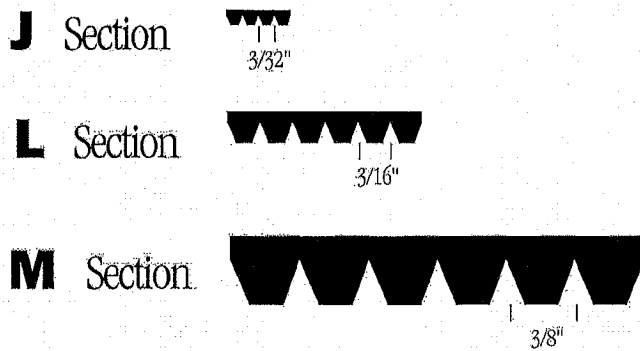
PowerRated® V-Belts



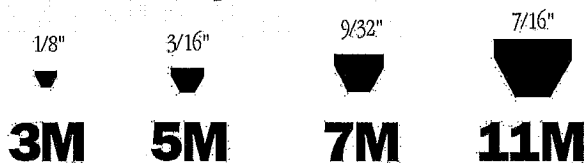
PowerBand® - Hi-Power II and Super HC®



Micro-V® Belts



Standard Polyflex®



Polyflex® JB®



BELT IDENTIFICATION

Synchronous Belts

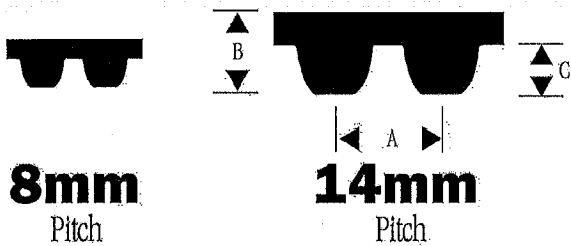
All synchronous belts are identified in a similar manner, in either English or metric units. Belts are measured by:

1. Pitch: Distance in inches or millimeters between two adjacent tooth centers as measured on the belt pitch line.

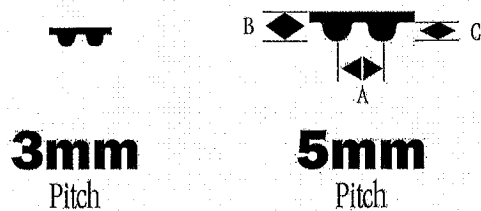
2. Pitch Length: Total length (circumference) in inches or millimeters as measured along the pitch line. It is equal to the pitch multiplied by the number of teeth in the belt.

3. Width: Denoted in inches or millimeters.

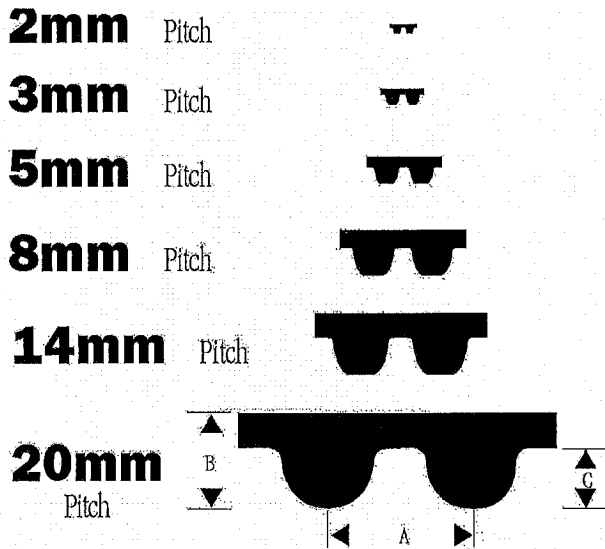
Poly Chain® GT®2



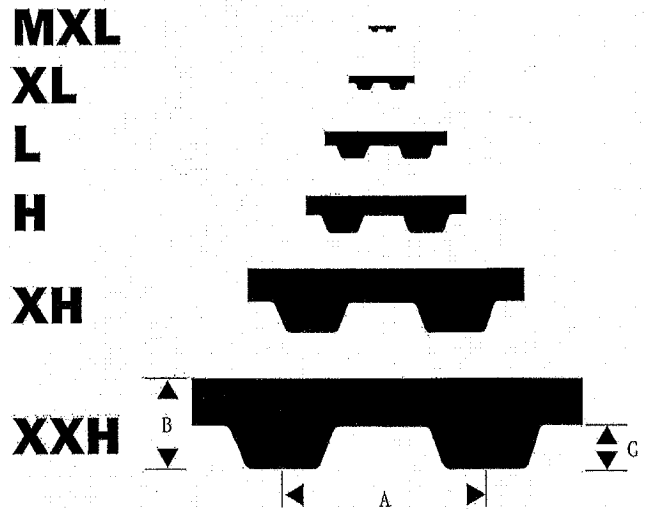
PowerGrip HTD®



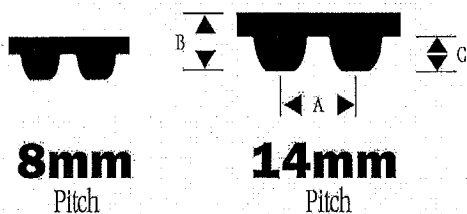
PowerGrip GT2



PowerGrip® Timing

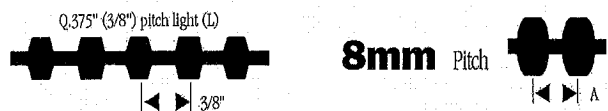


PowerGrip GT



Twin Power® Timing

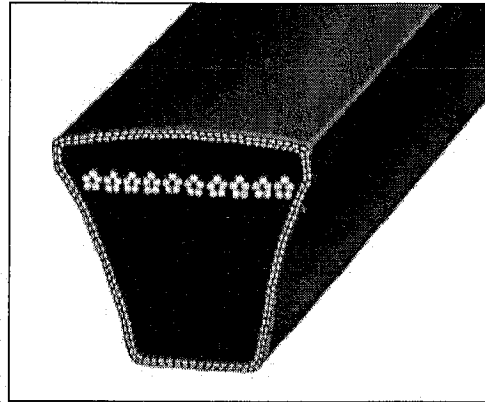
Twin Power® — PowerGrip GT & GT2



BELT TYPES

Narrow Section V-Belts

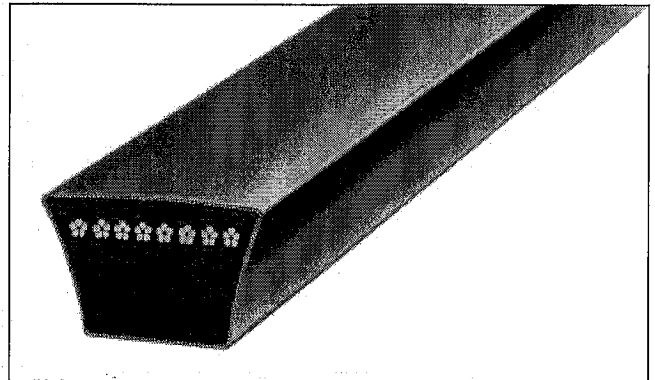
These high capacity belts are used to substantially reduce drive costs and decrease space requirements. This V-belt handles the complete range of drive horsepower recommended with three narrow cross sections instead of the five regular cross sections needed for classical heavy-duty belts. Specified by 3V, 5V or 8V cross sections. Specify Gates Super HC® V-Belts.



Classical Section V-Belts

These are the original belts used in heavy duty applications. They are specified by cross section and standard length. The size is designated as A, B, C, D or E. The easiest way to select a replacement is by finding the belt number on the worn belt. If not legible, measure the belts outside circumference with a flexible tape, preferably while it's still on the drive.

Then, order the Gates **Hi-Power II** V-Belt which has the next shorter standard length. For example: For an "A" section belt with a 28.0" O.C., order an A26 replacement belt.



Banded and Bandless Belts

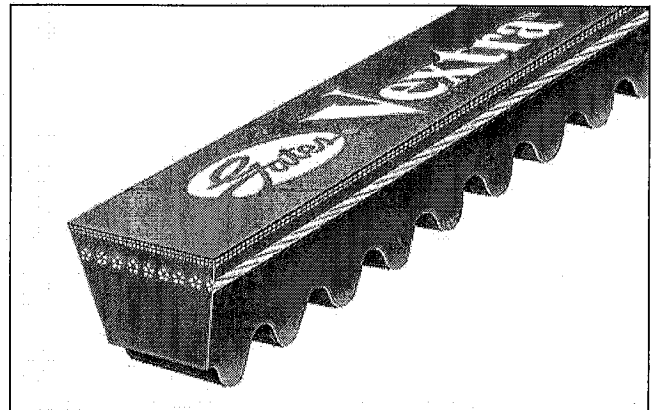
Banded belts, also called wrapped or covered belts, have a fabric cover. Un-notched and generally with concave sidewalls, they have rounded bottom corners and arched tops.

Bandless belts have no fabric cover. They have straight, cut-edge sidewalls and special molded notches. These notches reduce bending stress during operation which allow them to run smaller diameter sheaves than can comparable non-notched banded belts.

Gates offers these two types in both the classical and narrow sections. In the classical section, Gates **Tri-Power®** molded notch is available in AX, BX and CX cross sections. Its length is specified by the same standard belt number as other classical section belts.

Gates also offers **Super HC Molded Notch** V-Belts in 3VX and 5VX sizes.

In both cases, an "X" is used in the belt number to designate a molded notch construction. For example: An AX26 is a bandless, molded notch classical section belt. A 5VX1400 is a narrow section, bandless, molded notch belt with a 140" O.C.

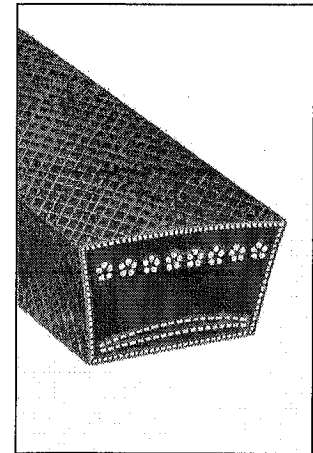
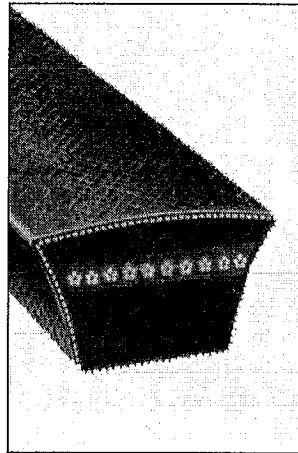


Note: The revolutionary Gates Vextra construction is used in the notched belts.

BELT TYPES

Light Duty Belts

These are used on light duty fractional horsepower drives and are designed for use with backside idlers. **Gates Truflex®** and **PowerRated®** V-Belts are offered in this category and are specified by cross section and outside circumference. **Truflex** is recommended for the lower lighter duty range. **PowerRated®**, a special belt designed for clutching, heavier shock-load and backside idler drives, is recognized by its green color. Reinforced with an aramid fiber tensile (pound for pound stronger than steel). **PowerRated** can interchange with **Truflex**, but **Truflex** cannot interchange with **PowerRated**.



Synchronous Belts

These belts are also known as timing or positive drive belts and are used where driveN shaft speeds must be synchronized to the rotation of the driveR shafts. They can also be used to eliminate noise and maintenance problems caused by chain drives.

Synchronous belts, such as **Gates Poly Chain® GT®2**, can be used in high horsepower drives... drives where space is severely limited... and where there is limited take up.

Synchronous drives are extremely efficient... as much as 98% with properly maintained **Poly Chain GT2** or **PowerGrip GT2** Systems. By contrast, chain drives are in the 91-98% efficiency range, while V-Belts average in the 93-98% range.

Distinctive tooth profiles (shapes) identify synchronous belts. Various sizes and constructions are available to meet a wide range of applications. The three important dimensions of a synchronous belt are pitch, width and pitch length. Tooth profiles must also be identified.

Belt Pitch - Distance (mm) between two adjacent tooth centers as measured on the belt's pitch line.

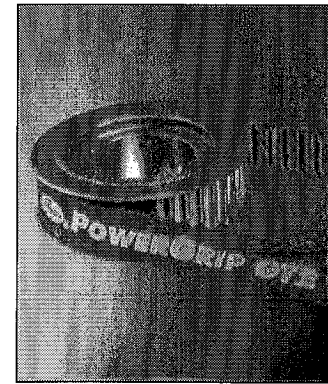
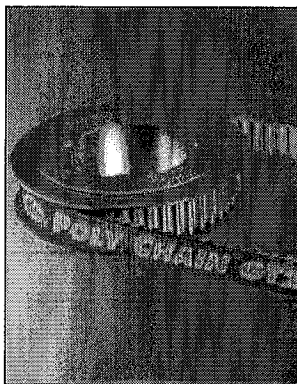
Belt Pitch Length - Circumference (mm) as measured along the pitch line.

Width - Top width (mm).

Tooth Profile - See page 14 for the easiest way to identify this.

Synchronous belts run on sprockets, which are specified by the following:

Pitch - Distance between groove centers, measured on the sprocket pitch circle. The pitch circle coincides with the pitch line of the mating belt.



Number of Sprocket Grooves

Width - Face width.

Note: The sprocket's pitch diameter is always greater than its outside diameter.

Note: PowerGrip GT2 belts must be used with PowerGrip GT2 sprockets for new designs

Note: 8 and 14 mm pitch PowerGrip GT2 belts can be used as replacement belts at the next smaller width for the following: HTD, Rpp, Rpp+Plus, HTB, HPT, HT100, HT150, ETH, HPR, HPPD, EHT or HTT.

Example: 14mm-170mm width – substitute a PowerGrip GT2-14mm-115 without any performance loss. Refer to page 22 for crossover information.

Note: The 8mm and 14mm PowerGrip GT belts can be used in the PowerGrip GT2, HTD, Rpp, Rpp+Plus, HPT, HPPD and HT sprockets. Refer to page 22 for crossover information.

Note: PowerGrip GT belts can be used as a substitute for HTD, Rpp, Rpp+Plus, HTB, HPT, HPPD, HT100, HT150, EHT or HPR without a performance loss. Refer to page 22 for crossover information.

BELT TYPES

Polyflex® JB® Belt

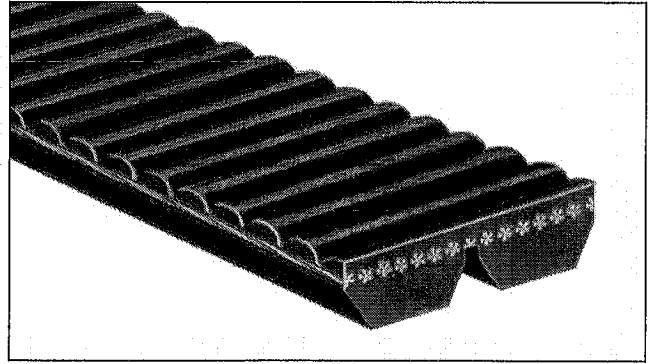
Here is a unique belt with a distinctive 60° belt angle and ribbed top specifically designed for long life in small diameter sheave drives. **Polyflex JB** is ideal for compact drives, drives with high speed ratios, and drives requiring especially smooth operation.

The "JB" refers to the belt's configuration. Two or three belts joined together to provide extra stability and improved performance. This joined belt style should be used instead of matched single belts whenever possible.

You'll find **Polyflex JB** Belts in these applications:

- Milling, grinding or drilling machines
- Lathes
- Machine spindle drives
- Centrifuges
- Blowers
- High speed compressors

Polyflex JB Belts are specified by Top Width and Effective Length

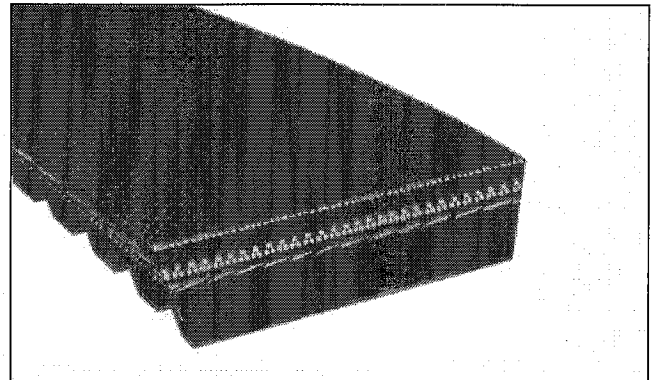


Multi-Speed Belts

(Variable Speed Drives)

Multi-Speed belts have a distinct shape. Multi-Speed belt top widths are usually greater than their thicknesses. This permits a greater range of speed ratios than standard belts. Usually cogged or notched on the underside, **Multi-Speed** belts are specified for equipment which require changes in drive speed during operation.

Multi-Speed belts are specified by **Top Width**, **Outside Circumference**, and the required **Groove Angle**. The groove angle can be measured from the drive pulleys.

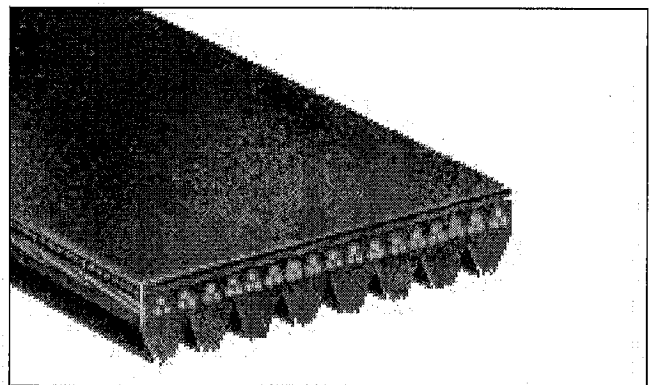


Micro-V® or V-Ribbed Belt

Gates Micro-V Belts outperform other V-ribbed belts because they are truncated (shorter). This shorter profile gives the new **Micro-V Belts** increased flexibility, reduced heat buildup and allows them to operate at extra high speeds on smaller diameter sheaves.

Two more advantages of the truncated are: (1) the belt does not bottom in the sheave, and (2) the belt can better tolerate debris in the sheave groove. They are extremely smooth running and highly resistant to oil, heat and other adverse conditions.

Three cross sections are available for industrial applications: J, L and M.



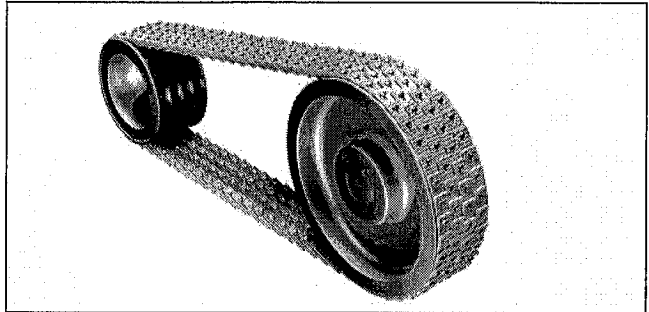
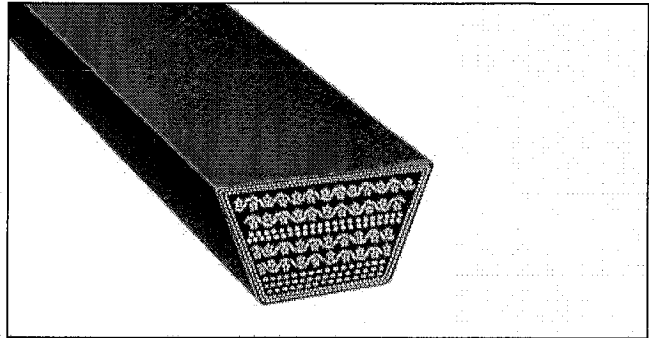
BELT STYLES

Spliced Belting

Used on drives with little or no take-up, or as an emergency belt replacement.

Belting is sold on reels in standard V-Belt cross sections. Ends are spliced with fasteners that require special assembly tools. Always use the correct fasteners with the correct belt type and cross section.

Nu-T-Link*, a new, high performance, spliced belt, is also available for use as emergency belting, and for drives where conditions are detrimental to rubber belts.



PowerBand® Belts

PowerBand belts were developed by Gates for drives subjected to pulsating loads, shock loads or extreme vibrations where single belts could flip over on the pulleys. A high-strength tie band permanently joins two or more belts to provide lateral rigidity. This keeps the belts running in a straight line in the pulley grooves.

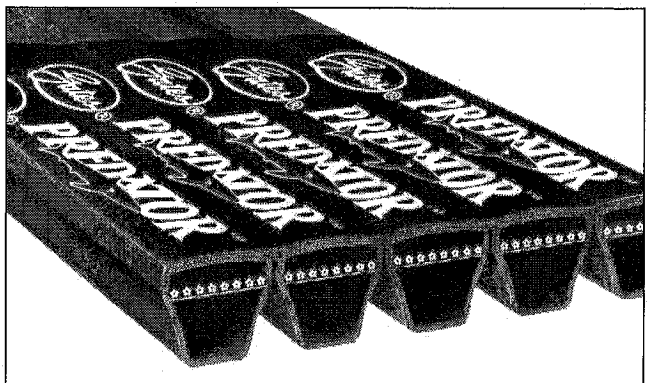
PowerBand construction is offered with **Gates Hi-Power® II, Super HC® and Super HC Molded Notch Belts.**

The **Gates Predator™ V-Belt** is a multi layered **PowerBand®** construction that adds strength, durability, shear and tear resistance and lateral rigidity to handle the toughest shock-loaded applications. It is available in **Super HC** and **Hi-Power II** profiles.



Predator V-Belts primary features:

- Aramid tensile cords for extraordinary strength, durability and virtually zero stretch.
- Chloroprene rubber compounds for superb oil and heat resistance.
- Specially-treated cover withstands slip and shear forces at peak loads without generating excessive heat. It also fends off penetration by foreign materials.
- Gates curves that compensate for effects that occur when belts bend around a sheave for uniform loading and maximum life.
- Precision-matched to maximize power absorption and belt life.

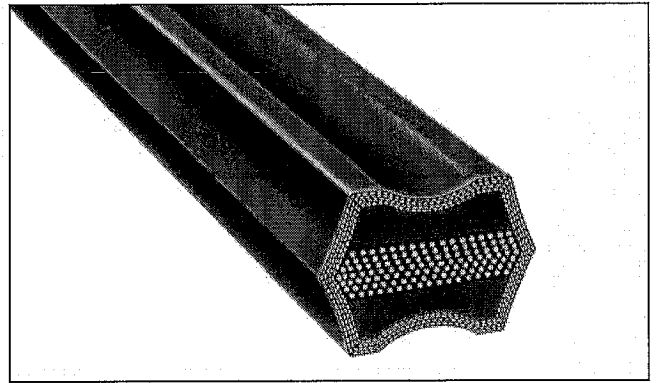


*Registered Trademark of Fenner-Manheim.

BELT STYLES

Dubl-V Belt

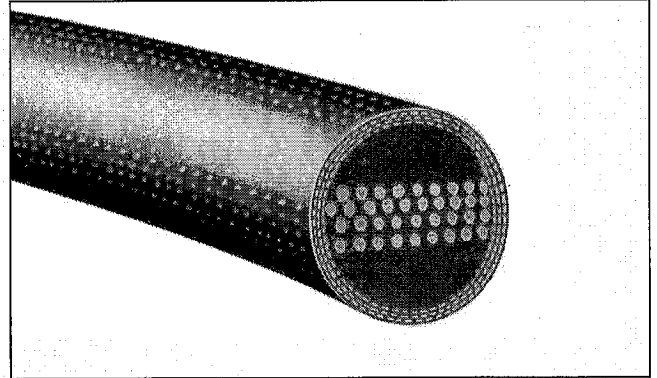
A special version of Gates Hi-Power® II for serpentine drives where power is transmitted by both the top and bottom of the belt. Dubl-V belts are specified by A, B, or C cross sections, and by Effective Length.



Round Endless Belts

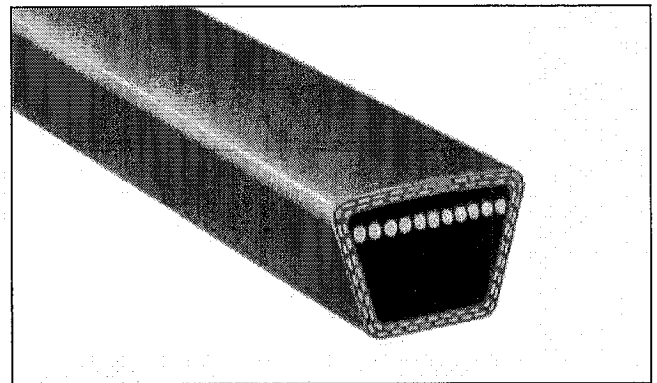
Recommended for replacing leather belting on serpentine or quarter-turn drives. They are specified by **Diameter** and **Inside Length**.

If your current drive has leather or round endless belting, you should consider a new drive design. V-belt drives offer many advantages in performance, even on serpentine or quarter-turn drives.



Power Cable®

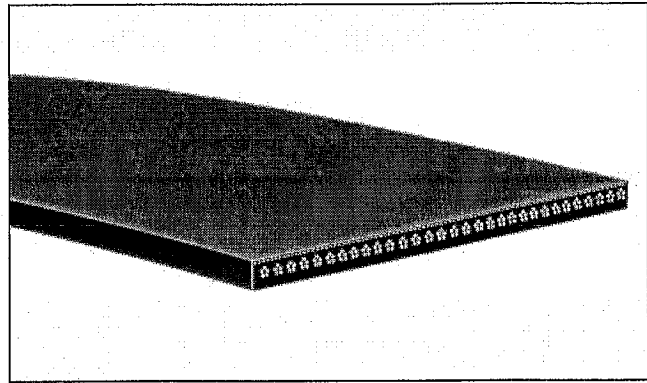
Recommended for the toughest shock load applications, especially on drives that can't be shut down for retensioning after initial belt run-in. Reinforced with an aramid fiber tensile (pound for pound stronger than steel), Power Cable belts last longer and costs less than steel cable belts.



BELT STYLES

Flat Belts

Gates Speed-Flex® Belts, are designed for high speed applications such as drill presses, lathes, grinders and other woodworking equipment. Gates Powercord® Belts are designed for general purpose, lower speed applications. Flat belts are specified by belt **Width** and required **Inside Diameter**.



Static Conductive Belts

Rubber Manufacturers' Association (RMA) has published **Bulletin IP 3-3** for static conductivity. Static conductivity testing involves passing an electrical current of specified voltage through a section of belt and then measuring the belt's resistance to conduct the current. A resistance reading of six (6) megohms or more constitutes a test failure. Past testing has demonstrated that six (6) megohms or less is sufficient to prevent measurable static voltage buildup, thus preventing a static discharge.

A static discharge can interfere with radios and electronic instruments or controls used in your facility. It can also cause bearing pitting if the discharge occurs through the bearing. Static discharge can pose a hazard on drives that operate within potentially explosive environments.

V-belts are generally manufactured in accordance with the RMA bulletin, but you must check the static conductivity with the manufacturer.

PowerGrip® and Poly Chain® belts do not meet the static conductivity requirements specified in RMA Bulletin IP-3-3/1995.

The RMA bulletin applies to new, clean belts. Belts can collect debris or become worn and damaged and prevent a circuit, thus negating the static conductivity of the belt.

When a belt is used in a hazardous environment, we recommend that additional protection be taken to assure no accidental static spark discharges. The entire system must be properly grounded. A static-conductive brush or similar device is recommended to bleed off any static buildup on the belt that might occur.

BELT DRIVE PERFORMANCE & TROUBLESHOOTING

To provide proper maintenance, you must understand the nature of the belt drives in your plant. You know the expected belt service life on each drive, and you are aware of the capabilities and limitations of this equipment.

On occasion, however, it is necessary to give some thought to belt service life, especially in these situations:

- When belt service life is meeting expectations, but you would like to reduce existing maintenance costs and down time.
- When belt service life is below the expected performance level and the situation must be improved.

Upgrade Drive Performance

A belt drive can sometimes be upgraded to improve performance. The first step is to see if simple improvements can be made at minimal costs. This involves checking the drive design for adequate capacity.

If further improvement is needed, the next step is to upgrade the drive to a higher performance belt system.

Here are examples of minor changes that could improve performance.

- Increase pulley diameters
- Increase the number of belts, or use wider belt
- Add vibration dampening to system
- Improve guard ventilation to reduce operating temperature
- Use at least the correct, minimum recommended pulley diameters on inside and backside idlers
- Use premium belts rather than general purpose types
- Replace pulleys when they are worn
- Keep pulleys properly aligned
- Place idler on span with lowest tension and as close to drives as possible
- Re-tension newly installed belts after a 4 - 24 hour run-in period
- Review proper belt installation and maintenance procedures

BELT DRIVE PERFORMANCE & TROUBLESHOOTING

The Gates Rubber Company is the recognized industry leader in product innovation and belt drive technology. New products and applications are continually made available to Gates customers. Here are examples of advanced Gates belt innovations.

Advanced Gates Belt Innovations

- Poly Chain® GT*2 positive drive (synchronous) belts
- Power Grip® GT2
- Polyflex® JB® belts
- Power Cable® belts
- PoweRated® light-duty V-belts
- Nu-T-Link* spliced belting
- Super HC® Molded Notch V-belts
- Predator™ Powerband belts
- Vextra™ technology

*Registered Trademark of Fenner-Manheim.

Your local Gates distributor or representative can work with you to upgrade your existing drives and reduce your maintenance and down time costs.

Or, you may have a problem or excessive maintenance costs with a non-belt drive, such as gear or chain. Again, your local Gates distributor or representative can offer you excellent advice as to whether or not a belt drive could solve the problem and reduce your maintenance costs.

Improving Poor Drive Performance

If your belt drive system is properly designed, installed and maintained, it will need very little attention. Occasionally, however, a drive can be accidentally damaged or knocked out of adjustment.

Changing operating requirements or environmental conditions can also create problems.

Design Performance Grouping – PowerGrip GT				
PowerGrip GT – 8 & 14mm Belts can be used to replace other non-Gates curvilinear belts in the same width				
Company	Product Trade Name	Nomenclature	Belt-Pitch	Profile
Bando	Synchro-Link – HT	1600-8M-20-H	8 & 14mm	HTD
Dodge	HT100	1600-8M-20-HT100	8 & 14mm	HTD
Electron	EHT	1600-8M-20	8 & 14mm	HTD
Gates	HTD	1600-8M-20	8 & 14mm	HTD
Jason	HTB	1600-8M-20	8 & 14mm	HTD
MBL	HTT	1600-8M-20	8 & 14mm	HTD
Opti Belt	HTD	1600-8M-20	8 & 14mm	HTD
Browning	HPT	1610-14M-40	14mm	RPP
Dayco	RPP	1610-14M-40	14mm	RPP
Goodyear	HPPD	1610-14M-40	14mm	RPP
T.B. Woods	RPP	1610-14M-40	14mm	RPP
Thermod	Syncho-Curve Timing	1610-14M-40	14mm	RPP

Design Performance Grouping – PowerGrip GT2				
PowerGrip GT2 – 8 & 14mm Belts can be used to replace other non-Gates curvilinear belts in the next smallest width				
Company	Product Trade Name	Nomenclature	Belt-Pitch	Profile
Bando	Synchro-Link – HT	1600-8M-20-H	8 & 14mm	HTD
Dodge	HT100	1600-8M-20-HT100	8 & 14mm	GT
Electron	EHT	1600-8M-20	8 & 14mm	HTD
Gates	HTD	1600-8M-20	8 & 14mm	HTD
Jason	HTB	1600-8M-20	8 & 14mm	HTD
MBL	HTT	1600-8M-20	8 & 14mm	HTD
Opti Belt	HTD	1600-8M-20	8 & 14mm	HTD
Browning	HPT	1610-14M-40	14mm	RPP
Dayco	RPP	1610-14M-40	14mm	RPP
Goodyear	HPPD	1610-14M-40	14mm	RPP
T.B. Woods	RPP	1610-14M-40	14mm	RPP
Thermod	Syncho-Curve Timing	1610-14M-40	14mm	RPP
Dayco	RPP Plus	1610-14M-40	14mm	RPP
Dayco	HPR	1610-14M-40	14mm	RPP
Dodge	HT150	1610-14M-40-HT-150	8 & 14mm	GT
T.B. Woods	RPP Plus	1610-14M-40	14mm	RPP
T.B. Woods	HPR	1610-14M-40	14mm	RPP
Competitors Width 8mm – Pitch	PowerGrip GT2 – Width 8mm – Pitch	Competitors Width 14mm – Pitch	PowerGrip GT2 – Width 14mm – Pitch	
20	20	40	40	
30	20	55	40	
50	30	85	55	
85	50	115	85	

TROUBLESHOOTING GUIDE

When troubleshooting a drive problem, your goal is to identify the cause(s), then take appropriate corrective action. We have developed a worksheet to help you with this process. Here is how to use it.

1. Describe your drive problem as accurately as possible. Use Step 1 as a guide. Use this step as a guide in the troubleshooting process.
2. Go through the list of "Drive Symptoms". Check those symptoms you observe and record them, as well as your observations of anything unusual about the drive.
3. Go through the "Probable Cause and Action Summary Table". List the probable cause(s) and corrective action. Also, review your list of observations.
4. Note your completed list of probable cause(s) and corrective action. Also, review your list of observations.
5. Determine if these two lists spotlight a particular problem source.

What to Do When All Else Fails

We've covered all of the most common belt drive problems you might encounter. However, if the problem still exists after all of your troubleshooting efforts have been exhausted, contact your Gates distributor. If he cannot solve the problem for you, he'll put you in touch with a qualified Gates representative.



TROUBLESHOOTING GUIDE

Step 1

Describe the problem

- *What is wrong?*
- *When did it happen?*
- *How often does it happen?*
- *What is the drive application?*
- *Have the machine operations or output changed?*
- *What kind of belt(s) are you using?*
- *What are your expectations for belt performance in this application?*

Step 2

Identify symptoms and record observations of anything unusual.

Drive Symptoms Check List

(Check those you observe)

- **Banded (Joined) Belt Problems**
 - Tie-band separation
 - Top of tie-band frayed, worn or damaged
 - Band comes off drive
 - One or more ribs run outside of pulley
- **V-belt Turns Over or Jumps off Sheave**
 - Single belt
 - One or more belts in a set
 - Joined or banded belts
- **Belt Stretches Beyond Take-Up**
 - Single belt
 - Multiple belts stretch unequally
 - All belts stretch equally
- **Premature Belt Failure**
 - Broken belt(s)
 - Belt(s) fail to carry load (slip). No visible reason
 - Edge cord failure
 - Belt delamination or undercord separation
- **Severe or Abnormal Belt Wear**
 - Wear on belt top surface
 - Wear on top corners of belt
 - Wear on belt sidewall
 - Wear on belt bottom corners
 - Wear on bottom surface of belt
 - Undercord cracking
 - Burn or hardening on bottom or sidewall
 - Belt surface flaking, sticky or swollen
 - Belt stretch
 - Extensive hardening of belt exterior

TROUBLESHOOTING GUIDE

All V-Belt Drives


- **Belt Noise**
 - Squeal or "chirp"
 - Slapping noise
 - Rubbing sound
 - Grinding
 - Unusually loud drive
- **Unusual Vibration**
 - Belts flopping
 - Excessive vibration in drive system
- **Problem With Pulleys**
 - Broken or damaged
 - Severe, rapid groove wear
- **Problems With Drive Components**
 - Bent or broken shafts
 - Damaged guard
- **Problems With Take Up**
 - Make sure you are using Gates belts
 - Not all belts are same

All Synchronous Belt Drives

- **Belt Problems**
 - Unusual noise
 - Tension loss
 - Excessive belt edge wear
 - Tensile break
 - Cracking
 - Premature tooth wear
 - Tooth shear
 - Belt ratcheting
 - Land area worn
- **Hot Bearings**
- **Performance Problems**
 - Incorrect driveN speeds
- **Sprocket Problems**
 - Flange failure
 - Unusual wear
- **Performance Problems**
 - Belt tracking problems
 - Excessive temperature: bearings, housings, shafts, etc.
 - Shafts out of sync
 - Vibration


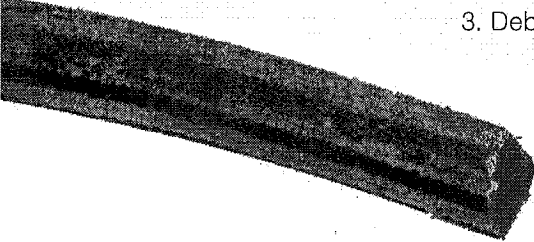
PROBLEM/SOLUTION SUMMARY TABLE

Premature Belt Failure

Symptoms	Probable Cause	Corrective Action
<ul style="list-style-type: none"> Broken belt(s) 	<ol style="list-style-type: none"> Under-designed drive Belt rolled or pried onto sheave Object falling into drive Severe shock load 	<ol style="list-style-type: none"> Redesign, using Gates manual. Use drive take-up when installing. Provide adequate guard or drive protection. Redesign to accommodate shock load.
<ul style="list-style-type: none"> Belts fail to carry load, no visible reason 	<ol style="list-style-type: none"> Underdesigned drive Damaged tensile member Worn sheave grooves Center distance movement 	<ol style="list-style-type: none"> Redesign, using Gates manual. Follow correct installation procedure. Check for groove wear; replace as needed. Check drive for center distance movement during operation.
<ul style="list-style-type: none"> Edge cord failure 	<ol style="list-style-type: none"> Pulley misalignment Damaged tensile member 	<ol style="list-style-type: none"> Check alignment and correct. Follow correct installation procedure.
<ul style="list-style-type: none"> Belt de-lamination or undercord separation 	<ol style="list-style-type: none"> Too small sheaves Use of too small backside idler 	<ol style="list-style-type: none"> Check drive design, replace with larger sheaves. Increase backside idler to acceptable diameter.

PROBLEM/SOLUTION SUMMARY TABLE

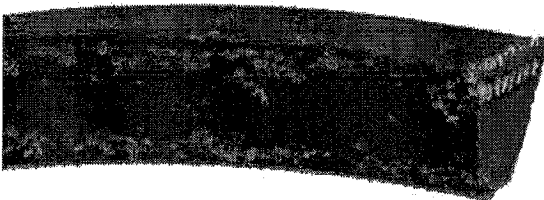
Severe or Abnormal V-Belt Wear

Symptoms	Probable Cause	Corrective Action
<ul style="list-style-type: none"> Wear on top surface of belt 	<ol style="list-style-type: none"> Rubbing against guard Idler malfunction 	<ol style="list-style-type: none"> Replace or repair guard. Replace idler.
<ul style="list-style-type: none"> Wear on top corner of belt 	<ol style="list-style-type: none"> Belt-to-sheave fit incorrect (belt too small for groove) 	<ol style="list-style-type: none"> Use correct belt-to-sheave combination.
<ul style="list-style-type: none"> Wear on belt sidewalls 	<ol style="list-style-type: none"> Belt slip Misalignment Worn sheaves Incorrect belt 	<ol style="list-style-type: none"> Retention until slipping stops. Realign sheaves. Replace sheaves. Replace with correct belt size.
<ul style="list-style-type: none"> Wear on bottom corner of belt 	<ol style="list-style-type: none"> Belt-to-sheave fit incorrect Worn sheaves 	<ol style="list-style-type: none"> Use correct belt-to-sheave combination. Replace sheaves.
<ul style="list-style-type: none"> Wear on bottom surface of belt 	<ol style="list-style-type: none"> Belt bottoming on sheave groove Worn sheaves Debris in sheaves 	<ol style="list-style-type: none"> Use correct belt/sheave match. Replace sheaves. Clean sheaves.
<ul style="list-style-type: none"> Undercord cracking 	<ol style="list-style-type: none"> Sheave diameter too small Belt slip Backside idler too small Improper storage 	<ol style="list-style-type: none"> Use larger diameter sheaves. Retention. Use larger diameter backside idler. Don't coil belt too tightly, kink or bend. Avoid heat and direct sunlight.

PROBLEM/SOLUTION SUMMARY TABLE

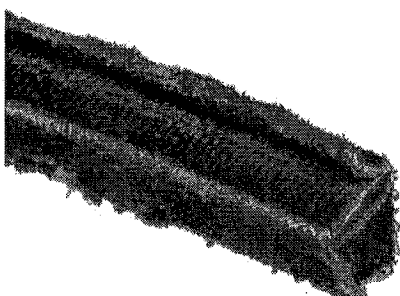
Severe or Abnormal V-Belt Wear-cont.

Symptoms	Probable Cause	Corrective Action
<ul style="list-style-type: none"> Undercord or sidewall burn or hardening 	<ol style="list-style-type: none"> Belt slipping Worn sheaves Underdesigned drive Shaft movement 	<ol style="list-style-type: none"> Retension until slipping stops. Replace sheaves. Refer to Gates drive manual. Check for center distance changes.
<ul style="list-style-type: none"> Belt surface hard or stiff 	<ol style="list-style-type: none"> Hot drive environment 	<ol style="list-style-type: none"> Improve ventilation to drive.
<ul style="list-style-type: none"> Belt surface flaking, sticky or swollen 	<ol style="list-style-type: none"> Oil or chemical contamination 	<ol style="list-style-type: none"> Do not use belt dressing. Eliminate sources of oil, grease or chemical contamination.



V-Belts Turn Over or Come Off Drive

Symptoms	Probable Cause	Corrective Action
<ul style="list-style-type: none"> Involves single or multiple belts 	<ol style="list-style-type: none"> Shock loading or vibration Foreign material in grooves Misaligned sheaves Worn sheave grooves Damaged tensile member Incorrectly placed flat idler Mismatched belt set Poor drive design 	<ol style="list-style-type: none"> Check drive design. Use Gates PowerBand® belts or Power Cable® belts. Shield grooves and drive. Realign the sheaves. Replace sheaves. Use correct installation and belt storage procedure. Carefully align flat idler on slack side of drive as close as possible to driveR sheaves. Replace with new set of matched belts. Do not mix old and new belts. Check for center distance stability and vibration dampening.



PROBLEM/SOLUTION SUMMARY TABLE

Belt Stretches Beyond Available Take-Up

Symptoms	Probable Cause	Corrective Action
• Multiple belts stretch unequally	<ol style="list-style-type: none"> 1. Misaligned drive 2. Debris in sheaves 3. Broken tensile member or cord damaged 4. Mismatched belt set 	<ol style="list-style-type: none"> 1. Realign and retension drive. 2. Clean sheaves. 3. Replace all belts, install properly. 4. Install matched belt set.
• Single belt, or where all belts stretch evenly	<ol style="list-style-type: none"> 1. Insufficient take-up allowance 2. Grossly overloaded or under designed drive 3. Broken tensile members 	<ol style="list-style-type: none"> 1. Check take-up. Use allowance specified in Gates design manuals. 2. Redesign drive. 3. Replace belt, install properly.

Belt Noise

Symptoms	Probable Cause	Corrective Action
• Belt squeals or chirps	<ol style="list-style-type: none"> 1. Belt slip 2. Contamination 	<ol style="list-style-type: none"> 1. Retension. 2. Clean belts and sheaves.
• Slapping Sound	<ol style="list-style-type: none"> 1. Loose belts 2. Mismatched set 3. Misalignment 	<ol style="list-style-type: none"> 1. Retension. 2. Install matched belt set. 3. Realign pulleys so all belts share load equally.
• Rubbing sound	<ol style="list-style-type: none"> 1. Guard interference 	<ol style="list-style-type: none"> 1. Repair, replace or redesign guard.
• Grinding sound	<ol style="list-style-type: none"> 1. Damaged bearings 	<ol style="list-style-type: none"> 1. Replace, align & lubricate.
• Unusually loud drive	<ol style="list-style-type: none"> 1. Incorrect belt 2. Incorrect Tension 3. Worn sheaves 4. Debris in sheaves 	<ol style="list-style-type: none"> 1. Use correct belt size. Use correct belt tooth profile for sprockets on synchronous drive. 2. Check tension and adjust 3. Replace sheaves 4. Clean sheaves, improve shielding, remove rust, paint, or remove dirt from grooves.

Unusual Vibration

Symptoms	Probable Cause	Corrective Action
• Belts flopping	<ol style="list-style-type: none"> 1. Loose belts (under tensioned) 2. Mismatched belts 3. Pulley misalignment 	<ol style="list-style-type: none"> 1. Retension. 2. Install new matched set. 3. Align pulley
• Unusual or excessive vibration	<ol style="list-style-type: none"> 1. Incorrect belt 2. Poor machine or equipment design 3. Pulley out of round 4. Loose drive components 	<ol style="list-style-type: none"> 1. Use correct belt cross section in pulley. Use correct tooth profile and pitch in sprocket. 2. Check structure and brackets for adequate strength. 3. Replace with non-defective pulley. 4. Check machine components and guards, motor mounts, motor pads, bushings, brackets and framework for stability adequate design strength, proper maintenance and proper installation.

PROBLEM/SOLUTION SUMMARY TABLE

Problems With Sheaves

Symptoms	Probable Cause	Corrective Action
• Broken or damaged sheave	<ol style="list-style-type: none"> 1. Incorrect sheave installation 2. Foreign objects falling into drive 3. Excessive rim speeds 4. Incorrect belt installation 	<ol style="list-style-type: none"> 1. Do not tighten bushing bolts beyond recommended torque values. 2. Use adequate drive guard. 3. Keep pulley rim speeds below maximum recommended value. 4. Do not pry belts onto pulleys.
• Severe Groove Wear	<ol style="list-style-type: none"> 1. Excessive belt tension 2. Sand, debris or contamination 3. Wrong belt 	<ol style="list-style-type: none"> 1. Retension, check drive design. 2. Clean and shield drive as well as possible. 3. Make sure belt and sheave combination is correct.

Problem With Other Drive Components

Symptoms	Probable Cause	Corrective Action
• Bent or broken shaft	<ol style="list-style-type: none"> 1. Extreme belt overtension 2. Overdesigned drive* 3. Accidental damage 4. Machine design error 5. Accidental damage to guard or poor guard design 6. Pulley mounted too far away from outboard bearing 	<ol style="list-style-type: none"> 1. Retension 2. Check drive design, may need to use smaller or fewer belts. 3. Redesign drive guard. 4. Check machine design. 5. Repair, redesign for durability. 6. Move pulley closer to bearing.

Hot Bearings

Symptoms	Probable Cause	Corrective Action
• Drive needs overtensioning	<ol style="list-style-type: none"> 1. Worn grooves - belts bottoming and won't transmit power until overtensioned* 2. Improper tension 	<ol style="list-style-type: none"> 1. Replace sheaves. Tension drive properly. 2. Retension.
• Sheaves too small	<ol style="list-style-type: none"> 1. Motor manufacturer's sheave diameter recommendation not followed 	<ol style="list-style-type: none"> 1. Redesign using drive manual.
• Poor bearing condition	<ol style="list-style-type: none"> 1. Bearing underdesigned 2. Bearing not properly maintained 	<ol style="list-style-type: none"> 1. Check bearing design. 2. Align and lubricate bearing.
• Sheaves too far out on shaft	<ol style="list-style-type: none"> 1. Error or obstruction problem 	<ol style="list-style-type: none"> 1. Place sheaves as close as possible to bearings. Remove obstructions
• Belt slippage	<ol style="list-style-type: none"> 1. Drive undertensioned 	<ol style="list-style-type: none"> 1. Retension.


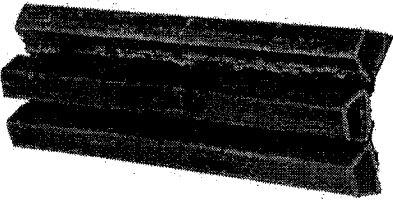
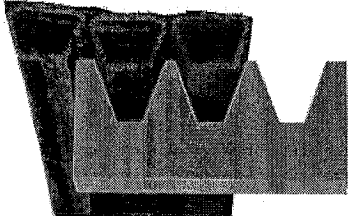
Performance Problems

Symptoms	Probable Cause	Corrective Action
• Incorrect driveN speed	<ol style="list-style-type: none"> 1. Design error 2. Belt slip 	<ol style="list-style-type: none"> 1. Use correct driveR/driveN sheave size for desired speed ratio. 2. Retension driveR. Use synchronous belt.

* Using too many belts, or belts that are too large, can severely stress motor or driveN shafts. This can happen when load requirements are reduced on a drive, but the belts are not redesigned accordingly. This can also happen when a drive is greatly overdesigned. Forces created from belt tensioning are too great for the shafts.

PROBLEM/SOLUTION SUMMARY TABLE

Problems With Banded (Joined) Belts

Symptoms	Probable Cause	Corrective Action
<ul style="list-style-type: none"> Tie band separation 	<ol style="list-style-type: none"> Worn sheaves Improper groove spacing 	<ol style="list-style-type: none"> Replace sheaves. Use standard groove sheaves.
<ul style="list-style-type: none"> Top of tie band frayed or worn 	<ol style="list-style-type: none"> Interference with guard Backside idler malfunction or damaged 	<ol style="list-style-type: none"> Check guard. Replace or repair backside idler
<ul style="list-style-type: none"> PowerBand® belt comes off drive repeatedly 	<ol style="list-style-type: none"> Debris in sheaves Misalignment 	<ol style="list-style-type: none"> Clean grooves. Use single belts to prevent debris from being trapped in grooves. Realign drive.
<ul style="list-style-type: none"> One or more "ribs" runs out of pulley 	<ol style="list-style-type: none"> Misalignment Undertensioned 	<ol style="list-style-type: none"> Realign drive. Retension.

Problems With Synchronous Belts

Symptoms	Probable Cause	Corrective Action
<ul style="list-style-type: none"> Unusual noise 	<ol style="list-style-type: none"> Misaligned drive Too low or high tension Backside idler Worn sprocket Bent guide flange Belt speed too high Incorrect belt profile for sprocket (i.e. HTD, GT®, etc.) Subminimal diameter Excess load 	<ol style="list-style-type: none"> Correct alignment. Adjust to recommended value Use inside idler. Replace. Replace. Redesign drive. Use proper belt/sprocket combination. Redesign drive using larger diameters. Redesign drive for increased capacity.

PROBLEM/SOLUTION SUMMARY TABLE

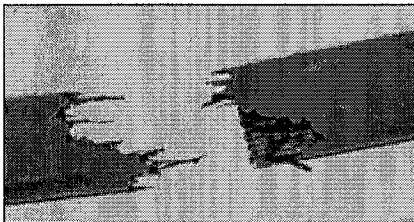
Tension Loss

- | | |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ol style="list-style-type: none"> 1. Weak support structure 2. Excessive sprocket wear 3. Fixed (non-adjustable) centers 4. Excessive debris 5. Excessive load 6. Subminimal diameter 7. Belt, sprocket or shafts running too hot 8. Unusual belt degradation | <ol style="list-style-type: none"> 1. Reinforce structure. 2. Use alternate sprocket material. 3. Use inside idler for belt adjustment. 4. Remove debris, check guard. 5. Redesign drive for increased capacity. 6. Redesign drive using larger diameters. 7. Check for conductive heat transfer from prime mover. 8. Reduce ambient drive temperature to 185°F maximum. |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

Excessive Belt Edge Wear

- | | |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ol style="list-style-type: none"> 1. Damage due to handling 2. Flange damage 3. Belt too wide 4. Belt tension too low 5. Rough flange surface finish 6. Improper tracking 7. Belt hitting drive guard or bracketry 8. Misalignment | <ol style="list-style-type: none"> 1. Follow proper handling instructions. 2. Repair flange or replace sprocket. 3. Use proper width sprocket. 4. Adjust tension to recommended value. 5. Replace or repair flange (to eliminate abrasive surface). 6. Correct alignment. 7. Remove obstruction or use inside idler. 8. Realign drive |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

Tensile Break



- | | |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ol style="list-style-type: none"> 1. Excessive shock load 2. Subminimal diameter 3. Improper belt handling and storage prior to installation (crimping) 4. Debris or foreign object in drive 5. Extreme sprocket run-out | <ol style="list-style-type: none"> 1. Redesign drive for increased capacity. 2. Redesign drive using larger diameters. 3. Follow proper storage and handling procedures. 4. Remove objects and check guard. 5. Replace sprocket. |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

Belt Cracking

- | | |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ol style="list-style-type: none"> 1. Subminimal diameter 2. Backside idler 3. Extreme low temperature at start-up. 4. Extended exposure to harsh chemicals 5. Cocked bushing/sprocket assembly | <ol style="list-style-type: none"> 1. Redesign drive using larger diameter. 2. Use inside idler or increase diameter of backside idler. 3. Pre-heat drive environment. 4. Protect drive. 5. Install bushing per instructions. |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

Premature Tooth Wear



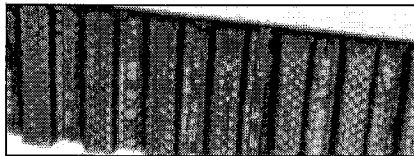
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|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ol style="list-style-type: none"> 1. Too low or high belt tension 2. Belt running partly off unflanged sprocket 3. Misaligned drive 4. Incorrect belt profile for sprocket (i.e. HTD, GT®, etc) 5. Worn sprocket 6. Rough sprocket teeth | <ol style="list-style-type: none"> 1. Adjust to recommended value. 2. Correct alignment. 3. Correct alignment. 4. Use proper belt/sprocket combination. 5. Replace. 6. Replace sprocket |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

PROBLEM/SOLUTION SUMMARY TABLE

Premature Tooth Wear-cont.

- | | |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> 7. Damaged sprocket 8. Sprocket not to dimensional specification 9. Belt hitting drive bracketry or other structure 10. Excessive load 11. Insufficient hardness of sprocket material 12. Excessive debris 13. Cocked bushing/sprocket assembly | <ul style="list-style-type: none"> 7. Replace. 8. Replace. 9. Remove obstruction or use idler 10. Redesign drive for increased capacity 11. Use a more wear-resistant sprocket 12. Remove debris, check guard. 13. Install bushing per instructions. |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

Tooth Shear

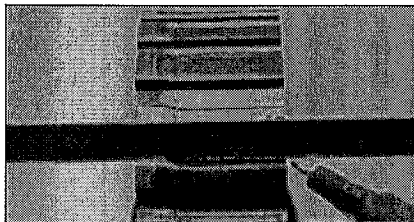


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|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> 1. Excessive shock loads 2. Less than 6 teeth-in-mesh 3. Extreme sprocket run-out 4. Worn sprocket 5. Backside idler 6. Incorrect belt profile for the sprocket (i.e. HTD, GT®, etc.) 7. Misaligned drive 8. Belt undertensioned | <ul style="list-style-type: none"> 1. Redesign drive for increased capacity. 2. Redesign drive. 3. Replace sprocket. 4. Replace. 5. Use inside idler 6. Use proper belt/sprocket combination. 7. Realign. 8. Adjust tension to recommended value. |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

Flange Failure

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|------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> 1. Belt forcing flange off | <ul style="list-style-type: none"> 1. Correct alignment or properly secure flange to sprocket. |
|------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|

Unusual Sprocket Wear



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|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> 1. Sprocket has too little wear resistance (i.e. plastic, aluminum, soft metals) 2. Misaligned drive 3. Excessive debris 4. Excessive load 5. belt tension too low or high 6. Incorrect belt profile (i.e. HTD, GT, etc.) | <ul style="list-style-type: none"> 1. Use alternate sprocket material. 2. Correct alignment. 3. Remove debris, check guard. 4. Redesign drive for increased capacity. 5. Adjust tension to recommended value. 6. Use proper belt/sprocket combination. |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

Belt Tracking

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|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> 1. Belt running partly off unflanged sprocket 2. Centers exceed 8 times small sprocket diameter and both sprockets are flanged. 3. Excessive belt edge wear | <ul style="list-style-type: none"> 1. Correct alignment. 2. Correct parallel alignment to set belt to track on both sprockets. 3. Correct alignment. |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

Excessive Temperature (Belt, Bearing, Housing, Shafts, etc.)

- | | |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> 1. Misaligned drive 2. Too low or high belt tension 3. Incorrect belt profile (i.e. HTD, GT, etc.) | <ul style="list-style-type: none"> 1. Correct alignment. 2. Adjust tension to recommended value. 3. Use proper belt/sprocket combination. |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

Shafts Out of Sync

- | | |
|----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> 1. Design error 2. Incorrect belt | <ul style="list-style-type: none"> 1. Use correct sprocket sizes. 2. Use correct belt with correct tooth profile for grooves. |
|----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|

Vibration

- | | |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> 1. Incorrect belt profile for the sprocket (i.e. HTD, GT, etc.) 2. Too low or high belt tension 3. Bushing or key loose | <ul style="list-style-type: none"> 1. Use proper belt/sprocket combination. 2. Adjust tension to recommended value. 3. Check and reinstall per instructions. |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

TROUBLESHOOTING TOOLS

You are faced with a problem drive and must determine the cause. The tools available to help you troubleshoot range from the surprisingly simple to complicated. Following is a list of tools you can use to effectively diagnose a problem. While Gates does not sell most of the items discussed in this section, unless noted, the items are readily available from industrial instrumentation outlets throughout the United States.

Eyes, Ears, Nose & Hands

When troubleshooting a belt drive problem, stand back and observe the drive while it is in operation and at rest. Do you smell warm rubber? Can you see anything unusual about the way the belt travels around the drive? Is the drive frame flexing under load? Do you hear chirping, squealing or grinding noises? Is there an accumulation of fabric dust beneath the drive which might interfere with the belts?

Squirt Bottle With Soapy Water

When a belt drive is excessively noisy, the belt is often incorrectly blamed. It is easy to eliminate the belt as the problem by spraying it with soapy water while it is running. If the noise goes away, or decreases, then the belt is part of the problem. If you still hear the same noise, the problem is likely due to other drive components.

Ball Of String

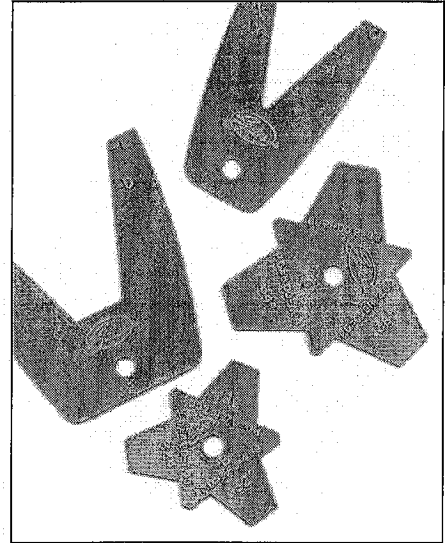
Variation in drive center distance, often caused by weak supporting structure, can cause problems from vibration to short belt life. To determine if center distance variation exists, turn off the drive and tightly tie a piece of string from the driver to the driven shaft. Start up the drive and note if the string stretches almost to the point of breaking, or goes slack. If either is the case, the problem could be center distance variation. It is particularly important to observe the string right at drive start up when the loads are highest. String can also be used to check pulley alignment.

Belt & Sheave Groove Gauges

If you suspect a belt-to-sheave groove mismatch, English and metric belt and sheave groove gauges can be used to check dimensions. These also are handy for identifying a belt cross section for replacements and for checking sheave grooves for wear.

These gauges are available from your belt supplier. For price information, contact your Gates distributor.

English Gauge:
Form #13998
Metric Gauge:
Form #13998-M



Long Straight Edge

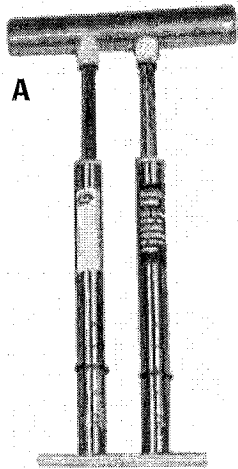
While V-Belts can be somewhat forgiving of misalignment, this condition can still affect V-Belt performance. Even slight misalignment can cause major problems on a synchronous drive. Use a long straight edge, made of wood, metal or any rigid material, to quickly check drive alignment. Simply lay the straight edge across the pulley faces and note the points of contact (or lack of contact).

Design Flex® and Design View®

Gates design suite of engineering programs include interactive support software and a user friendly interface for rapid data retrieval and smooth design work.

NOTE: In some cases redesign of the drive is necessary. Gates Drive Design software provides a quick, accurate and flexible method of correctly redesigning problem drives.

TROUBLESHOOTING TOOLS



Belt Tension Testers

Improper belt tension, either too high or too low, can cause belt drive problems. An "experienced" thumb may be okay for ordinary drives, but for critical drives, Gates recommends using a tension gauge. Proper tension and installation can extend belt life and reduce costly downtime.

Several types of tension gauges are available.

A. "Double Barrel" Tension Tester (Product No. 7401-0075)

Maximum deflection force: 66 lbs. For use with all multiple V-Belt and large synchronous drives, including PowerBand® and Poly Chain® GT® belt drives.

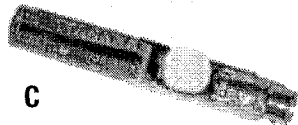
*A 5-Barrel Tension Tester is also available. Contact your Gates representative for details.

B. Tension Tester (Pencil Type) (Product No. 7401-0076)

Maximum deflection force: 30 lbs. For use with all small V-Belt and synchronous drives, including PowerBand and Poly Chain GT belt drives.

The pencil type tension testers are recommended for use with:

- Super HC V-Belts
- Hi Power II V-Belts
- PowerBand Belts
- Poly Chain GT2 Belts
- PowerGrip GT2 Belts



C. Krikit Gauge (Product No. 7401-0071)

For use with:
•Automotive V-Belts

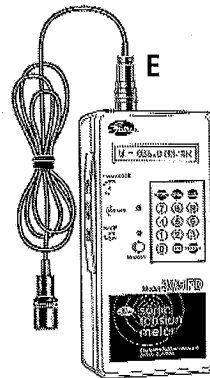
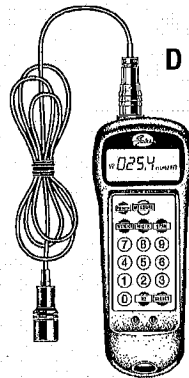
D. Sonic Tension Meter

Now!- More compact and easy to use.

For extremely accurate belt tension measuring, the Gates Sonic Tension Meter is an electronic device that measures the natural frequency of a free stationary belt span and instantly computes the static belt tension based upon the belt span length, belt width and belt type.

Features:

- Uses sound waves instead of force/deflection.
- Results are repeatable with any operator.
- Portable, lightweight and easy to use.
- Fast. Calculates tension in seconds.
- Can be used in almost any environment.
- Model 505C runs on two AAA batteries.
- Model 305FD runs on four AAA batteries.
- Model 305FD connects to a computer for data downloading.



D. Model 505C - Product No. 7420-0201

E. Model 305FD - Product No. 7420-0203

Accessories:

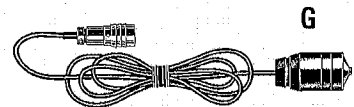
F. Flexible Sensor - Product No. 7420-0204 (Optional with 505C)

G. Optional Inductive Sensor - Product No. 7420-0212

Both Models:

For use with these belts:

- All synchronous belts
- Micro-V® belts
- Polyflex® belts



TROUBLESHOOTING TOOLS

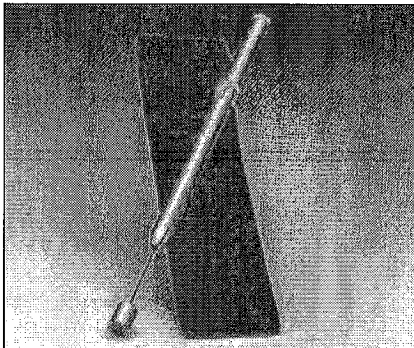
Tension Gauge

Improper belt tension, either too high or too low, can cause belt drive problems. Several types of tension gauges are available; see page 35. An inexpensive pencil type is adequate for most situations. See your local Gates distributor for price and availability.



Vibrotach Tachometer

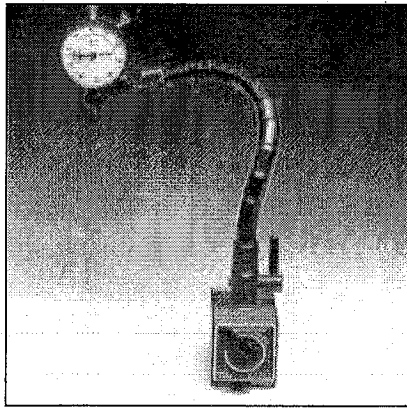
This tool can be used to isolate the forcing frequency behind vibration problems. It is a small, hand-held device which can be butted up against the vibrating equipment. A thin metal reed protrudes from the end, the length of which can be varied. As you vary the length, the reed will vibrate wildly at some point. The tachometer scale then gives you the forcing rpm or frequency. Once the system frequencies are identified, it is easy to trace and correct the source of the problem.



Available from:
Martin Engineering Co.
U.S. route 34
Neponset, IL 61345
1-800-544-2947

Dial Indicator

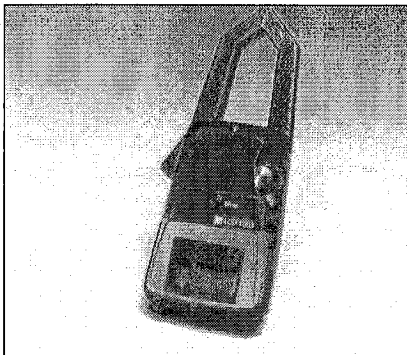
Improperly mounted sheaves or out-of-round pulleys are sometimes the root of vibration or more severe problems. This device can be used to measure side-to-side sheave wobble or diameter variation by holding it up to the sheave sidewall or top of the belt inside the pulley groove, respectively. **IMPORTANT:** Always turn off the machine before using the dial indicator. Rotate the drive by hand to make your measurements.



Clamp-On Ammeter

If belts are failing prematurely, it's possible the drive load was underestimated when the drive was designed. Use the ammeter to check the actual load being delivered by an electric motor. The clamp-on style allows you to do this safely, without baring wires or worrying about electrical connections.

This tool also can be used to troubleshoot vibration problems if they are caused by electrical sources such as arcing switches, power surges or electrical connections.

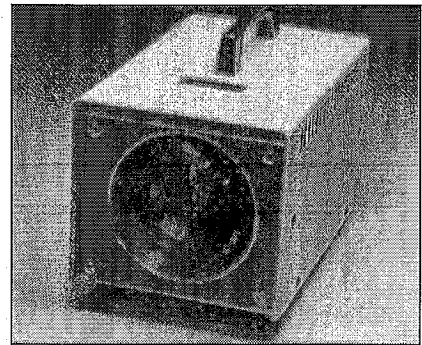


Needle Pyrometer

The pyrometer allows you to accurately measure internal and external belt temperatures.

Strobe Tachometer

You cannot always see what is happening to a drive while it is in operation. This instrument allows you to stop the action to get a better idea of the dynamic forces affecting the drive. The strobe tachometer is best used after initial diagnosis of the problem because it helps pinpoint the cause. It will help you identify such things as single or dual mode belt span vibration and frame flexure.



DotLine Laser Tool

- Compact design
- Includes an adjustable pivoting mounting arm
- Laser projects either a dot or a line
- Laser line is very easy to read on targets
- Adjustable targets for custom sheave/sprocket edge thickness available
- Includes a hard foam filled plastic carrying case



TECHNICAL INFORMATION

Table No. 1

Belt Section, Sheave Diameters and Standard Groove Angles*

Belt Section	Sheave Datum Diameter (D.D.) (In.)	Standard Groove Angle ($\pm 0.20^\circ$)
A, AX	Up to 5.4	34
A, AX	Over 5.4	38
B, BX	Up to 7.0	34
B, BX	Over 7.0	38
C, CX	Up to 7.99	34
C, CX	8.0 to 12.0	36
C, CX	Over 12.0	38
D	Up to 12.99	34
D	13.0 to 17.0	36
D	Over 17.0	38
E	Up to 24.0	36
E	Over 24.0	38
Belt Section	Sheave Outside Diameter (O.D.) (In.)	Standard Groove Angle ($\pm 0.20^\circ$)
3V, 3VX	Up to 3.49	36
3V, 3VX	3.50 to 6.00	38
3V, 3VX	6.0 to 12.00	40
3V, 3VX	Over 12.00	42
5V, 5VX	Up to 9.99	38
5V, 5VX	10.00 to 16.0	40
5V, 5VX	Over 16.00	42
8V	Up to 15.99	38
8V	16.00 to 22.4	40
8V	Over 22.4	42

Table No. 2

Maximum Allowable Outside Diameters For Cast Iron Pulleys

Maximum Shaft Speed (RPM)	Maximum Allowable Pulley Diameter (In.)
600	41.4
870	28.5
1,160	21.4
1,400	17.7
1,600	15.5
1,750	14.2
2,000	12.4
2,400	10.3
2,800	8.8
3,000	8.3
3,450	7.2
4,000	6.2
4,500	5.5
5,000	5.0
7,500	3.31
10,000	2.48

*For these data on Micro-V[®] and Polyflex[®] JB[™] belts, refer to Micro-V Drive Design Manual 15408 and Polyflex JB Drive Design Manual 18595.

TECHNICAL INFORMATION

Electric Motor Frames Assignments and Minimum V-Belt Sheave Diameters

Table No. 3A

The National Electric Manufacturers Association (NEMA) publishes recommendations for the minimum diameter of sheaves to be used on General Purpose electric motors. Purpose of the recommendations is to prevent the use of too small sheaves, which can result in shaft or bearing damage because belt pull goes up as sheave diameter goes down.

The NEMA Standard MG-1-14.42, November 1978 shows minimum recommended sheave diameters as a function of frame number. The table below lists the NEMA frame assignments and minimum diameter recommendations according to the 1964 rerating program.

Frame No.	Shaft Dia. (In.)	Horsepower at Synchronous Speed, rpm				Super HC® V-Belts & PowerBand® Belts	Hi Power® II, PowerBand & Tri-Power® V-Belts
		3600 (3450)*	1800 (1750)*	1200 (1160)*	900 (870)*	Min. Outside Dia. (In.)	Min. Datum Dia. (In.)
143T	0.875	1-1/2	1	3/4	1/2	2.2	2.2
145T	0.875	2-3	1-1/2-2	1	3/4	2.4	2.4
182T	1.125	3	3	1-1/2	1	2.4	2.4
182T		5	—	—	—	2.4	2.6
184T	1.125	—	—	2	1-1/2	2.4	2.4
184T		5	—	—	—	2.4	2.6
184T		7-1/2	5	—	—	3.0	3.0
213T	1.375	7-1/2-10	7-1/2	3	2	3.0	3.0
215T	1.375	10	—	5	3	3.0	3.0
215T		15	10	—	—	3.8	3.8
254T	1.625	15	—	7-1/2	5	3.8	3.8
254T		20	15	—	—	4.4	4.4
256T	1.625	20-25	—	10	7-1/2	4.4	4.4
256T		—	20	—	—	4.4	4.6
284T	1.875	—	—	15	10	4.4	4.6
284T		—	25	—	—	4.4	5.0
286T	1.875	—	30	20	15	5.2	5.4
324T	2.125	—	40	25	20	6.0	6.0
326T	2.125	—	50	30	25	6.8	6.8
364T	2.375	—	—	40	30	6.8	6.8
364T		—	60	—	—	7.4	7.4
365T	2.375	—	—	50	40	8.2	8.2
365T		—	75	—	—	8.6	9.0
404T	2.875	—	—	60	—	8.0	9.0
404T		—	—	—	50	8.4	9.0
404T		—	100	—	—	8.6	10.0
405T	2.875	—	—	75	60	10.0	10.0
405T		—	100	—	—	8.6	10.0
405T		—	125	—	—	10.5	11.5
444T	3.375	—	—	100	—	10.0	11.0
444T		—	—	—	75	9.5	10.5
444T		—	125	—	—	9.5	11.0
444T		—	150	—	—	10.5	—
445T	3.375	—	—	125	—	12.0	12.5
445T		—	—	—	100	12.0	12.5
445T		—	150	—	—	10.5	—
445T		—	200	—	—	13.2	—

*Approximate Full Load Speeds

For other than the General Purpose AC motors (for example, DC motors, Definite Purpose motors, motors with special bearings or motors that are larger than those covered by the NEMA standard), consult the motor manufacturer for minimum sheave diameter recommendations. It is helpful to the manufacturer to include details of the application with your inquiry.

TECHNICAL INFORMATION

Minimum Recommended Sprocket Outside Diameters for General Purpose Electric Motors Synchronous Belts

Data in the white area are from NEMA Standard MG-1-14-42, June 1972. Figures in black area are from MG-1-43, January 1968. The gray area is a composite of electric motor manufacturer data. They are generally conservative and specific motors and bearings may permit the use of a smaller motor sprocket. Consult the motor manufacturer.

NOTE: For a given horsepower and speed, the total belt pull is related to the motor sprocket size. As the size **decreases**, the total belt pull **increases**. Therefore, to limit the resultant load on motor and shaft bearings, NEMA lists minimum sprocket sizes for the various motors. The sprocket on the motor (DriveR sprocket) should be at least this large.

Table No. 3B

Motor Horsepower	Motor RPM (60 Cycle and 50 Cycle Electric Motors)						Motor Horsepower
	575 485*	690 575*	870 725*	1160 950*	1750 1425*	3450 2850*	
1/2	-	-	2.0	-	-	-	1/2
3/4	-	-	2.2	2.0	-	-	3/4
1	2.7	2.3	2.2	2.2	2.0	-	1
1-1/2	2.7	2.7	2.2	2.2	2.2	2.0	1-1/2
2	3.4	2.7	2.7	2.2	2.2	2.2	2
3	4.1	3.4	2.7	2.7	2.2	2.2	3
5	4.1	4.1	3.4	2.7	2.7	2.2	5
7-1/2	4.7	4.1	4.0	3.4	2.7	2.7	7-1/2
10	5.4	4.7	4.0	4.0	3.4	2.7	10
15	6.1	5.4	4.7	4.0	4.0	3.4	15
20	7.4	6.1	5.4	4.7	4.0	4.0	20
25	8.1	7.4	6.1	5.4	4.0	4.0	25
30	9.0	8.1	6.1	6.1	4.7	-	30
40	9.0	9.0	7.4	6.1	5.4	-	40
50	9.9	9.0	7.6	7.4	6.1	-	50
60	10.8	9.9	9.0	7.2	6.7	-	60
75	12.6	11.7	8.6	9.0	7.7	-	75
100	16.2	13.5	10.8	9.0	7.7	-	100
125	18.0	16.2	13.5	10.8	9.5#	-	125
150	19.8	18.0	16.2	11.7	9.5	-	150
200	19.8	19.8	19.8	-	11.9	-	200
250	19.8	19.8	-	-	-	-	250
300	24.3	24.3	-	-	-	-	300

*These RPM are for 50 cycle electric motors.

Use 8.6 for Frame Number 444 T only.

TECHNICAL INFORMATION

Minimum Recommended Sheave Diameter By Belt Cross Section

Belt Cross Section	Min. Recommended Datum Diameter (Standard Groove) (In.)
Classical V-Belts	
AX	2.20
A	3.00
BX	4.00
B	5.40
CX	6.80
C	9.00
D	13.00
E	21.00
Belt Cross Section	Min. Recommended Outside Diameter (Standard Groove) (In.)
Narrow V-Belts	
3VX	2.20
3V	2.85
5VX	4.40
5V	7.10
8V	12.50
Light Duty V-Belts	
2L	0.8
3L	1.5
4L	2.5
5L	3.5
Micro-V® Belts	
J	0.8
L	3.00
M	7.00
Polyflex® JB® Belts	
5M	1.04
7M	1.57
11M	2.54

Table No. 4A

Minimum Recommended Sprocket Sizes

Table No. 4B

Minimum Recommended Sprocket Sizes

Belt Pitch	Min. Recommended Sprocket Size (No. of Teeth)
PowerGrip® Timing	
MXL	12
XL	12
L	12
H	14
XH	18
XXH	18
PowerGrip HTD®*	
3M	12
5M	14
PowerGrip GT®	
8M	22
14M	28
PowerGrip GT®2/HTD	
20M	34
PowerGrip GT®2	
2M	12
3M	16
5M	18
8M	22
14M	28
Poly Chain® GT®2	
8M	22
14M	28

*Not a standard line item.

TECHNICAL INFORMATION

Minimum Recommended Idler Diameters

Table No. 5

Belt Cross Section	Min. O.D. Grooved Inside Idler (In.)	Min. O.D. Flat Inside Idler (In.)	Min. O.D. Outside Idler (In.)
A, AA, AX	2.75	2.25	4.25
B, BB, BX	4.00	3.75	6.00
C, CC, CX	6.75	5.75	8.50
D	9.00	7.50	13.50
3V, 3VX	2.65	**	4.25
5V, 5VX	7.10	**	10.00
8V	12.50	**	17.50

** Not recommended.

NOTE: See the "Idler Details" section in the Heavy-Duty Drive Design Manual #14995-A for Minimum Flat Idler Widths.

Minimum Center Distance Allowances for Belt Installation and Takeup

Table No. 6

V-Belt Number	Minimum Center Distance Allowance for Installation (Inches)						Minimum Center Distance Allowance for Initial Tensioning and Subsequent Takeup (Inches)
	3V/3VX		5V/5VX		8V		All Cross Sections
	Super HC® V-Belt	Super HC PowerBand® Belt*	Super HC V-Belt	Super HC PowerBand Belt*	Super HC V-Belt	Super HC PowerBand Belt*	All Types
Up to and Incl. 475	0.5	1.2					1.0
Over 475 to and Incl. 710	0.8	1.4	1.0	2.1			1.2
Over 710 to and Incl. 1060	0.8	1.4	1.0	2.1	1.5	3.4	1.5
Over 1060 to and Incl. 1250	0.8	1.4	1.0	2.1	1.5	3.4	1.8
Over 1250 to and Incl. 1700	0.8	1.4	1.0	2.1	1.5	3.4	2.2
Over 1700 to and Incl. 2000			1.0	2.1	1.8	3.6	2.5
Over 2000 to and Incl. 2360			1.2	2.4	1.8	3.6	3.0
Over 2360 to and Incl. 2650			1.2	2.4	1.8	3.6	3.2
Over 2650 to and Incl. 3000			1.2	2.4	1.8	3.6	3.5
Over 3000 to and Incl. 3550			1.2	2.4	2.0	4.0	4.0
Over 3550 to and Incl. 3750					2.0	4.0	4.5
Over 3750 to and Incl. 5000					2.0	4.0	5.5
Over 5000 to and Incl. 6000					2.0	4.0	6.0

*Also use these figures for individual Super HC V-Belts in deep groove sheaves.

TECHNICAL INFORMATION

Minimum Center Distance Allowances for Belt Installation and Takeup

Table No. 7

V-Belt Number	Minimum Center Distance Allowance For Installation (Inches)										Minimum Center Distance Allowance For Initial Tensioning and Subsequent Takeup (Inches)
	A		B		C		D		E		All Cross Sections
	Hi-Power II and Tri-Power [®] Molded Notch V-Belts	Hi-Power II PowerBand Belt*	Hi-Power II and Tri-Power Molded Notch V-Belts	Hi-Power II PowerBand Belt*	Hi-Power II and Tri-Power Molded Notch V-Belts	Hi-Power II PowerBand Belt*	Hi-Power II and Tri-Power Molded Notch V-Belts	Hi-Power II PowerBand Belt*	Hi-Power II V-Belts	Hi-Power II PowerBand Belt*	All Types
Up To and Incl. 35	0.75	1.20	1.00	1.50							1.00
Over 35 To and Incl. 55	0.75	1.20	1.00	1.50	1.50	2.00					1.50
Over 55 To and Incl. 85	0.75	1.30	1.25	1.60	1.50	2.00					2.00
Over 85 To and Incl. 112	1.00	1.30	1.25	1.60	1.50	2.00					2.50
Over 112 To and Incl. 144	1.00	1.50	1.25	1.80	1.50	2.10	2.00	2.90			3.00
Over 144 To and Incl. 180			1.25	1.80	2.00	2.20	2.00	3.00	2.50	3.40	3.50
Over 180 To and Incl. 210			1.50	1.90	2.00	2.30	2.00	3.20	2.50	3.50	4.00
Over 210 To and Incl. 240			1.50	2.00	2.00	2.50	2.50	3.20	2.50	3.60	4.50
Over 240 To and Incl. 300			1.50	2.20	2.00	2.50	2.50	3.50	3.00	3.90	5.00
Over 300 To and Incl. 390					2.00	2.70	2.50	3.60	3.00	4.00	6.00
Over 390					2.50	2.90	3.00	4.10	3.50	4.40	1.5% of belt length

*Also use these figures for individual Hi-Power II and Tri-Power Molded Notch V-Belts in deep groove sheaves.

Micro-V[®] Belts

V-Belt Number	Minimum Center Distance Allowance for Installation (Inches)			Minimum Center Distance Allowance For Initial Tensioning and Subsequent Takeup (Inches)
Standard Effective Length (In.)	J	L	M	All Cross Sections
Up through 20.0	0.4	—	—	0.3
20.1 through 40.0	0.5	—	—	0.5
40.1 through 60.0	0.6	0.9	—	0.7
60.1 through 80.0	0.7	1.0	—	0.9
80.1 through 100.0	0.8	1.2	1.5	1.1
100.1 through 120.0	—	1.2	1.6	1.3
120.1 through 160.0	—	1.4	1.7	1.7
160.1 through 200.0	—	—	1.8	2.2
200.1 through 240.0	—	—	1.9	2.6
240.1 through 300.0	—	—	2.2	3.3
300.1 through 360.0	—	—	2.5	3.9
60.1 through 370.0	—	—	2.7	4.6
Polyflex [®] JB [®] Belts				
	5M	7M	11M	
280-300	0.4	—	—	0.2
307-710	0.6	0.6	1.0	0.6
730-1090	0.9	0.9	1.2	1.1
1120-1500	1.1	1.1	1.4	1.4
1550-1900	—	1.1	1.5	1.4
1950-2300	—	1.5	1.9	1.8

TECHNICAL INFORMATION

Poly Chain® GT2® Installation & Tensioning Allowances

Center Distance Allowance For Installation and Tensioning

Table No. 8

Belt Length	Standard Installation Allowance (Flanged Sprockets Removed For Installation)	Tensioning Allowance (Any Drive)
40" and under (1000mm and under)	0.07" 1.8mm	0.03" 0.8mm
Over 40" to 70" (Over 1000mm to 1780mm)	0.11" 2.8mm	0.03" 0.8mm
Over 70" to 100" (Over 1780mm to 2540mm)	0.13" 3.3mm	0.04" 1.0mm
Over 100" to 130" (Over 2540mm to 3300mm)	0.16" 4.1mm	0.04" 1.0mm
Over 130" to 180" (Over 3300mm to 4600mm)	0.21" 5.3mm	0.05" 1.3mm

Additional Center Distance Allowance For Installation Over Flanged Sprocket*

(Add to Installation Allowance in Above Table)

Belt Pitch	One Sprocket Flanged	Both Sprockets Flanged
8mm	0.86"	1.31"
8mm	21.8mm	33.3mm
14mm	1.23"	1.97"
14mm	31.2mm	50.0mm

* For drives that require installation of the belt over one sprocket at a time, use the value for both sprockets flanged, even if only one sprocket is flanged.

TECHNICAL INFORMATION

Table No. 9

Power Grip GT2® Center Distance Allowance For Installation and Tensioning

Length Bolt (mm) (in)	Standard Installation Allowance (Flanged Sprockets Removed For Installation) (mm) (in)	Tensioning Allowance (All Drives) (mm) (in)
Up to 125 5	0.5 0.02	0.5 0.02
Over 125 to 250 5 to 10	0.8 0.03	0.8 0.03
Over 250 to 500 10 to 20	1.0 0.04	0.8 0.03
Over 500 to 1000 20 to 40	1.8 0.07	0.8 0.03
Over 1000 to 1780 40 to 70	2.8 0.10	0.8 0.04
Over 1780 to 2540 70 to 100	3.3 0.13	1.0 0.04
Over 2540 to 3300 100 to 130	4.1 0.16	1.3 0.05
Over 3300 to 4600 130 to 180	4.8 0.19	1.3 0.05
Over 4600 to 6800 180 to 270	5.6 0.22	1.3 0.05

Additional Center Distance allowance For Installation Over Flanged Sprockets*

(Add to Installation Allowance in Above Table)

Pitch	One Sprocket (mm) Flanged (in)	Both Sprockets (mm) Flanged (in)
5mm	13.5 0.53	19.1 0.75
8mm	21.8 0.86	33.3 1.31
14mm	31.2 1.23	50.0 1.97
20mm	47.0 1.85	77.5 3.05

* For drives that require installation of the belt over one sprocket at a time, use the value for "Both Sprockets Flanged"

TECHNICAL INFORMATION

Table No. 10

**Power Grip® Timing Belts
Center Distance Allowance
for Installation and
Tensioning**

Belt Length (In.)	Standard Installation Allowance (Flanged Pulleys Removed For Installation)	Tensioning Allowance (Any Drive)
3.6 to 5.0	.02"	.02"
Over 5.0 to 10.0	.03"	.03"
Over 10.0 to 20.0	.04"	.03"
Over 20.0 to 40.0	.05"	.04"
Over 40.0 to 60.0	.07"	.05"
Over 60.0 to 180.0	.12"	.08"

Additional Center Distance Allowance for Installation Over Flanged Pulleys*

(Add to Installation Allowance in Above Table)

Belt Pitch	Small Pulley Flanged	Both Pulleys Flanged
0.080" (MXL)	.33"	.49"
0.200" (XL)	.46"	.71"
0.375" (L)	.64"	.85"
0.500" (H)	.64"	.96"
0.875" (XH)	1.14"	1.92"
1.250" (XXH)	1.53"	2.65"

*For drives that require installation of the belt over one pulley at a time, use the value for both pulleys flanged — even if only one pulley is flanged.

Table No. 11

Estimating Belt Length from Drive Dimensions

(2 Pulleys)

$$\text{Belt Length} = 2C + 1.57(D + d) + \frac{(D - d)^2}{4C}$$

Where: C = Shaft Center Distance

- a.) For Super HC®: Belt Length = Belt Outside Diameter
D = O.D. of Larger Pulley
d = O.D. of Smaller Pulley
- b.) For Hi-Power® II and Tri-Power® Molded Notch: Belt Length = Datum Length
D = Datum Diameter of Larger Pulley
d = Datum Diameter of Smaller Pulley
- c.) For Synchronous Belts: Belt Length = Pitch Length
D = Pitch Diameter of Larger Sprocket
d = Pitch Diameter of Smaller Sprocket

GATES PUBLICATIONS

Additional Gates Publications to Guide You in Design, Selection and Usage of Gates Belts and Pulleys

Gates produces many other publications — each designed to do a specific job.

Some provide you with the necessary information to design new belt drives — others provide you with product descriptions and specifications to guide in the selection of types and sizes of belts and pulleys — some contain application listings showing manufacturers' makes and models with the corresponding Gates Replacement Belt Numbers.

In all cases, the publications listed below have one thing in common — they will help you specify the most economical and proper Gates belt or pulleys best for your application.

Description

Form Number

V-Belt Technical Manuals

Heavy-Duty V-Belt Drive Design Manual 14995-A

Synchronous Drive Manuals

Poly Chain® GT® 2 Belt Drive Design Manual 17595

PowerGrip® GT® 2 Belt Drive Design Manual 17195

Light Power & Precision Drive Catalog 17183

Replacement Guides

Belt Replacement Guide for Variable Speed Drives 12684

Metric V-Belt Interchange 19998-Y

Sheaves, Pulleys & Sprockets 19994-B

For additional information visit our web site at: www.gates.com

WORKSHEET

High Speed Drive Survey and Energy Savings Worksheet

CUSTOMER INFORMATION

Distributor _____

Customer _____

DRIVE INFORMATION

I.D. of Drive (location, number, etc.) _____

Description of DriveN Equipment _____

Manufacturer of DriveN Equipment _____

Horsepower Rating of Motor _____ DriveN HP Load (Peak) _____ (Normal) _____

Motor Frame Size _____ Motor Shaft Dia. _____ DriveN Shaft Dia. _____

Speed:

DriveR RPM _____ RPM Measured with Contact or Strobe Tachometer Yes No

DriveN RPM _____ RPM Measured with Contact or Strobe Tachometer Yes No

Speed Ratio _____ Speed Up _____ or Speed Down _____

Center Distance: Minimum _____ Nominal _____ Maximum _____

Existing Drive Components: DriveR _____ DriveN _____

Belts _____ Belt Manufacturer _____

Ambient Conditions:

Temperature _____ Moisture _____ Oil, etc. _____

Abrasives _____ Shock Load _____

Static Conductivity Required? Yes No

Maximum Sprocket Diameter (OD) and Width Limitations (for guard clearance):

DriveR: Max. OD _____ Max. Width _____ DriveN: Max. OD _____ Max. Width _____

Guard Description _____

Motor Mount:

Double Screw Base? Yes No Motor Mounted on Sheet Metal? Yes No

Adequate Structure? Yes No Floating/Pivot Motor Base? Yes No

Start Up Load:

%Motor Rating at Start Up _____ AC Inverter? Yes No Soft Start? Yes No

Duty Cycle:

Number of Starts/Stops _____ times per _____ (hour, day, week, etc.)

ENERGY SAVINGS INFORMATION

Energy Cost per KW-Hour _____

Hours of Operation: _____ Hours per Day _____ Days per Week _____ Weeks per Year

WORKSHEET

Low Speed Drive Design Information Sheet

For Drive Selections with Shaft Speeds Less Than 500 rpm

Distributor: _____

Customer: _____

Drive Identification (location, number, etc.) _____

DriveR Information:

Motor Nameplate Data

Rated Horsepower _____ Rated RPM _____ Efficiency _____

Rated Voltage _____ Rated Amps _____ Rated Torque _____

Actual Motor Load _____

Motor Type: AC Three-Phase AC Single-Phase DC (Direct Current)
Output Speed: Constant Variable

Measured Motor Data

Voltage: Phase 1 _____ Phase 2 _____ Phase 3 _____

Amps: Phase 1 _____ Phase 2 _____ Phase 3 _____

Reducer Information:

Reducer Type: Helical Planetary Cycloidal Worm Combination Type Other

Reducer Efficiency _____ Output RPM _____ Reducer Ratio _____

Rated Input HP/Torque _____ Rated Output HP/Torque _____

Existing Drive Information:

Drive Type: Chain V-Belt Synchronous Belt

If chain, Type: 2/#60, #80, etc. _____ Lubed Unlubed

Current Drive Service Life _____

DriveR Sprocket/Sheave _____ (teeth/OD) DriveR Shaft Diameter _____

DriveN Sprocket/Sheave _____ (teeth/OD) DriveN Shaft Diameter _____

Center Distance:

Minimum _____ Nominal _____ Maximum _____

Type of Center Distance Adjustment: _____

Idler used: Yes No Inside Backside

DriveN Information:

Type of Equipment: _____ Actual Horsepower Required _____

Required Operating RPM _____ Required Speed Ratio _____

Hours/Day _____ Days/Week _____ Weeks/Year _____

Shock Load: Light Moderate Severe

Start Up Load: % Overload _____ Starting Torque _____

Special Requirements:

Space Limitations:

Maximum DriveR Dia. _____ Maximum DriveN Dia. _____

Maximum DriveR Width _____ Maximum DriveN Width _____

Environmental Conditions:

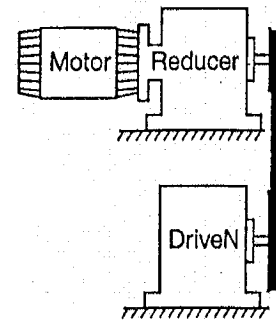
Temperature Range _____ Belt Conductivity Required

Oil Mist Oil Splash Moisture Abrasives

Drive Sketch:

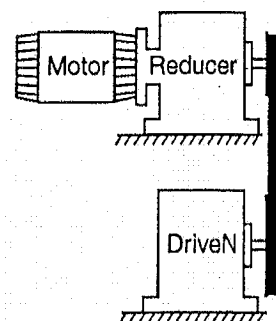
Drive Layout (check one)

Motor Reducer
Belt Drive Driven



Belt Drive on
Reducer Output Shaft

Motor Belt Drive
Reducer Driven



Belt Drive on
Reducer Input Shaft



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INSTALLATION INSTRUCTIONS POLYESTER VINYL BUG SCREEN PANELS

SERIES 1.2 – 0704

All “soft” bug screen panels are designed to provide ease of installation, quick removal, convenient storage, and optimum panel inter-changeability.

Panels are constructed of a woven, vinyl coated polyester 8 x 10 mesh, trimmed with polyester/vinyl binding, and attached using Velcro fastener material. They are designed for extended life and performance in all weather conditions for temperatures ranging from 120°F to minus 40°F.

CAUTION: READ ALL INSTRUCTIONS BEFORE PROCEEDING

1. To avoid damage in shipping, shop handling, subsequent paintings, etc., each panel has been **pre-fitted** with a matching Velcro “hook” tape that must first be removed and bonded to the structural frame. This is done by using the special, pressure-sensitive adhesive back on the Velcro “hook” tape.
2. The perimeter, or 1” edge of the bug screen framework, is to be used to apply the Velcro “hook” tape. The painted or galvanized structural frame surface should be **clean, dry, and free of oil**. The best adhesive bonding results will be obtained when installed at or above 60°F.

CAUTION: A newly painted surface should have cured for at least 72 hours prior to application.

NOTE: In field retrofit, applications to the surface should be thoroughly cleaned to remove any “dead” paint. To clean, use 50/50 isopropanol/water, MEK or similar solution prior to applying the permanent Velcro “hook” tape.

3. The back of the Velcro “hook” is prepared with a special, pressure-sensitive adhesive. Peel the clear protective backing from the “hook”, being careful not to touch the adhesive, and install the Velcro tape immediately to the 1” metal framework surface area around the perimeter of the panel opening. In joining the two surfaces, use finger pressure to firmly smooth the tape in place (especially important at corners and along edges). Note: A hard rubber roller can be used to ensure a smooth, firm fit.

4. For best results, round off or trim the outside corners to prevent "snagging"
5. Insert the 1" square "studs" at each corner in the ¼ hole in the framework. The stud should cover the ends of the "hook" tape in order to secure it and prevent the corners from coming loose in the future. These normally will need to be tapped or driven into place, and will provide a positive attachment point at each corner of each panel.
6. Allow adhesive to dry for 48 to 72 hours before cycling (attaching and removing panels). If necessary, drying time can be speeded up by applying heat to 200°F (example: hair dryer or heat gun).

OPERATION: Individual panels should be kept clean to ensure adequate airflow and maximum cooling performance, especially in hot weather. As with any filtration medium, dirty or clogged screens or fin tubes will adversely affect the cooler operation.

GENERAL CHARACTERISTICS

- Highly resistant to water, oil, ultraviolet rays (sun light), and chemicals
- Vibration or pressure increases closure and holding strength
- Quick panel placement by simply pressing panel edges to permanent Velcro "hook" material on the framework
- Quick panel removal by simply "peeling" perimeter edges from permanent "hook" material on the framework.
- Exceptionally strong and treated to meet State of California Fire Code Bulletin 117-Class 1 (most stringent in the U.S.)
- Flexible and light weight for ease of installation, handling, and storage



AXH air-coolers

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 (918) 283-9200 Fax (918) 283- 9229
 www.axh.com

Job number: 118455A
 Customer: MURPHY OIL CANADA
 Quantity: 1.00
 Model: 96-BZ

Parts List

Note: Quantity Shown is for One Unit Only

Revision	Engineer	Date	Description
0	JB	01/26/2012	Initiated parts list
1	JB	02/24/2012	Added nameplate mod to elec motor

QUANTITY

DESCRIPTION OF PARTS

** 1.00 FAN EA FAN

Make: Moore
 Blade Tips: VT
 Class: 10,000 HD
 Series: 42
 Diameter: 96"
 No. Blades: 6
 Rotation: Left Hand
 Angle: 18.9
 Bore: 2-7/16"
 Keyway: 5/8"

1.00 LOUVERS EA LOUVERS

Auto louvers over water section to include (1) Durastroke 1500 pivot mount
 Manual side recirculation louvers to include manual operator
 Auto end recirculation louver to include (1) Durastroke 1500 pivot mount
 Auto top recirculation louver to include (1) Durastroke 1500 pivot mount. Top louver to be linked to roll louver
 Auto roll recirculation louver to be linked to top louver

3.00 Air Motor EA

Durastroke 1500

** 1.00 Electric-Motor EA Item for Attached Notes

Make: TECO Westinghouse
 Catalog #: EP0254 - M13 Drain mod M1A Nameplate mod
 Horsepower: 25
 RPM: 1800
 V/P/HZ: 460/3/60
 Frame: 284T
 Enclosure: TEFC
 Shaft: Vertical
 Mounting: W-6
 Special Notes: Single winding, variable torque, VFD compatible, CSA.
 Motor to be nameplated for: Class 1 Zone 2 Group IIA

1.00 SB-284T EA Slide Base 284T frame motor

** = RECOMMENDED SPARE PART



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Revision	Engineer	Date	Description
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1	JB	02/24/2012	Added nameplate mod to elec motor

QUANTITY	DESCRIPTION OF PARTS		
** 2.00	BR-TAF-2.4375-PB	EA	#037584 Dodge TAF Bearing 2.4375 Pillow Block
** 1.00	SHAFT---FAN	EA	FAN SHAFT PER DWG
** 1.00	V-Belt-Drive-Assembly	EA	V-BELT DRIVE ASSEMBLY
<p>Fan Sheave O.D.: 28.00 No. of grooves: 3 Belt Pitch: 5V Bushing Style: E Bore: 2-7/16 Keyway: 5/8x5/16</p> <p>Motor Sheave O.D.: 6.30 No. of grooves: 3 Belt Pitch: 5V Bushing Style: SK Bore: 1-7/8 Keyway: 1/2x1/4</p> <p>V-Belts Type: 5VX1120 C.D.: 26.8 HP Each: 16.38 1 Banded set of 3 Belts per drive</p>			
1.00	VS-VS2EX	EA	Vib. Switch Murphy VS-2-EX Explosion Proof CSA Stamp

** = RECOMMENDED SPARE PART

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INTRODUCTION

This manual has been prepared for the purpose of providing general information and recommendations for the operation and maintenance of your air-cooled heat exchanger in order to insure that it will continue to provide you maximum performance in future years under a variety of operating conditions.

Normal maintenance items and light repairs as outlined can be achieved with basic mechanics tools. These include adjusting v-belt tension, checking and adjusting fan blade pitch angle, lubrication of bearings, setting of vibration switches and the periodic cleaning of fin tubes, both externally and internally. For more specific and detailed information please refer to the individual manufacturer's maintenance instructions for the specific item or component in questions (i.e. motors, fans, bearings, and controls). The Table of Contents indicates the appropriate section where this information is contained.

Naturally, prudent judgment should always be exercised when repairing, replacing or particularly modifying any original parts to make certain that they are equivalent to the original design. **AXH air-coolers** stocks most standard parts and components and are available within a 24 hour emergency basis if necessary.

RECEIPT OF EQUIPMENT & SITING

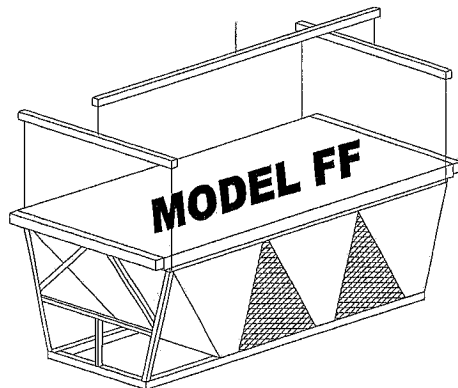
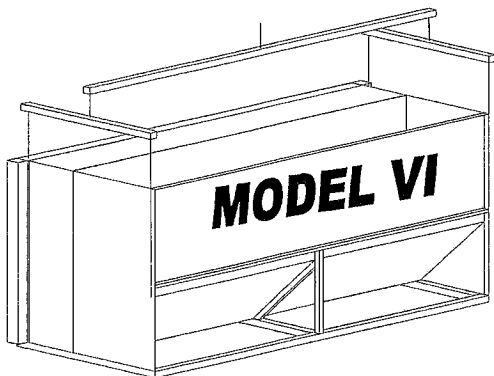
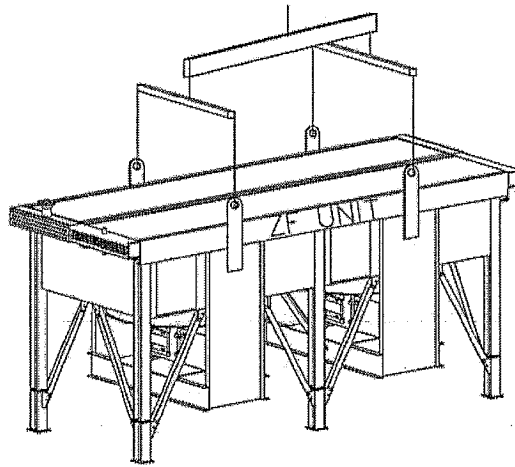
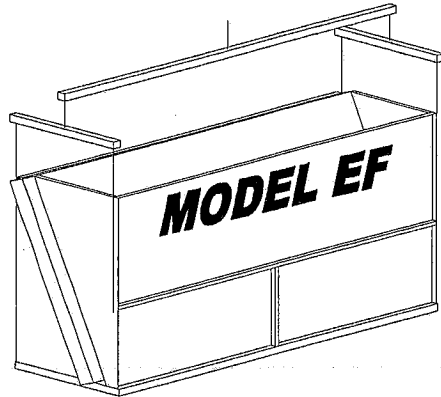
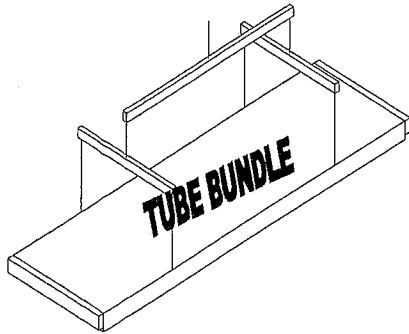
Upon arrival at site, the cooler should be inspected thoroughly by receiving personnel. Damage in transit could be the result of dropping or being struck by heavy objects or equipment. Observe the sub-skid, flanges, plenum side panels and coil sections for any apparent physical damage. Dents, bent flanges, crushed fins, damaged controls are among other items that should be described on the bill of lading document and presented by the carrier. Prompt reporting will expedite filing of claims and will expedite resolution and compensation from the responsible party.

Installation of the cooler(s) is the responsibility of the purchaser or contractor who must insure that the cooler intake areas are free from obstructions and provide adequate airflow. Spacing of air coolers should be adequate to avoid hot air re-circulation (and the affects of other coolers). The impact of grouping coolers closely together may be compensated for by either elevating and/or separating them.

The cooler is normally completely shop assembled and no field assembly at the job-site is required. However, occasionally optional or special accessories may require disassembly to meet transportation height or width limitations. In the event some assembly of the unit is required, the appropriate assembly instructions will accompany the shipment. The packing list should be checked carefully to see that all parts shipped with the cooler are on hand. These parts may be shipped separately, secured to the skid base (if so designed) or inside the plenum area.

UNLOADING & HANDLING COOLERS

Spreader bars should be used for lifting when the cooler width is over eight (8) feet. The cooler is normally supplied with multiple lifting points to be used for off loading from carrier. Lifting by any other point may cause damage to the cooler. Following are some recommended ways of lifting. Please refer to the illustration below that resembles the type of **AXH air-coolers** cooler to be handled and use it as a guide on how to unload and handle the cooler properly. (See unit name plate for unit type i.e. EF, VI, FF, ZF, etc.)



PRIOR TO RUN-IN & START UP

HYDROSTATIC TEST

AXH air-coolers tube bundles (sections) are hydrostatically tested to 1.3 times the design pressure as required by ASME before being released for shipment. To ensure that no damage has been done during shipment and/or installation, it is good practice to hydro test the entire system, including piping, heat exchangers, pumps, etc., prior to start up.

BEARINGS

Check bearings for lubrication. **Caution: DO NOT OVER GREASE.** The manufacturer has greased the bearings and no additional grease is necessary at start up. Remote lubrication lines, when provided, should be loosened at the bearing end, and checked to be sure they are filled with grease from the fitting end. This will ensure that the lube lines are full of grease and free of air and any debris. During high-speed operation too much grease will cause overheating. When dust and water are present bearings should contain as much grease as the operating speed will permit since a full bearing with very slight leakage is the best protection against the entrance of foreign material. Under normal conditions refer to the following table as a general guideline, although certain conditions may require a change of lubrication periods other than those described. Bearing mounting bolts and set screws should be checked for tightness. See bearing manufacturer recommended lubrication chart for recommended maintenance schedule and type of grease.

FANS

Check fan blade bolts and hub bushing set screws for tightness. Rotate fan by hand to insure that shaft, speed reducer, and driver turn freely. The fan blades should be checked for adequate tip clearance and blade pitch angle. To measure this, first move all blades past a fixed point on the inside of the fan ring and observe which blade has the least amount of clearance at that point. Then move the blade selected 360 degrees to the point of minimum clearance. Refer to the section on fans. If the fan is found not to be centered in the fan ring, slight adjustment of the tip clearance can be made by loosening the fan shaft bearing bolts and moving the complete fan and fan shaft assembly until it is centered in the fan ring. To check the fan blade angle, use a level bubble protractor (this can be obtained from *AXH air-coolers*). Loosen the nuts on the bolts and place the protractor on the angle setting mark or the clevis. Refer to fan manufactures information for proper location and air-x-hemphill parts list for design angle. Using a mallet, tap on the shank end of the blade to adjust the angle. Tighten fan blade bolts to the proper torque (refer to manufactures maintenance instructions) making sure to tighten evenly. Recheck blade angle. Occasionally coolers may be equipped with an auto-variable type fan. These fans have blade angles controlled by varying the air supply pressure. Air pressure should be applied to the fan before starting to check for proper operation. **Before starting, any electric motor should be "bumped" to check for proper direction of fan rotation and air flow.** This will also insure that the motor is in proper working order.

LOUVERS/SHUTTERS

Check all mounting brackets and bolts for tightness. To insure that the linkage is adjusted properly on manually operated louvers, operate blades from a fully open to a fully closed position. On automatic louvers with air motors (optional) air should be applied to actuator to check for proper linkage adjustment, free operation, and sufficient air supply. For further information on air motors see attached manufacture maintenance instructions.

CAUTION: DO NOT WALK ON LOUVERS OR USE THEM AS A LADDER

V-BELT DRIVES

Check V-Belt tension in accordance with V-Belt tensioning section of this manual.

GEAR BOX

When supplied, check gearbox for oil. Gears are shipped without oil and must be filled and serviced in accordance with the instructions contained later in this operating manual.

VIBRATION SWITCH (OPTIONAL)

For Murphy switches, after the switch has been installed, adjust it by turning the adjustment screw in a clockwise direction until the starting torque does not trip the vibration switch. For other brands see the specific manufacture's information.

PROCESS START-UP

The process start-up should be conducted in a manner that will minimize thermal shock of the tube bundles. Over cooling of fluids during periods of low ambient temperature and/or low heat load duty should also be avoided, especially during start up.

HEADER ACCESS PLUGS

Header plugs opposite each tube are installed at room temperature. To correct any minor leaking, it may be necessary to tighten the plugs when the bundle is at operating temperature. **WARNING: DO NOT** tighten plugs while bundle is under pressure. If any plugs are removed, the soft iron gasket (shoulder plugs only) should always be replaced. Replacement gaskets are in stock and may be ordered from **AXH air-coolers**. When installing the plugs, a thread lubricant and/or anti-galling compound should be used.

LONG TERM MAINTENANCE

FIN CLEANING

Fins should be kept free of dirt and lint. Bug and lint screens are an available option that will greatly assist in keeping tube bundles clean. Fin tubes can be cleaned by directing compressed air perpendicular to the tubes in a direction OPPOSITE to the normal airflow. Caution should be taken when using steam or chemicals to clean fins. DO NOT clean or spray water when the section/bundle is hot.

TUBE CLEANING

The internal cleaning of tubes can be done in several different ways:

1. **Mechanical Cleaning** - This consists of using a drill, (or wire brushes), on long rods, and rotating them with air or electric motors. This is normally followed by a treated water or chemical wash or air purge.
2. **Chemical Cleaning** - This consists of circulating chemical solutions through the tubes. The solution should contain inhibitors to avoid corrosion of the tube walls.
3. **High Pressure Water Sprays** - This consists of placing a high-pressure water jet head at the end of hollow rods and pushing through the individual tubes.

NOTE: The last two processes will not work on tubes that have been "plugged" with sealing pins.

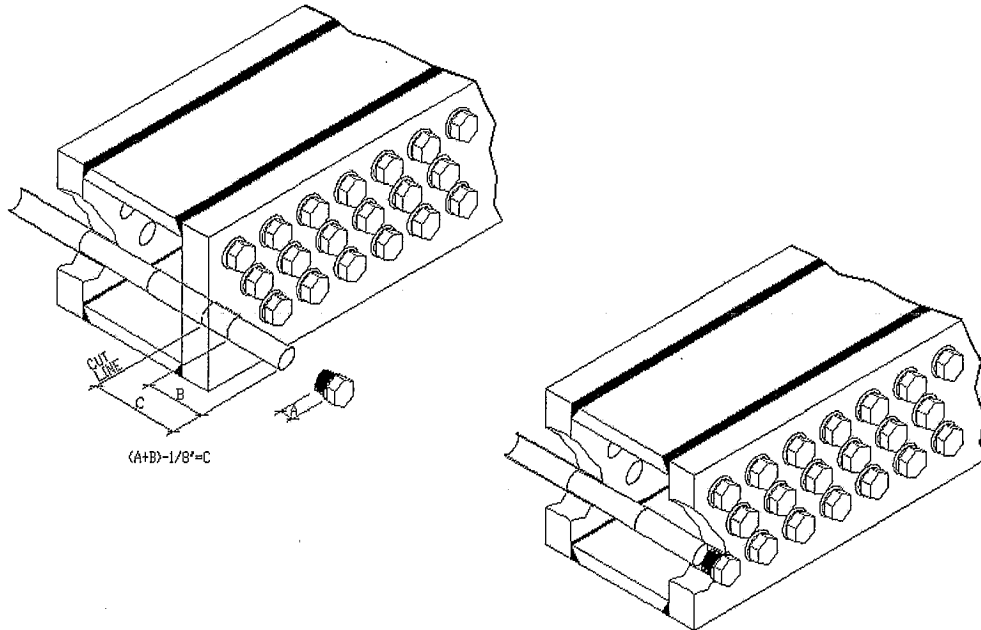
LEAKING TUBES

Tube leaks are generally of two types: 1) leaks through the tube wall itself, and more commonly 2) leaks in the tube end attachment in the header (tube sheet). In the first case it is desirable to plug both ends of the tube. Only a limited number of tubes can be sealed off in this manner before performance is adversely affected and will vary with each specific application. When cooling performance falls below acceptable limits, the tube bundle may be re-tubed. If leaks develop in the tube end attachment at the tube sheet, re-rolling of the tube may be necessary. Care must be taken in selecting the proper tube expander for the tube size (diameter) and gauge of tube to be rolled. When rolling a tube, excess or "over-rolling" must be avoided. Consult the factory for further information on taper sealing pins to plug the tubes and tube roller sizes.

INSTRUCTIONS FOR USING TAPER PINS FOR SEALING TUBES

- 1.) Remove header access plug from one end of leaking tube (do not switch plugs in holes) and replace with new gaskets whenever possible.
- 2.) Insert taper sealing pin through plug hole into tube and tap lightly with hammer until seated firmly, but not too tight to be removed.
- 3.) Measure plug to determine the depth it was originally screwed into header plug sheet. (Dimension A)
- 4.) Measure the distance that the taper pin protrudes from the header plug sheet in "seated" position. (Dimension B).
- 3.) Add the distance measured in Steps 3 and 4 and subtract 1/8". This will be the length which should be cut off the large end of the taper sealing pin. ($A+B-1/8" = \text{Dimension C}$)
- 4.) Remove the taper pin from the end of the tube.
- 5.) Cut the end off the large end of the taper pin to the length calculated in Step 5. CAUTION: Do not cut the pin too short.
- 6.) Re-insert the taper sealing pin in the tube and drive securely into place.
- 7.) Lubricate the access plug and replace it in plug sheet and run in tightly. The plug should now seat tightly and hold taper pin in place.
- 8.) Repeat operation on other end of tube.
- 9.) Hydro-test section to insure proper pressure seal without leaks.

NOTE: If the access plug that was removed does not seal properly, replace it along with the gasket if it is a shoulder type plug.



INSPECTION

TUBES

Tubes should be inspected for internal and external corrosion and/or erosion periodically. This depends on the severity and type of service and atmosphere that the tubes are operating in. Inspection of the tubes should be performed every six months to one year intervals. Tube wall thickness can be checked externally using an ultrasonic technique.

FANS

Fans should be inspected for wear or loose bolts (cracks, pitting and corrosion) on all surfaces. These inspections should be performed every six months. In addition to surface inspections, all bolts and nuts must be checked for proper torque. (See the fan section of the manual).

BEARINGS

In addition to checking bearings as recommended by the manufacture, the mounting bolts should be checked for proper torque and alignment. These checks should be done at least every six months.

STRUCTURE

A general inspection of the structure should be performed every six months to a year. This inspection should include checks for corrosion, damaged members, sheeting guards and for loose bolts.

HEADERS

Headers should be inspected for corrosion periodically. This corrosion should not be allowed to proceed past the stated corrosion allowance as stated on the individual job specification data sheet.

RECOMMENDED SPARE PARTS

We suggest that one each of the parts that are identified as recommended spare parts on the Table of Contents page, be kept in stock or be readily available. The down time caused by waiting for delivery of a replacement part may cost far more in lost production or service than the cost of the item itself.

Spare parts orders should be specified in accordance with the parts list description and always include the corresponding *AXH air-coolers'* model and job number.

WARRANTY

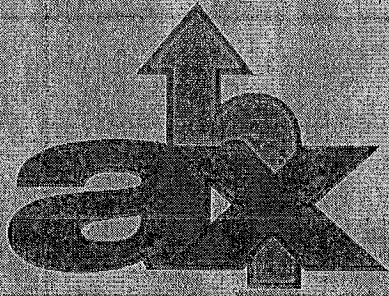
AXH air-coolers warrants that the equipment it *manufactures* is free of defects in material and workmanship, when operated in accordance with conditions stated, for a period of one (1) year after start-up not to exceed fifteen (15) months from shipment. Such warranty shall not apply to any equipment that has been altered or repaired by other than the Company's personnel. The Company's obligation under this warranty is limited, however, to repairing or, if in the Company's judgment it seems more appropriate, to furnishing without charge, F.O.B. the Company's factory, a similar part to replace any part which after examination shall, to its own satisfaction be determined to have been defective at the time it was shipped. This warranty applies only if the Company received an immediate written notice upon discovery of such defect. The Company makes no warranties covering deterioration or failure due to corrosion, erosion or fouling or due to improper installation or operation. EXCEPT AS SPECIFICALLY STATED ABOVE, AXH AIR-COOLERS HEREBY DISCLAIMS ANY AND ALL WARRANTIES, EXPRESS OR IMPLIED, WHETHER OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, OR OTHERWISE.

LIMITATION OF LIABILITY

The remedies set forth herein are exclusive. AXH air-coolers shall not be liable, in excess of the purchase price of the equipment, for any damages, whether in contract, in tort or on any other basis, sustained by the customer or any other person arising from or related to the delivery, use or failure of the equipment or for any delay, special, incidental, consequential, indirect or commercial damages whether due to lost profits or otherwise resulting from the delivery, use or failure of the equipment. If it is ever necessary to contact our plant for service or replacement parts, it is essential that our job number and other identifying data be obtained from the metal nameplate attached to the cooler, or the nameplate attached to the tube bundle header box, which also contains the design pressure, temperature, and serial number.

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AXH air-coolers

Only the name is new... AXH air-coolers

...combines 40 years of leadership experience in the air-cooled heat exchanger industry that encompasses the entire spectrum of air-coolers from initial thermal application and mechanical engineering, through design drafting, project management and after market support. To meet the growing market demands and customer expectations Air-x-hemphill was merged into AXH air-coolers in early 2005 in conjunction with a major expansion of both physical facilities and personnel.

Capabilities

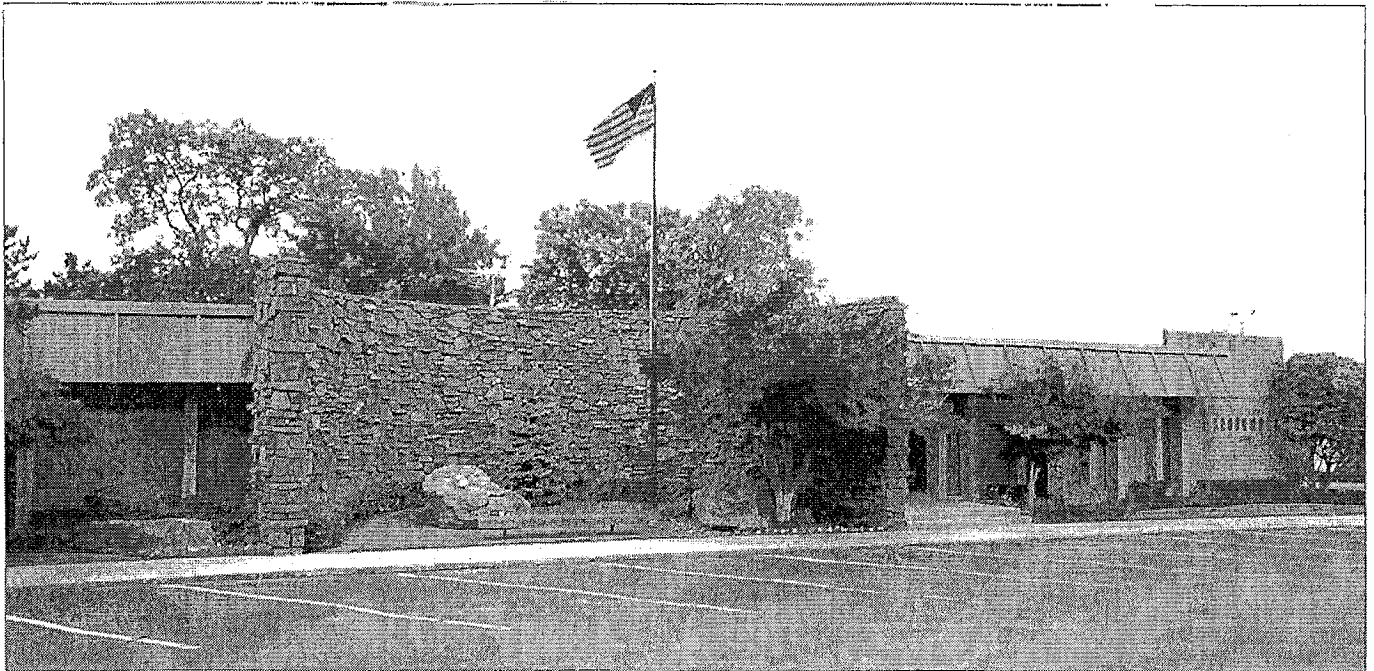
AXH air-coolers' offers an unparalleled level of experience and technical expertise throughout the entire organization, coupled with the largest manufacturing facility in the industry. A complete range of air-cooler models, types and sizes can be provided to fit any standard or custom application. Importantly we have the capability to design, supply and duplicate virtually any replacement cooler or section as well as support the reapplication of existing coolers.

Reliability

We have manufactured thousands of air-coolers for the natural gas compression and process industries and have an established reputation for meeting delivery requirements. Foremost we are committed to quality assurance and on time shipment.

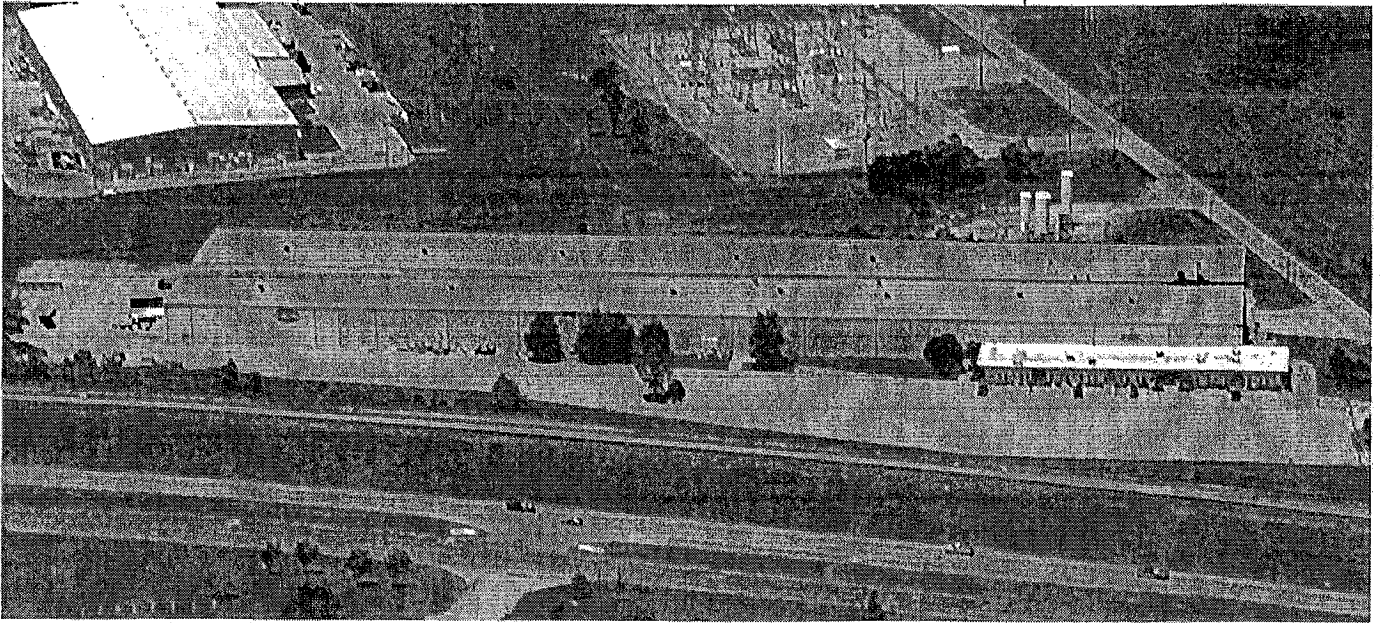
Integrity

AXH air-coolers' objective and commitment is to consistently provide customers with the highest quality air-coolers and support at a competitive price.

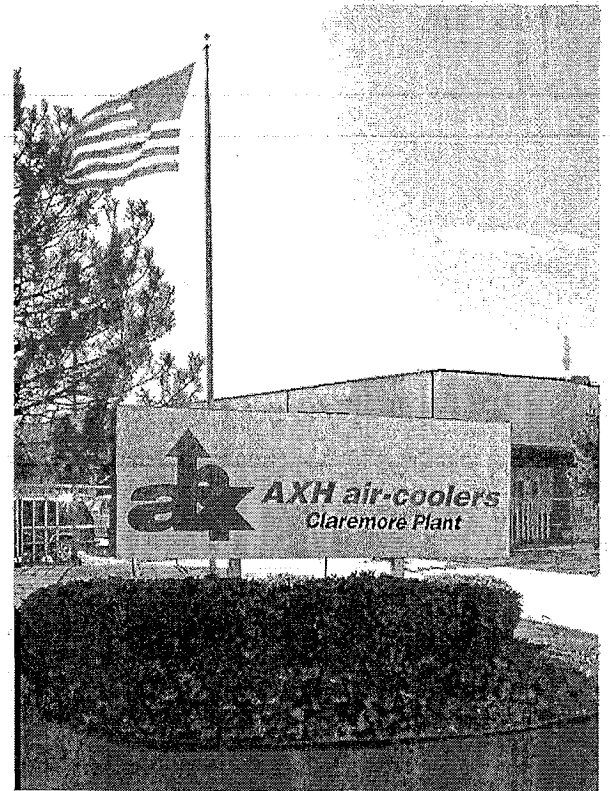


Corporate and sales office

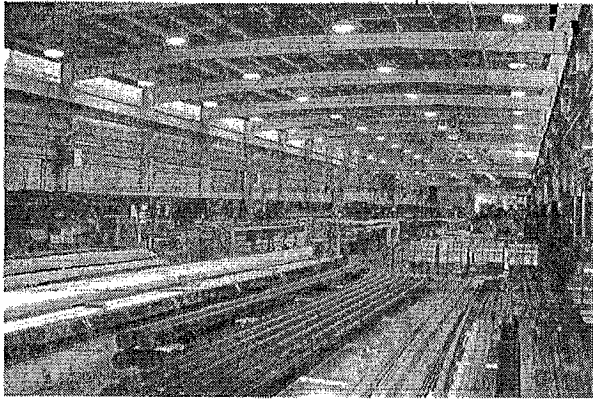
Facilities



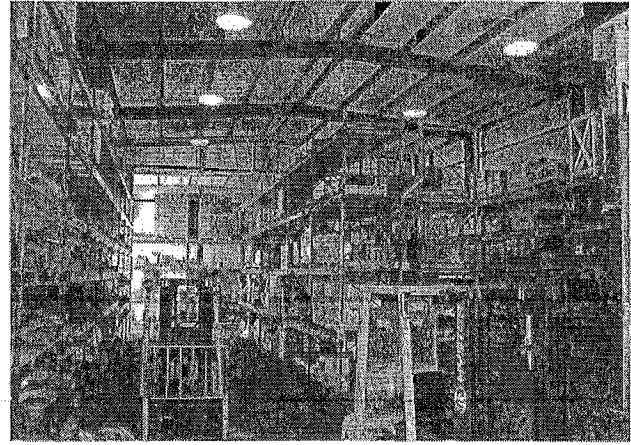
A new 161,000 square foot plant is located on 12 acres outside Tulsa and adjacent to Route 66 in Claremore, Oklahoma.



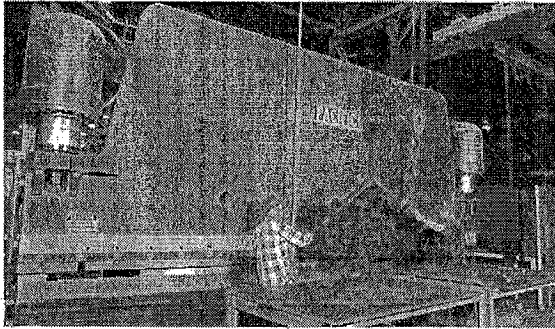
Capabilities



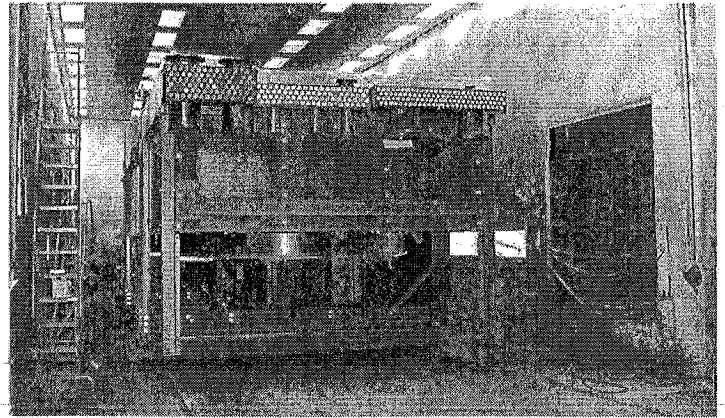
Finning area in 750 foot long East bay



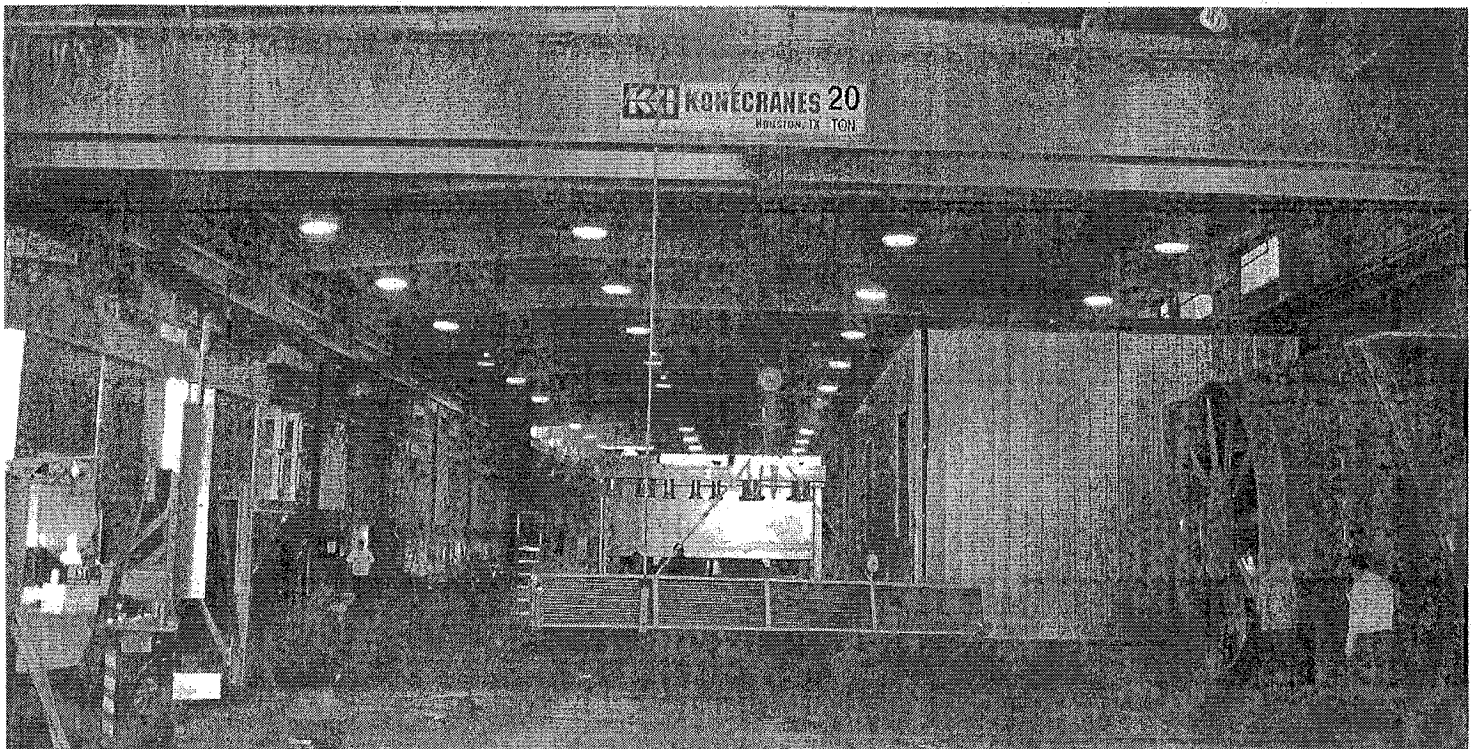
5,000 sq. ft. parts warehouse



400 ton, 3/4" X 22' press brake



Larger of two paint booths - 1,900 sq. ft.



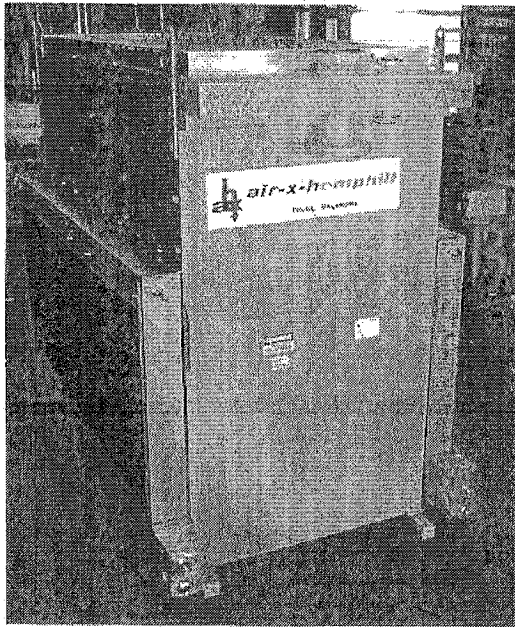
East bay final assembly area



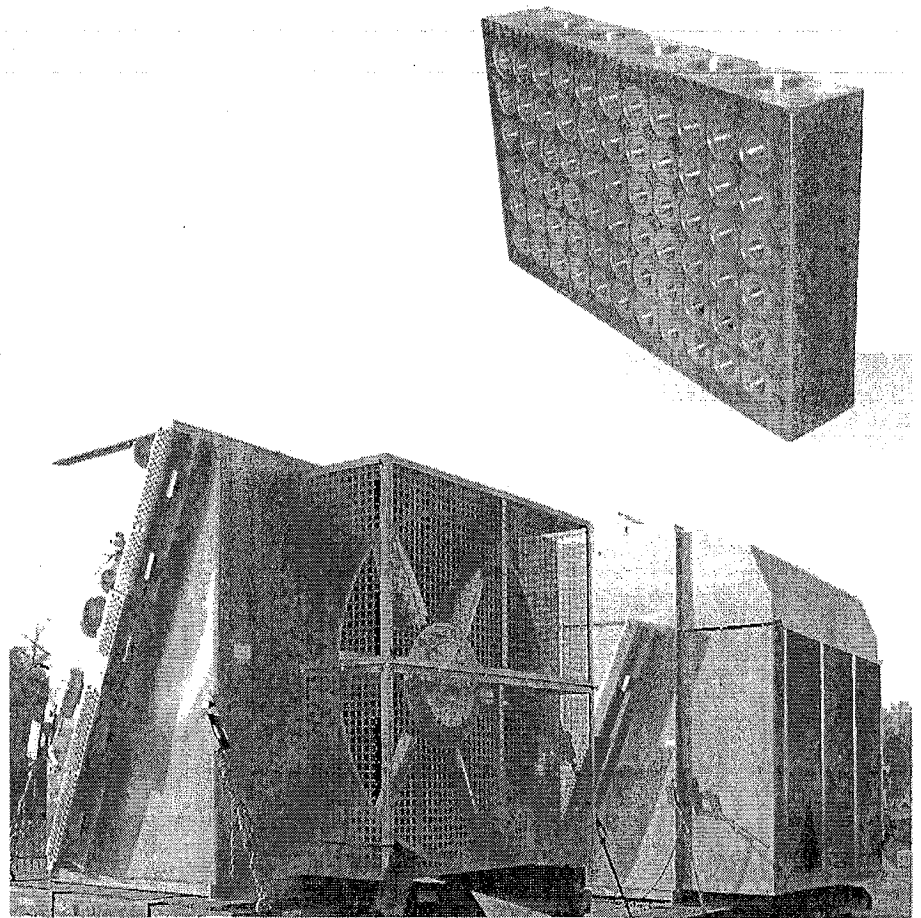
(46) ASME code welding stations providing Stick, MIG, TIG & sub-arc procedures



Model 120EF with internal electric motor drive

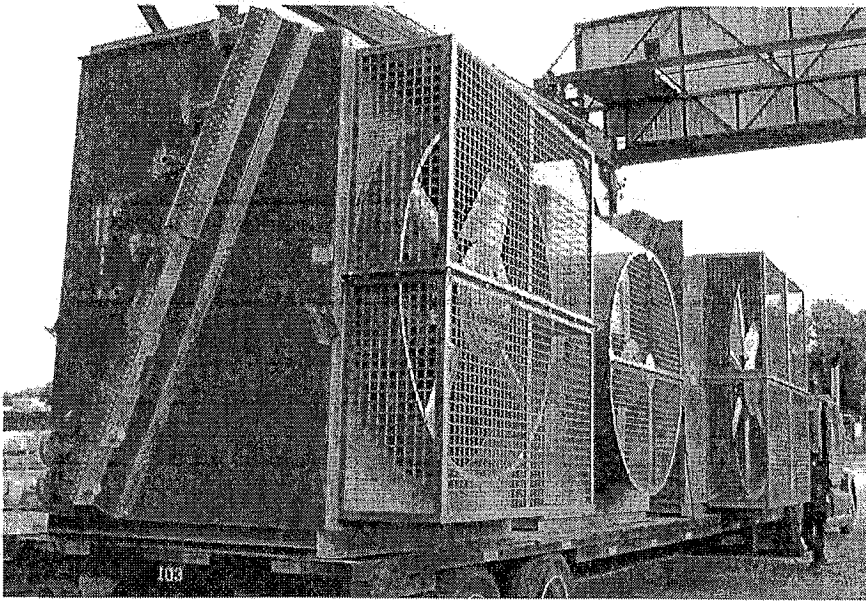


Type HF incorporating evaporative inlet cooling

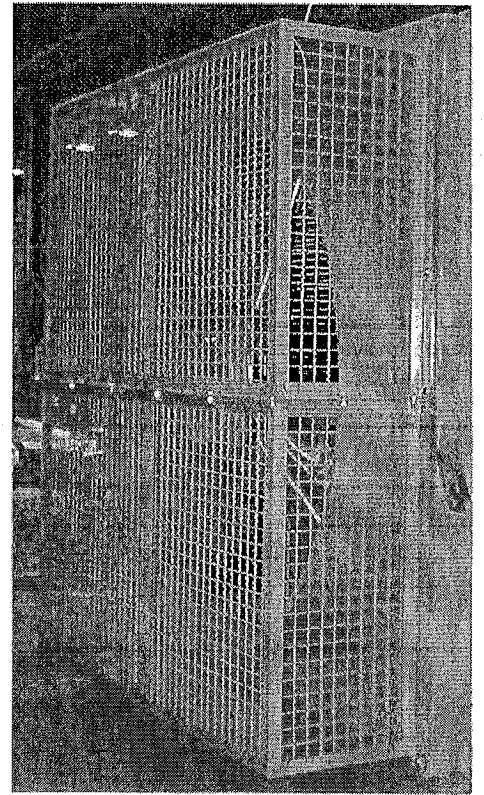


EF Models departing with warm air recirculation

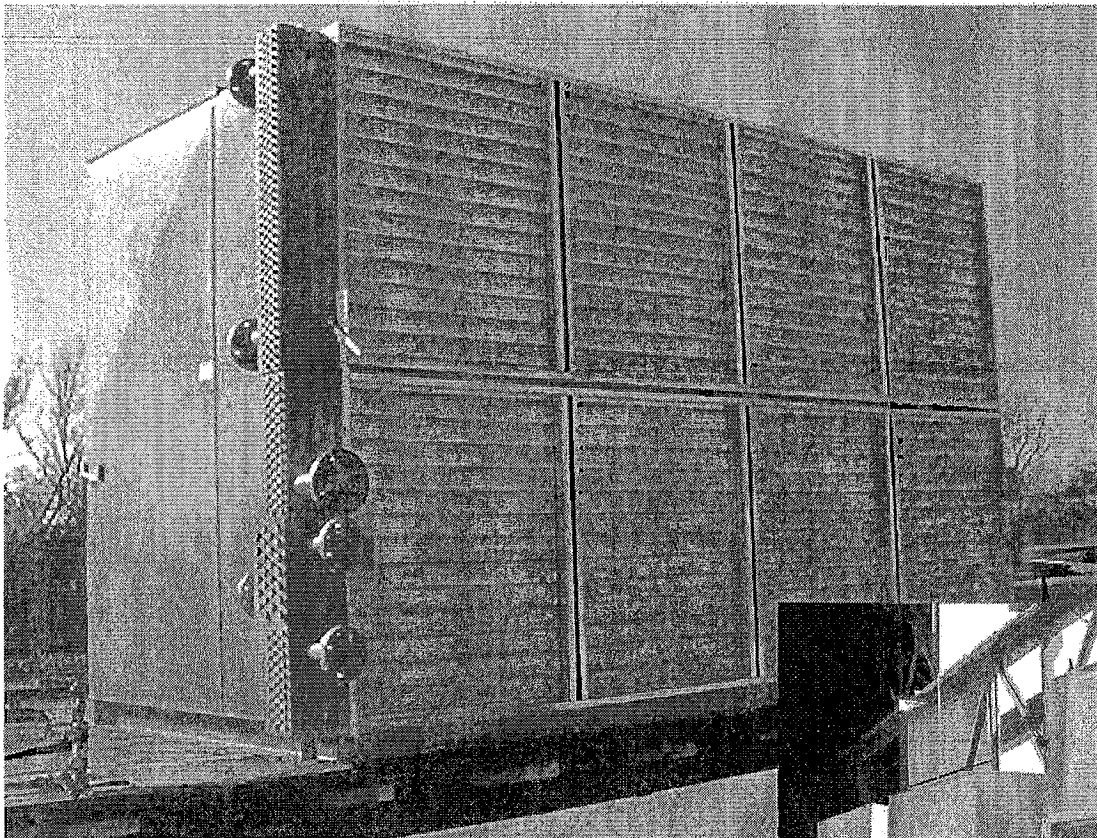
Reliability



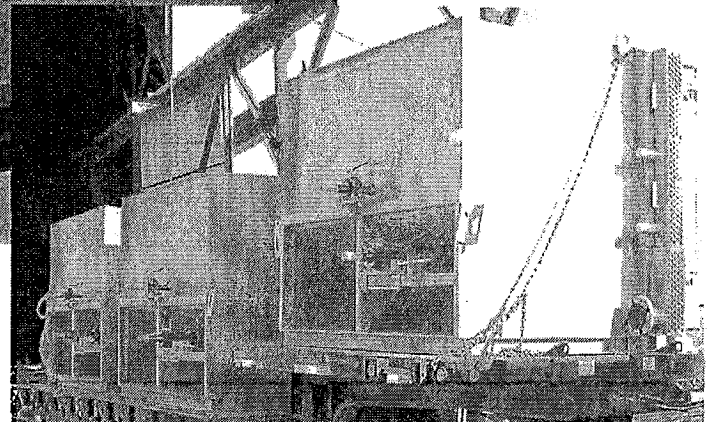
EF coolers ready for shipment

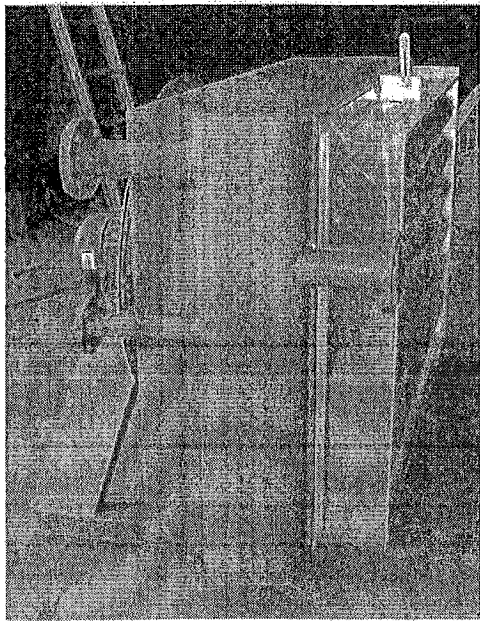


Type EF fan guard and "soft" bug screen frame

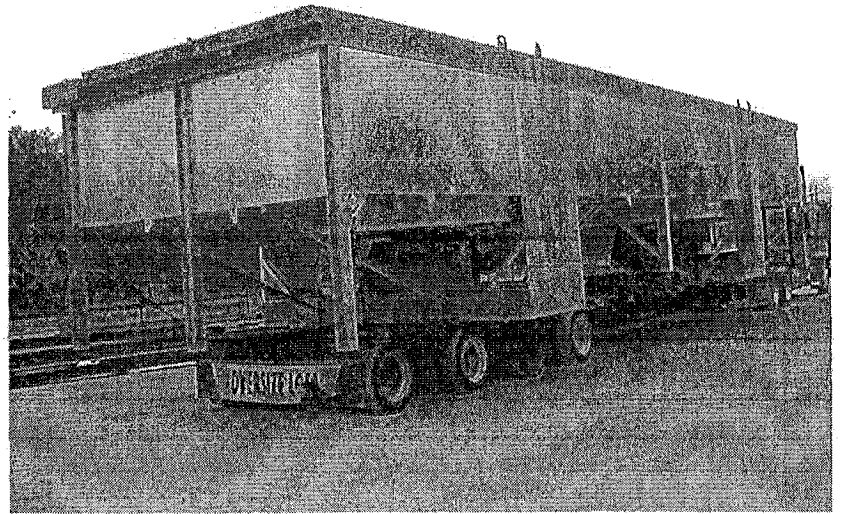


Induced Draft - Type VI's

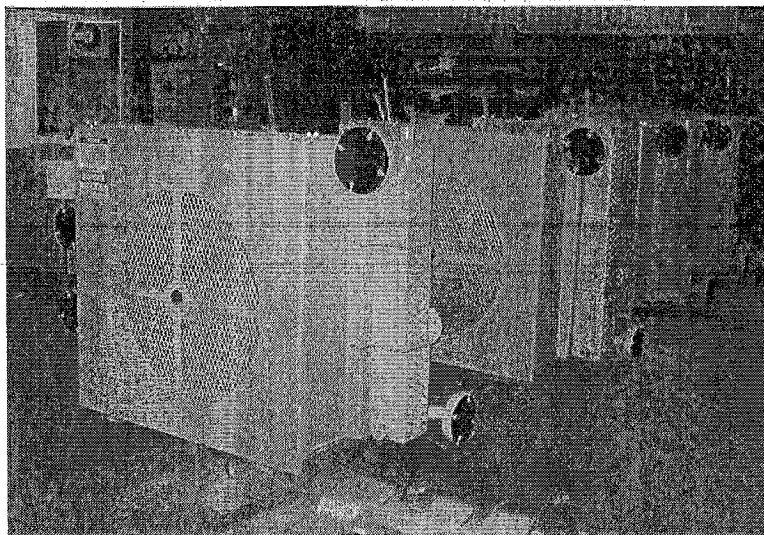




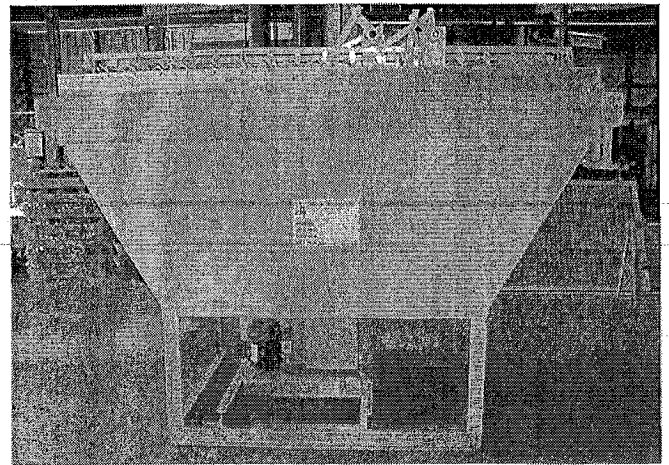
Model VV with Obround headers



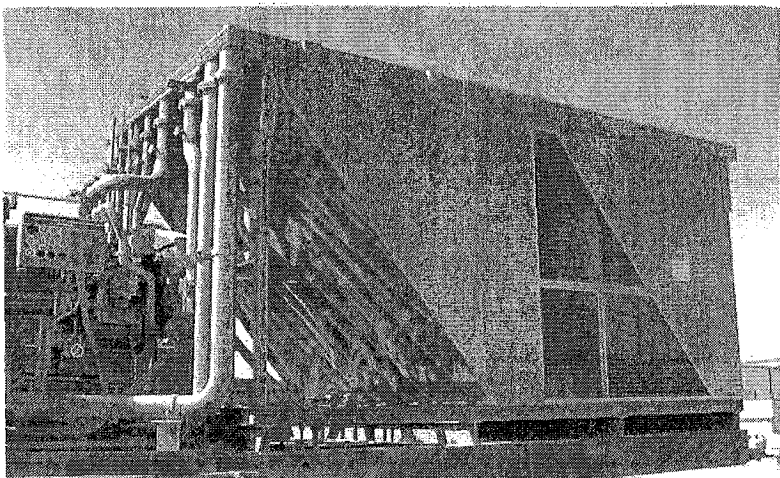
Model 180-2ZF destined for overseas



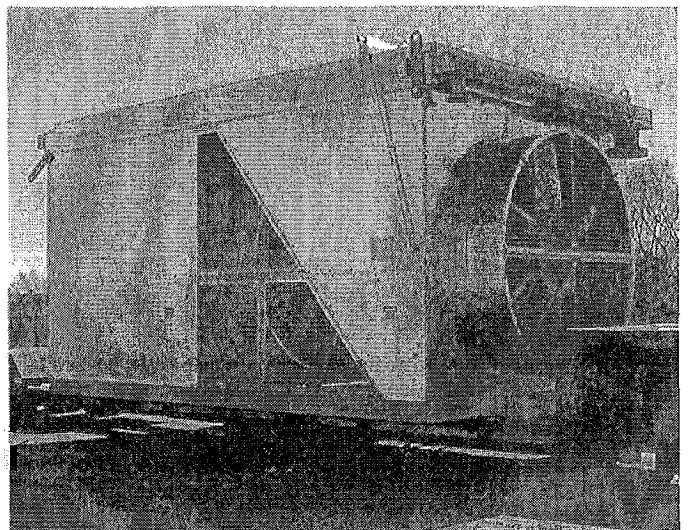
Direct Drive Model 36VVF's



Model 60HF

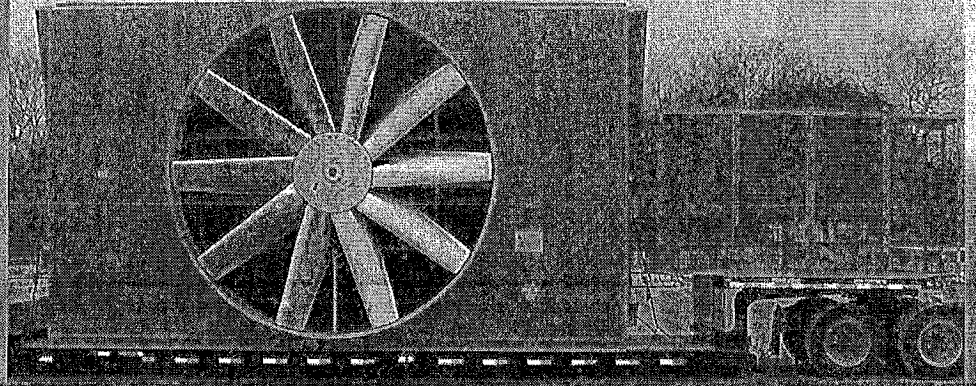
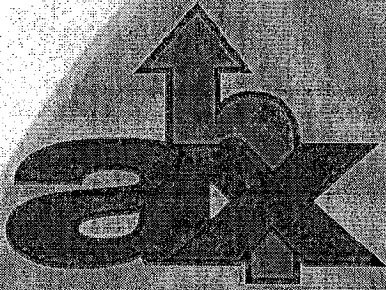


Packaged two-fan, Model 120FF2

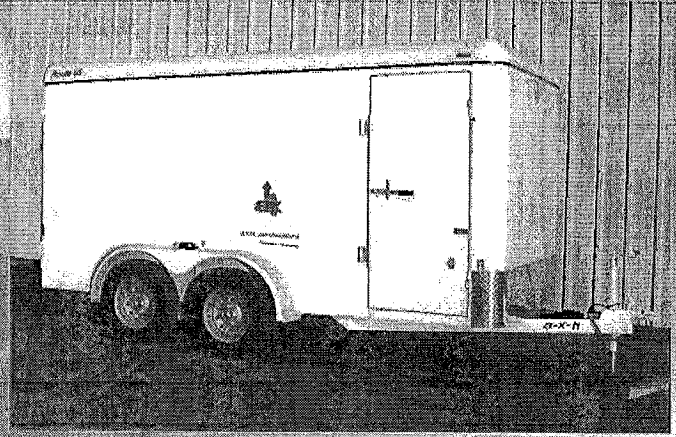


Galvanized Model 108FF2

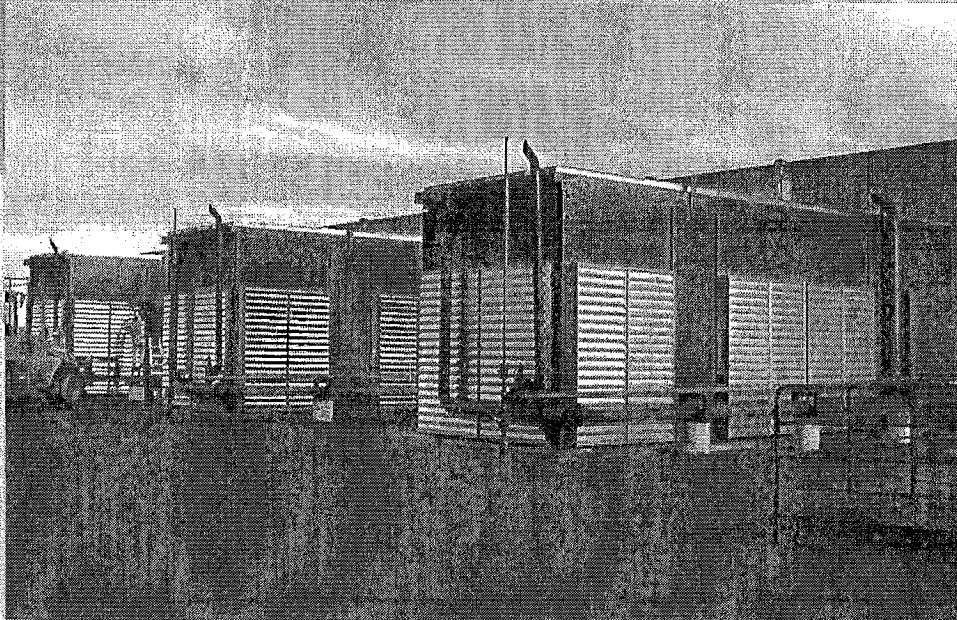
Integrity



Air Cooled Heat Exchangers



Fully equipped for field service



AXH air-coolers

401 East Lowry, Claremore, Oklahoma 74017

(918) 283-9200 Fax (918) 283-9229

www.axh.com

Quality Control Documents

- U-1A Manufacturer's Data Reports for Pressure Vessels
 - Name Plates
 - Inspection and Testing
 - Weld Procedures
 - Qualifications and Maps
- NDE Testing and Hydro-testing
 - Material Records
 - Travel Sheets
 - Bill of Materials
 - Packing Slips

Quality Control Documents

- U-1A Manufacturer's Data Reports for Pressure Vessels
 - Tag # AC-5020

FORM U-1A MANUFACTURER'S DATA REPORT FOR PRESSURE VESSELS
 (ALTERNATIVE FORM FOR SINGLE CHAMBER, COMPLETELY SHOP OR FIELD FABRICATED VESSELS ONLY)
 AS REQUIRED BY THE PROVISIONS OF THE ASME CODE RULES, SECTION VIII, DIVISION 1

1. Manufactured and certified by: AXH air-coolers, LLC - 401 EAST LOWRY ROAD - CLAREMORE, OKLAHOMA 74017
 (Name and address of manufacturer)
 2. Manufactured for: MURPHY OIL CANADA, 4000, 520 - 3RD AVENUE SOUTHWEST, CALGARY, ALBERTA, CANADA T2P 3Y3
 3. Location of installation: UNKNOWN
 (Name and address)
 4. Type HORZ. H. EXCHANGER 118455.1 V7152.213 118455HDR-BFWATER R0&118455-CRN1 R0 21007 2012
 (Horizontal or vertical, tank) (Manufacturer's serial no.) (CRN) (Drawing number(s)) (National Board Number) (Year built)
 5. The chemical and physical properties of all parts meet the requirements of material specifications of the ASME BOILER AND PRESSURE VESSEL
 CODE. The design, construction and workmanship conform to ASME Rules, Section VIII, Division 1. 2010 EDITION
 Year

to: NO ADDENDA
 Addenda, if applicable (date) (Code Case numbers) (Special Service per UG-120 (d))

6. Shell: TUBE/PLUG: SA-516-70N FR & BK 1" .0625 FR & BK 0' 5 1/8" 8' 11 1/8"
 (Material spec. number, grade) (Nominal thickness) (Corr. allow) (Inner diameter) (Length (overall))

7. Seams: CORNER JOINT SEE REMARKS 1.0 1150° 1 - - - *2
 [Long, (welded, dbl., R.T. (Spot or Full) (Eff. %) (H.T. temp.) (Time, hr) (Girth (welded, dbl., singl., lap, butt)) (R.T. (spot or full)) (Eff. %) (No. of courses) (No. of courses)]

8. Heads: (a) Material WRAPPERS: SA-516-70N (b) Material ENDS: SA-516-70N
 (Spec. no., grade) (Spec. no., grade)

	Location (Top, Bottom, Ends)	Minimum Thickness	Corrosion Allowance	Crown Radius	Knuckle Radius	Elliptical Ratio	Conical Apex Angle	Hemispherical Radius	Flat Diameter	Side to Pressure (Convex or Concave)
a	WRAPPERS	1/2"	.0625	-	-	-	-	-	**	FLAT
b	ENDS	3/8"	.0625	-	-	-	-	-	***	FLAT

If removable, bolts used (describe other fastenings)

9. MAWP 256 psi. N/A at max. temp 212 °F N/A
 (Internal) (External) (Internal) (External)
 Min. design metal temp. -49 °F at 256 psi. Hydro., pres., or comb. test pressure 333 psi.

Proof Test NONE

10. Nozzles, inspection, and safety valve openings:

Purpose (Inlet, Outlet, Drain)	No.	Diameter or size	Type	Material		Nozzle Thickness		Reinforcement Material	Attachment Details		Location (Insp. Open.)
				Nozzle	Flange	Nom.	Corr.		Nozzle	Flange	
INLET/OUTLET	2	3"-150#	PIPE/RFWN	SA333-GR6	SA350-LF2	S/160	0.0625	NONE	UW-16(a)	UW-16(a)	HEADER
INSTRUMENT	4	1"	CPLG	SA350-LF2	-	6000#	0.0625	NONE	UW-16(a)	-	HEADER
PLUGS	424	3/4"-16	UNF	SA350-LF2	-	-	-	-	-	-	HEADER

11. Supports: Skirt NO Lugs N/A Legs N/A Other STRUCTURE Attached BOLTED
 (Yes or no) (Number) (Number) (Describe) (Where and How)

12. Remarks: Manufacturer's Partial Data Reports properly identified and signed by Commissioned Inspectors have been furnished for the following items of the report:

(Name of part, item number, Manufacturer's name and identifying stamp)
 *2 HEADERS, ONE AT EACH END. **WRAPPERS FLAT DIA. 2 1/2" X 8' 11 1/8". ***ENDS FLAT DIA. 2 1/2" X 4 1/8".
 212 TUBES SA-179 5/8" O.D. X .065 MW 16' 0" LG. RADIOGRAPH PER CUSTOMER SPECIFICATION'S.
 IMPACTS EXEMPT PER UCS-66(a) CURVE D. PRESSURE RELIEF DEVICE BY OTHERS. CONSTRUCTED IN ACCORDANCE WITH APPENDIX 28.

CERTIFICATE OF SHOP / FIELD COMPLIANCE	
We certify that the statements made in this report are correct and that all details of design, material, construction, and workmanship of this vessel conform to the ASME BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 1. "U" Certificate of Authorization Number <u>34,950</u> expires <u>02/07/2014</u>	
Date <u>3-21-2012</u> Co. name <u>AXH air-coolers, LLC.</u> Signed <u>Kerrie Weeks</u> (Manufacturer) (Representative)	
CERTIFICATE OF SHOP / FIELD INSPECTION	
Vessel constructed by <u>AXH air-coolers, LLC.</u> at <u>401 E. LOWRY ROAD - CLAREMORE, OKLAHOMA 74017</u>	
I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and/or the State or Province of <u>OKLAHOMA</u> and employed by <u>SENECA INSURANCE COMPANY OF TEXAS</u>	
have inspected the component described in this Manufacturer's Data Report on <u>3-20-12</u> and state that, to the best of my knowledge and belief, the Manufacturer has constructed this pressure vessel in accordance with ASME BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 1. By signing this certificate neither the Inspector nor his employer makes any warranty, expressed or implied, concerning the pressure vessel described in this Manufacturer's Data Report. Furthermore, neither the inspector nor his/her employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.	
Date <u>3-21-12</u> Signed <u>[Signature]</u> Commissions <u>NB12461A OK883</u> (Authorized Inspector) (National Board (incl. endorsements,) State, Province, and number)	

Quality Control Documents

- Name Plates
- Tag # AC-5020

U
W
HT

NB 21007

CERTIFIED BY **AXH air-coolers, LLC**

CLAREMORE, OKLAHOMA BF WATER

MAX. ALLOWABLE WORKING PRESSURE 256 PSI @ 212 °F

MIN. DESIGN METAL TEMP. -49 °F @ 256 PSI

SER. NO. 118455.1 CRN. V7152.213

YEAR 2012 HYDRO. 333 PSIG SERVICE



AXH AIR COOLERS
QC CERTIFIED

RW 3/8/12

WISco
WCI RC
Initials <i>VP</i>
Date <i>3-28-12</i>
117

Quality Control Documents

- Inspection and Testing
 - Stress Relieve Charts
- Radiographic Inspection Reports
- Magnetic Particle Examination Record
- Liquid Penetrant Examination Record
- Hydrostatic Test Gauge Certificate
 - Hardness Test Report
- Run-In and Noise Testing Report
 - Nozzle Load Calculations
 - Tag # AC-5020

Customer Information

Your PO#: 500594

Part #: 118455.1

Description :BF WATER FR HEADERS

Thermal Specialties Heat Treating Certification

Thermal Specialties Information

Date Processed: 03/14/2012

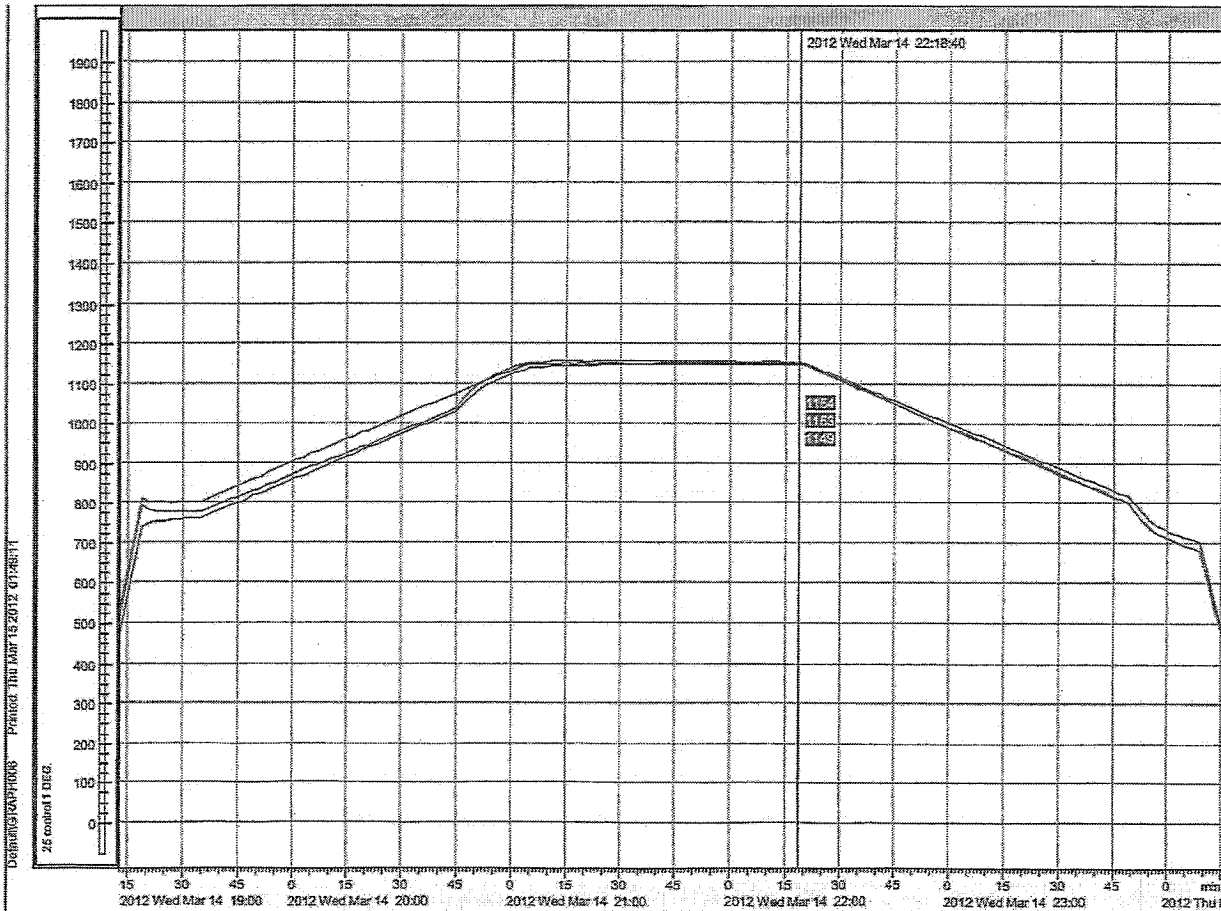
TSHTSO#: 174668

Furnace#: 25

Calibration Date: 02/22/2012

Thermocouple Type K

Approved by: JL



VJ
3-15-12



Thermal Specialties certifies that the item has been processed in accordance with customer's requirements. Processes were obtained through standard approved methods and in accordance with Thermal Specialties quality assurance manual



1030 N. Iriquois Ave.

118455.1 BF

918-585-8200

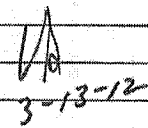
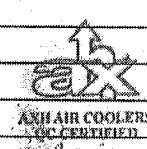
Bill of Lading

(PWHT Chart On Reverse Page)

Sold To:		Ship To:	
Customer Name	AXH AIR-COOLERS	Customer Name	AXH AIR-COOLERS
Bill to Address	401 E. LOWRY RD.	Ship to Address	401 E. LOWRY RD.
City, ST, Zip	CLAREMORE, OK 74017	City, ST, Zip	CLAREMORE, OK 74017
Telephone	918-283-9200	Telephone	918-283-9200
Contact:	JEFF STEELE	Contact:	JEFF STEELE
E-Mail		E-Mail	

Customer PO No.	N/A	Ship Date	03/13/2012
Customer Job No.	MULTI	Ship Time	08:00
Bill of Lading No.	N/A	Ship Method	ZENTECH

Part Quantity		Part Name	Weight
1	118455.1 BF WATER BK	HEADER	N/A

Part Description
PWHT OF (1) HEADER



Zentech Job Number	1-30-12-126	Zentech Operator	ROBERT AGEE
Experian Seq. Num.	210	Furnace Number	4

Signed for By		Signed for Date	
---------------	--	-----------------	--

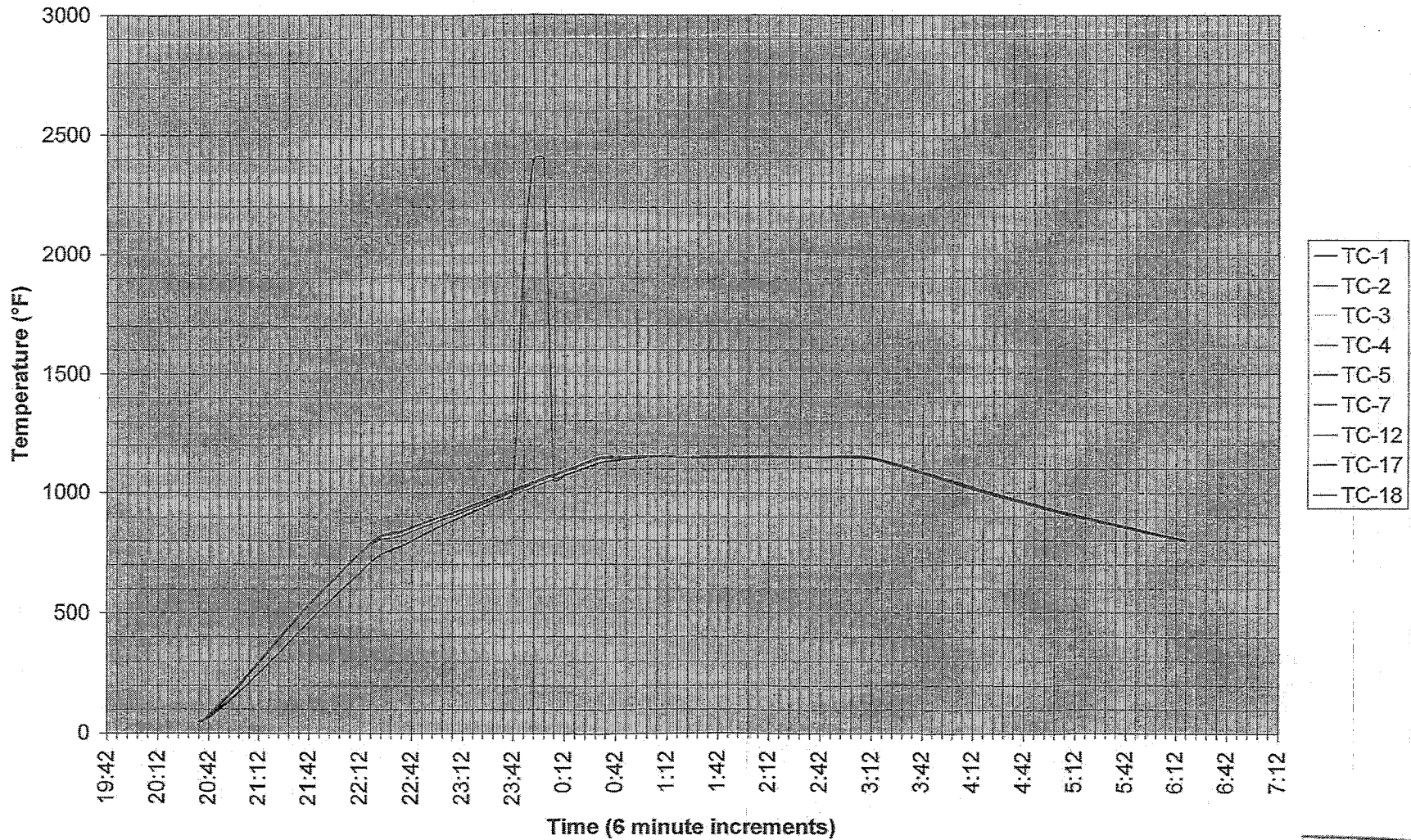
WISco
 W I R E
 Initials: *RA*
 Date: 3-14-12
 117

AXH AIR-COOLERS
MULTI
N/A
118455.1 BF

1-30-12-126

3/13/2012

Zentech Thermal Processing Furnace No. 4



Calibration Date: 7/1/2011
Calibration Due: 7/1/2012

Signed By: ROBERT AGE

WIScon
WIRE
Initials: <i>RA</i>
Date: <i>3-13-12</i>
117

CUSTOMER: AXH IRISNDT# 135878 DATE: 3-12-12
 LOCATION: Claremore JOB#: 118455.1 FR P.O.#: _____ PART#: _____
 MATERIAL: CS CODE: ASME ORIG. FILM _____ REPAIR FILM _____

TESTING VARIABLES
 Ir₁₉₂ Co₆₀ X-Ray Cl 38 kV _____ mA _____ EFSS: .149
 PROCESSING: MANUAL AUTOMATIC SINGLE FILM COMPOSITE FILM
 EXPOSURE: DWE/SWV DWE/DWV SWE/SWV
 FILM: TYPE F-80 CLASS 1 SENSITIVITY .016
 FILM USAGE: 3½ x 8½ 3½ x 10 _____ 3½ x 17 _____ 4½ x 10 _____ 4½ x 17 _____ 14 x 17 _____
 7 x 8½ _____ 7 x 17 _____ 8 x 10 _____ 70mm _____ Other _____

FILM I.D.	INTERVAL	I.Q.I.	SHIM	MAT'L THK	SOD Inches	O.F.D. Inches	DENSITY	IRISNDT Proc.	DIA.	DISCONTINUITIES	ACCEPT	REJECT
1	1-2	BF	Ø	.500	4"	.500	2-4	R+2			✓	
2	2-3										✓	
3												
4	1-2	BF	Ø	.375	6 1/4	.375	2-4	R+2			✓	
5												
6												
7												
8												
9												
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29												
30												

WISco
 WORE
 Initials: KP
 Date: 3-14-12
 117

IRISNDT Procedure:
 RT 1, 2, 2A, 6, 7 - Single Wall Exposure
 RT 3, 3A, 4, 5, 8, - Double Wall Exposure
 S.O.D. = Source-to-object distance
 O.F.D. = Object-to-film distance
 S.O.D. + O.F.D. = S.F.D

TERMS AND ABBREVIATIONS

AB - Arc Burns	EUC - External Undercut	IC - Internal Concavity	P - Porosity
BT - Burn Through	IUC - Internal Undercut	LF - Lack of Fusion	S - Slag
CK - Crack	HB - Hollow Bead	LC - Low Cover	RS - Round Seam
EP - Excessive Penetration	IP - Incomplete Penetration	MA - Misalignment	LS - Long Seam
	IQI - Image Quality Indicator (Penetrameter)		

Unit # _____ Miles: _____
 In _____ Out _____ Hrs. _____
 In _____ Out _____ Hrs. _____
 Personnel: J. Wolff, J. Garcia

Interpretation by: _____
 ASNT SNT-TC-1A (Level) _____
W 3-12-12 W W CERT. # _____
 (Print) (Signature)
 Client Representative: _____

Tulsa: 1115 W. 41st Street, Tulsa, OK 74107, Ph (918) 446-8773 Fax (918) 446-8777
 Deer Park: 905 Georgia Ave., Deer Park, TX 77536, Ph (281) 476-4444 Fax (281) 476-4450
 Houston: 1729 D Brittonmore, Houston, TX 77043, Ph (713) 461-6363 Fax (713) 461-0074

CUSTOMER: AXH IRISNDT#: 135878 DATE: 3-12-12
 LOCATION: Claremore JOB#: 118455.1 BK P.O.#: _____ PART#: _____
 MATERIAL: 9/8 CODE: ASME ORIG. FILM REPAIR FILM _____

TESTING VARIABLES
 Ir₁₀₂ Co₆₀ X-Ray Cl 38 KV _____ mA _____ EFSS: 149
 PROCESSING: MANUAL AUTOMATIC SINGLE FILM COMPOSITE FILM
 EXPOSURE: DWE/SWV DWE/DWV SWE/SWV
 FILM: TYPE F-80 CLASS 1 SENSITIVITY 1.016
 FILM USAGE: 3 1/2 x 8 1/2 3 1/2 x 10 _____ 3 1/2 x 17 _____ 4 1/2 x 10 _____ 4 1/2 x 17 _____ 14 x 17 _____
 7 x 8 1/2 _____ 7 x 17 _____ 8 x 10 _____ 70mm _____ Other _____

FILM I.D.	INTERVAL	I.Q.I.	SHIM	MAT'L THK	SOD Inches	OFD Inches	DENSITY	IRISNDT Proc.	DIA.	DISCONTINUITIES	ACCEPT	REJECT
1	1-2	BF Ø		.500	7"	.0002-4		R+2			✓	
2	2-3											
3												
4	1-2	BF Ø		.375	6 1/4"	.3752-4		R+2			✓	
5												
6												
7												
8												
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28												
29												
30												

WISCO
 WLR
 Initials: WLR
 Date: 3/12/12
 117

IRISNDT Procedure:
 RT 1, 2, 2A, 6, 7 - Single Wall Exposure
 RT 3, 3A, 4, 5, 8, - Double Wall Exposure
 S.O.D. = Source-to-object distance
 O.F.D. = Object-to-film distance
 S.O.D. + O.F.D. = S.F.D.

TERMS AND ABBREVIATIONS
 AB - Arc Burns
 BT - Burn Through
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 EP - Excessive Penetration
 EUC - External Undercut
 IUC - Internal Undercut
 HB - Hollow Bead
 IP - Incomplete Penetration
 IQI - Image Quality Indicator (Penetrameter)
 IC - Internal Concavity
 LF - Lack of Fusion
 LC - Low Cover
 MA - Misalignment
 P - Porosity
 S - Slag
 RS - Round Seam
 LS - Long Seam

Unit # _____ Miles: _____
 In _____ Out _____ Hrs. _____
 In _____ Out _____ Hrs. _____
 Personnel: Joseph J. Garcia

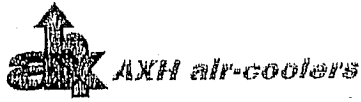
Interpretation by: _____
 ASNT SNT-TC-1A
WLR (Print) _____ (Level)
 _____ (Signature) CERT. # _____
 Client Representative: AXH

Tulsa 1115 W. 41st Street
 Tulsa, OK 74107
 Ph (918) 446-8773 Fax (918) 446-8777

Deer Park 905 Georgia Ave.
 Deer Park, TX 77536
 Ph (281) 476-4444 Fax (281) 476-4450

Houston 1729 D Brittmoores
 Houston, TX 77043
 Ph (713) 461-6363 Fax (713) 461-0074

AXAIR COOLERS
 QC CERTIFIED



REPORT OF NONDESTRUCTIVE TESTING
MAGNETIC PARTICLE EXAMINATION RECORD

REFERENCE STANDARD: ASME SECT.V, ASME SECT. VIII DIV.1, APPENDIX 6
AXH AIR-COOLERS STANDARD MS-20.0 REVISION: 0

EXAMINATION EQUIPMENT & METHOD

MAGNETIZING EQUIPMENT: Parker Research Contour Probe SERIAL #: 3563

CURRENT TYPE: AC DC

MT TYPE: WET DRY FLOURESCENT VISIBLE

LIGHTING EQUIPMENT: FLOURESCENT LIGHT
 WHITE LIGHT USING PARKER RESEARCH Y300 OR Y400 PROBE LIGHTING
 FLASHLIGHT # OF BATTERIES TYPE: CELL
MAXIMUM DISTANCE FROM OBJECT: _____ FEET
 OTHER _____

MINIMUM LIGHT INTENSITY ON SURFACE TO BE EXAMINED: 100 FOOT CANDLES

EXAMINATION RESULTS

IDENTIFICATION:

CUSTOMER: MURPHY OIL CORP. DATE: 3-13-12

JOB #: 118455 ITEM #: 1FRBK (EXAMPLE: .1, .2, .3)

MATERIAL TYPE: SA516-70N MATERIAL THICKNESS: _____

EXAMINATION PERFORMED:

- PLATE EDGES - BEFORE WELDING (ALL TUBE AND PLUG SHEETS WHICH HAVE BEEN BEVELED / MACHINED FOR WELD JOINT PREPARATION), AND AFTER WELDING (PERIPHERAL EDGE OF TUBE AND PLUG SHEETS) PER ASME SECTION VIII, DIV. 1, UG-93 BEFORE 2-29-12 AFTER 3-13-12
- ALL WELDED SEAMS WHERE ACCESSIBLE
- ALL FINAL WELD SEAMS, NOZZLES, & COUPLINGS WHERE ACCESSIBLE
- ALL NOZZLE & COUPLING ROOT PASSES WHERE ACCESSIBLE
- OTHER _____

EXAMINATION RESULTS:

ACCEPT

REJECT

DESCRIPTION AND/OR MAP OF INDICATIONS FOUND



AXH AIR COOLERS
QC CERTIFIED

Smith
EXAMINER

II
QUALIFICATION LEVEL

Resized only
WISco
W R
Initials: RS
Date: 3-28-12
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REPORT OF NONDESTRUCTIVE TESTING
LIQUID PENETRANT EXAMINATION RECORD

REFERENCE STANDARD: ASME SECT.V, ASME SECT. VIII DIV.1, APPENDIX 8
AXH AIR-COOLERS STANDARD MS-21.0 REVISION: 0

EXAMINATION EQUIPMENT & METHOD

LIQUID PENETRANT TYPE: DUBL CHECK DP-60 OTHER: Chemetall Oakite/Ardrox 906

CLEANER / REMOVER: DUBL CHECK DR-60 OTHER: Chemetall Oakite/Ardrox 9PR50

DEVELOPER: DUBL CHECK D-100 OTHER: Chemetall Oakite/Ardrox 9D1B

LIGHTING EQUIPMENT: FLOURESCENT LIGHT
 FLASHLIGHT # OF BATTERIES TYPE: CELL
MAXIMUM DISTANCE FROM OBJECT: FEET
 OTHER

MINIMUM LIGHT INTENSITY ON SURFACE TO BE EXAMINED: 100 FOOT CANDLES

EXAMINATION RESULTS

IDENTIFICATION:

CUSTOMER: MURPHY OIL CORP DATE: 3-13-12

JOB #: 118455 ITEM #: .1 FR/BK (EXAMPLE: .1, .2, .3)

MATERIAL TYPE: SA516-70N MATERIAL THICKNESS:

EXAMINATION PERFORMED:

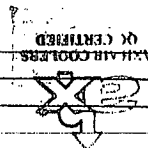
- PLATE EDGES - BEFORE WELDING (ALL TUBE AND PLUG SHEETS WHICH HAVE BEEN BEVELED / MACHINED FOR WELD JOINT PREPARATION), AND AFTER WELDING (PERIPHERAL EDGE OF TUBE AND PLUG SHEETS) PER ASME SECTION VIII, DIV. 1, UG-93
BEFORE 3-13-12 AFTER
- ALL WELDED SEAMS WHERE ACCESSIBLE
- ALL FINAL WELD SEAMS, NOZZLES, & COUPLINGS WHERE ACCESSIBLE
- ALL NOZZLE & COUPLING ROOT PASSES WHERE ACCESSIBLE
- ALL NOZZLE AND COUPLING HOLE OPENINGS FOR LAMINATION
- OTHER

EXAMINATION RESULTS:

ACCEPT

REJECT

DESCRIPTION AND/OR MAP OF INDICATIONS FOUND



V Smith
EXAMINER

H
QUALIFICATION LEVEL

WISco
W <input type="checkbox"/> R <input checked="" type="checkbox"/> D <input type="checkbox"/>
Initials: <u>VP</u>
Date: <u>3-28-12</u>
117

#102

Certificate of Site Calibration

Precision Calibrations

Customer AXH Air Coolers
Address 401 E. Lowry Road
 Claremore, OK 74017 US

Instrument ID 102
Description Pressure Gage
Equipment ID NONE
Certificate # 1418

Instrument Type Pressure Gage
Manufacturer Ashcroft
Model Number 0-600 psi
Serial Number nsn
Calibrated 1/7/2012
Next Due Date* 1/7/2013

Frequency 12 Months
Status In Service
Procedure MFG SPEC
Temp n/a
Humidity n/a

* Any number of factors may cause the calibration to drift out of specification before the recommended interval has expired.

Calibration Data

Group # 1				Range Acc % 1.0000			
Group Name Measure				Reading Acc % 0.0000			
Stated Accy Pct of Range				Plus/Minus 0			
<u>Nom In Val / In Val</u>	<u>In Type</u>	<u>Out Val</u>	<u>Out Type</u>	<u>End As</u>	<u>Lft As</u>	<u>Dev%</u>	<u>Pass/Fail</u>
50 / 50	PSI	50	PSI	45	50	0.00%	Pass
200 / 200	PSI	200	PSI	190	200	0.00%	Pass
400 / 400	PSI	400	PSI	390	400	0.00%	Pass
600 / 600	PSI	600	PSI	580	600	0.00%	Pass

Instrument Calibration Results As Found: *Failed*
 As Left: *Passed*

Standards Used for Calibration

<u>Test Instrument ID</u>	<u>Description</u>	<u>Manufacturer</u>	<u>Model Number</u>	<u>Serial Number</u>	<u>(As Of Cal Entry Date)</u>	
					<u>Last Cal Date</u>	<u>Next Cal Date</u>
MEC-009	Fluke Calibrator 744B	Fluke	2020	6765909	11/6/2011	2/6/2012
MEC-028	Pressure Transducer	Omega	PX02SI-10KGI	194164	8/8/2011	8/8/2013

Notes about this calibration

Calibration Result Calibration Successful
Technician Nathan Saylor
Finalized By Nathan Saylor
Finalized On 1/8/2012 9:02:54PM

DECLARATION

Precision Calibrations certifies that all calibration measurements meet ISO 10042-1 and ANSI/NCSL Z540-1 specifications and are traceable to standards maintained by the National Institute of Standards and Technology (NIST), a natural physical constant, or a ratiometric method of self-calibration. Do not reproduce except in full, and written permission of Precision Calibrations. Calibrations listed relate only to the instrument identified above.

Precision Calibrations - 500 S Lynn Riggs Blvd #371, Claremore, Ok 74017
 Telephone: (918) 978-3378



401 E. LOWRY ROAD
CLAREMORE, OKLAHOMA 74017

HARDNESS TESTING INSPECTION REPORT

PROCEDURE: AXH MS-29.0
 CODE SPECIFICATION: _____
 ACCEPT. CRITERIA: _____
 JOB NO.: 118455.1 BF WATER HEADERS
 DATE: 3-13-12

MATERIAL TYPE: SA516-70 N SURFACE CONDITION: GROUND
 HEAT TREATMENT: YES
 EQUIPMENT: KRAUTKRAMER MIC-10 CALIBRATION DATE: 3-13-12

CALIBRATION BLOCKS: _____

HARDNESS SCALE READING:		ROCKWELL B	VICKERS					
		ROCKWELL C	BRINELL					
ITEM	COMPONENT IDENTIFICATION AND LOCATION OF READING		BRINELL IMPRESSION		BRINELL BAR HARDNESS	HARDNESS VALUE	ACCEPT	REJECT
			BAR	MATERIAL				
FRT	LS1	WECD				187		
		H#2				176		
	ES1	W				189		
		H				175		
	N1	W				188		
		H				179		
	N2	W				187		
		H				177		
BK	LS1	WECD				187		
		H#2				175		
	ES1	W				186		
		H				177		

TECHNICIAN: V Smith (PRINT)
V Smith (SIGNATURE)

3-15-12 (DATE)
R. Johnson (INITIALS)
 ONLY



WISco
 WORD
 Initials: RP
 Date: 3-15-12
 117

I am in full agreement with report contents.
 CLIENT REPRESENTATIVE: _____ (SIGNATURE)



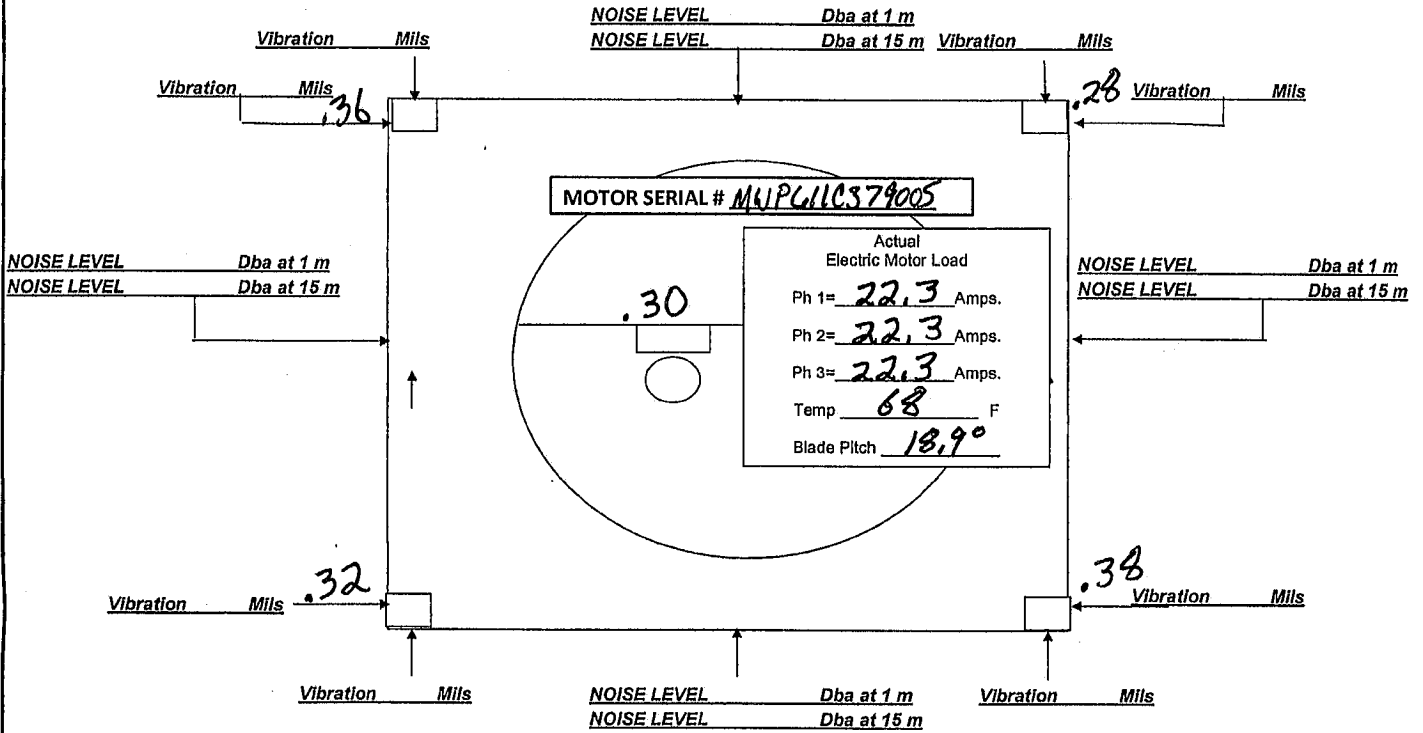
AXH air-coolers

401 East Lowery Rd. - Claremore, Ok. 74017
918-283-9200 - fax: 918-283-9229
www.axh.com

JOB NUMBER(S): 118455
CUSTOMER: MURPHY OIL CORPORATION
QUANTITY: 1 MOTOR
MODEL: 96BZF
Date: 3-21-12

RUN-IN & NOISE TESTING

BACK HEADER END



FRONT HEADER END

*UP INFINITE/monkeys
3/22/12
10/10 A.M.*

TESTING PERFORMED

1. Vibration Displacement in Mils. Peak to peak
2. Vibration Meter: Balmac Model 205
3. Noise Meter: Extech Model 407764
ANSI S1.4-1983 Type 2, IEC 651



AXH air-coolers

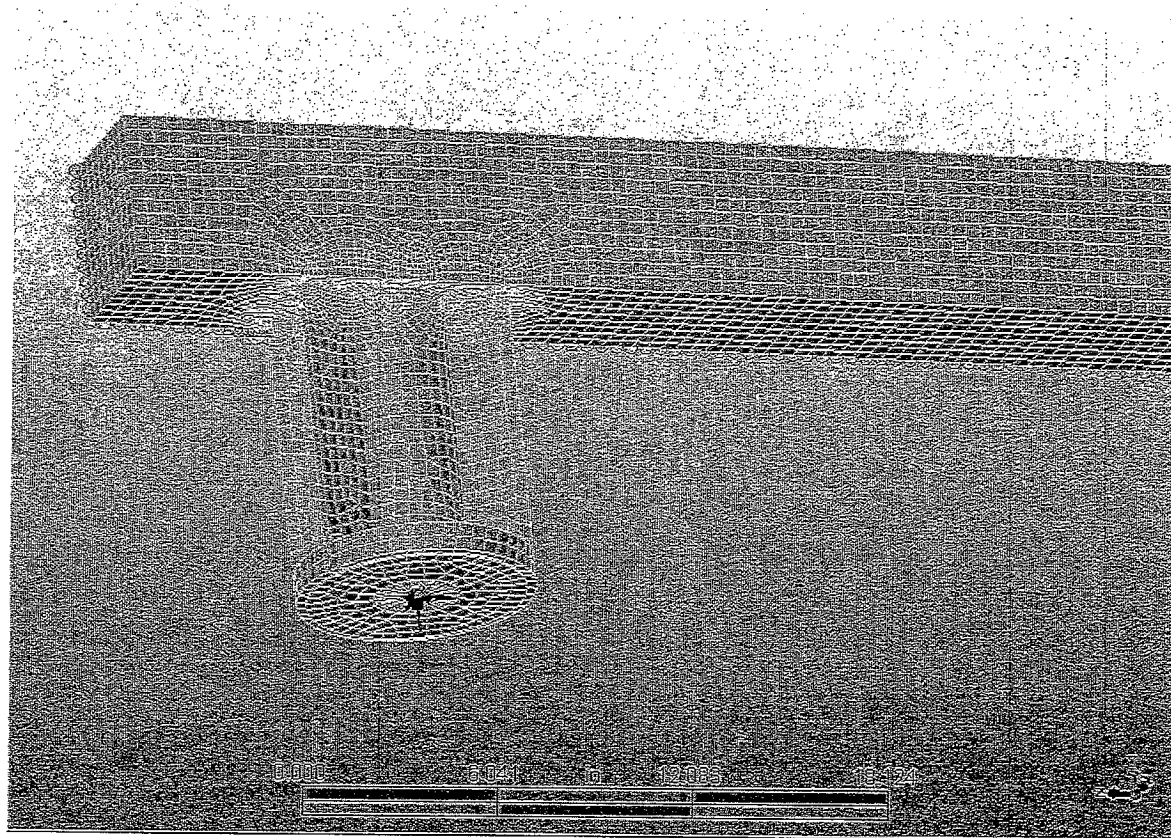
Tested By: *[Signature]*
Date Tested: 3-21-12
Time Tested: 6:50 am/pm

Review ONLY

WISCO
W <input type="checkbox"/> R <input checked="" type="checkbox"/>
Initials: <i>[Signature]</i>
Date: 3-28-12
117

Section C - Finite Element Analysis 96BZF

118455



Nozzle Loading Analysis
AXH Job # 118454 96BZF Cooler

Executive Summary

The nozzles need to be verified to be suitable for 3x API-661 Nozzle loads. The finite model was constructed using 8 node Brick elements. Due to symmetry, only 1/2 of the header was modeled and the middle of the header was treated as being restrained from translations in all 3 directions. The nozzle was modeled with gussets. The loads applied are as follows:

Internal Pressure = 178 psig

3x API-661 Nozzle Loads applied to end of nozzle.

$F_x = 1,350$ lbs

$F_y = 1,140$ lbs

$F_z = 1,350$ lbs

$M_x = 10,800$ lb-in

$M_y = 16,200$ lb-in

$M_z = 10,800$ lb-in

The resulting von-mises stresses were calculated and compared to the ASME Sec. VIII, Div. 1 Allowable Tensile Stresses. Since the von mises are less than these allowable stresses, the model is considered to be acceptable.

Allowable Tensile Stresses at 473 Deg. F:

A-333-Gr. 6 Nozzle - $S_a = 17,100$ psi

A-516-70N Plate = 20,000 psi

Summary

Model Information

Analysis Type - Static Stress with Linear Material Models

Units - English (in) - (lbf, in, s, °F, °R, V, ohm, A, in-lbf)

Model location - C:\Paulin\AXHAXH118454\Box Header 96BZF.fem

Design scenario description - Design Scenario # 1

Analysis Parameters Information

Load Case Multipliers

Static Stress with Linear Material Models may have multiple load cases. This allows a model to be analyzed with multiple loads while solving the equations a single time. The following is a list of load case multipliers that were analyzed with this model.

Load Case	Pressure/Surface Forces	Acceleration/Gravity	Rotation	Angular Acceleration	Displaced Boundary	Thermal	Voltage
-----------	-------------------------	----------------------	----------	----------------------	--------------------	---------	---------

1	1	0	0	0	0	0	0
---	---	---	---	---	---	---	---

Multiphysics Information

18466 Rev 0

Default Nodal Temperature	0 °F
Source of Initial Nodal Temperatures	Model file
Time step from Heat Transfer Analysis	Last
Default nodal voltage	0 V
Source of nodal voltages	Model file

Processor Information

Type of Solver	Automatic
Disable Calculation and Output of Strains	No
Calculate Reaction Forces	Yes
Invoke Banded Solver	Yes
Avoid Bandwidth Minimization	No
Stop After Stiffness Calculations	No
Displacement Data in Output File	No
Stress Data in Output File	No
Equation Numbers Data in Output File	No
Element Input Data in Output File	No
Nodal Input Data in Output File	No
Centrifugal Load Data in Output File	No

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Part Information

Part ID	Part Name	Element Type	Material Name
1	Box Header 96BZF	Brick	Steel (ASTM - A36)
2	Part 2	Rigid	Rigid elements have no material properties or the material properties have not been defined.

Element Information

Element Properties used for:

- Box Header 96BZF

Element Type	Brick
Compatibility	Not Enforced
Integration Order	2nd Order
Stress Free Reference Temperature	0 °F

Element Properties used for:

- Part 2

Element Type	Rigid
Stiffness	10000000000
Component DOF - Tx	Yes
Component DOF - Ty	Yes
Component DOF - Tz	Yes
Component DOF - Rx	Yes
Component DOF - Ry	Yes

Component DOF - Rz	Yes
--------------------	-----

118468 Rev 0

Material Information

Steel (ASTM - A36) -Brick

Material Model	Standard
Material Source	Autodesk Simulation Material Library
Material Source File	C:\Program Files\Autodesk\Algor Simulation 2012\matlibs\algor.mat.mlb
Date Last Updated	2004/09/30-16:00:00
Material Description	Structural Steel
Mass Density	0.000735 lbf-s ² /in/in ³
Modulus of Elasticity	29000000 lbf/in ²
Poisson's Ratio	0.29
Shear Modulus of Elasticity	11200000 lbf/in ²
Thermal Coefficient of Expansion	6.5e-006 1/°F

Loads

FEA Object Group 2: Surface Pressure/Tractions

Surface Pressure/Traction

ID	Description	Part ID	Surface ID	Magnitude (lbf/in ²)	X Magnitude (lbf/in ²)	Y Magnitude (lbf/in ²)	Z Magnitude (lbf/in ²)	Multiplier Table Id	Multiplier	Type	Follows Displacement	Apply Modified Pressure	Pressure Type	Loss Coefficient (lbf/in ²)
2	Unnamed	1	50	256.000000	0.000000	0.000000	0.000000	1	1.000000	Pressure	No	No	Static pressure	0.000000

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4	Unnamed	1	42	256.000000	0.000000	0.000000	0.000000	1	1.000000	Pressure	No	No	Static pressure	0.000000
5	Unnamed	1	51	256.000000	0.000000	0.000000	0.000000	1	1.000000	Pressure	No	No	Static pressure	0.000000
8	Unnamed	1	66	256.000000	0.000000	0.000000	0.000000	1	1.000000	Pressure	No	No	Static pressure	0.000000

FEA Object Group 3: Nodal Forces

Nodal Force

ID	Description	Vertex ID	Node Number	Magnitude (lbf)	Vx	Vy	Vz	Multiplier Table ID
1	Unnamed	27917	14531	1350.000000	1.000000	0.000000	0.000000	1

FEA Object Group 4: Nodal Forces

Nodal Force

ID	Description	Vertex ID	Node Number	Magnitude (lbf)	Vx	Vy	Vz	Multiplier Table ID
2	Unnamed	27917	14531	1140.000000	0.000000	1.000000	0.000000	1

FEA Object Group 5: Nodal Forces

Nodal Force

ID	Description	Vertex ID	Node Number	Magnitude (lbf)	Vx	Vy	Vz	Multiplier Table ID
3	Unnamed	27917	14531	1350.000000	0.000000	0.000000	1.000000	1

FEA Object Group 6: Nodal Moments

Nodal Moment

ID	Description	Vertex ID	Node Number	Magnitude (lbf-in)	Vx	Vy	Vz	LC_Placeholder	Coordinate System ID
1	Unnamed	27917	14531	10800.000000	1.000000	0.000000	0.000000	1	0

FEA Object Group 8: Nodal Moments

Nodal Moment

ID	Description	Vertex	Node	Magnitude	Vx	Vy	Vz	LC_Placeholder	Coordinate System
----	-------------	--------	------	-----------	----	----	----	----------------	-------------------

		ID	Number	(lbf-in)					ID
2	Unnamed	27917	14531	10800.000000	0.000000	0.000000	1.000000	1	0

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FEA Object Group 12: Nodal Moments
Nodal Moment

ID	Description	Vertex ID	Node Number	Magnitude (lbf-in)	Vx	Vy	Vz	LC_Placeholder	Coordinate System ID
3	Unnamed	27917	14531	16200.000000	0.000000	1.000000	0.000000	1	0

Constraints

FEA Object Group 14: Surface Boundary Conditions
Surface Boundary Condition

ID	Description	Part ID	Surface ID	Tx	Ty	Tz	Rx	Ry	Rz
2	Unnamed	1	55	Yes	Yes	Yes	No	No	No

FEA Object Group 15: Edge Boundary Conditions
Edge Boundary Condition

ID	Description	Part ID	Edge ID	Tx	Ty	Tz	Rx	Ry	Rz
1	Unnamed	1	266	Yes	Yes	Yes	Yes	Yes	Yes

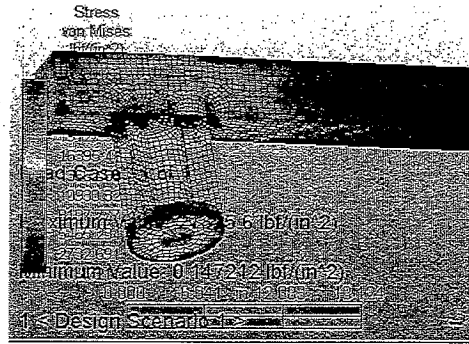
FEA Object Group 16: Surface Boundary Conditions
Surface Boundary Condition

ID	Description	Part ID	Surface ID	Tx	Ty	Tz	Rx	Ry	Rz
3	Unnamed	1	58	No	No	Yes	Yes	Yes	No

Results Presentation Images

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Stress



Box Header 96BZF

Stress
von Mises
lb/in²

27325.58
24593.04
21668.49
19127.96
16395.41
13662.86
10930.32
8197.77
5465.22
2732.67
0.147212

Load Case: 1 of 1

Maximum value: 27325.6 lb/in²

Minimum value: 0.147212 lb/in²

1 < Design Scenario 1 >

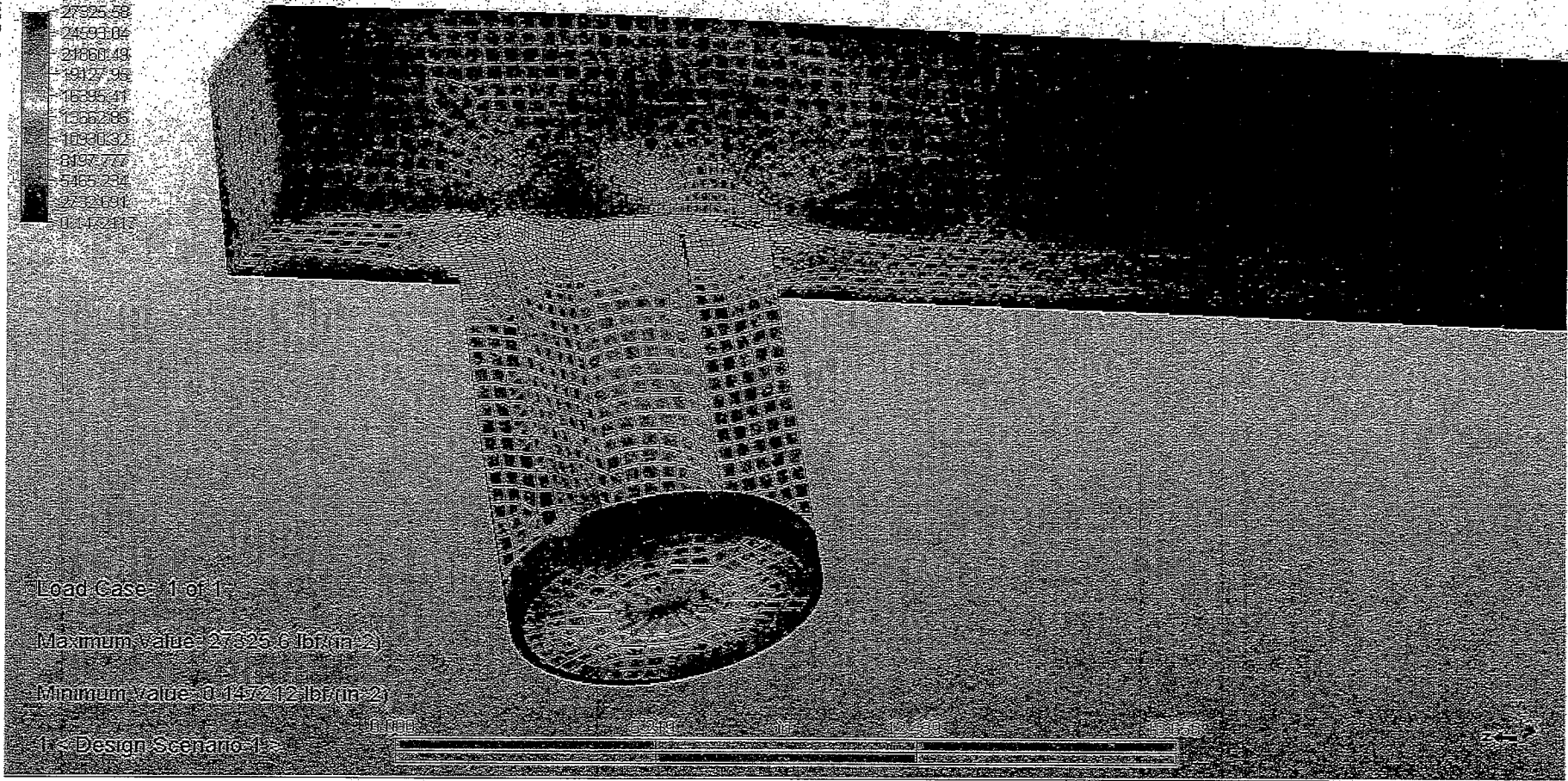


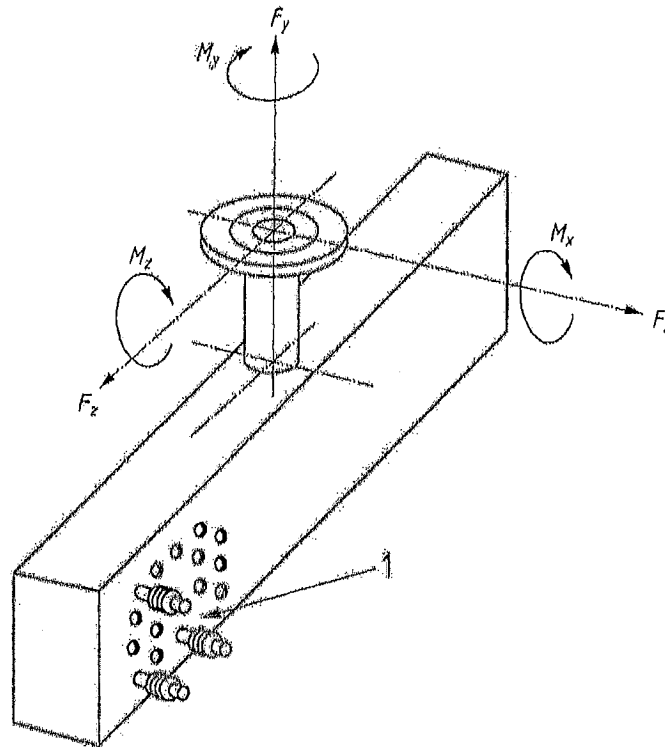
Table of Contents

<u>Section</u>	<u>Description</u>
A	API-661 Nozzle Loads
B	Finite Element Analysis 42ZF
C	Finite Element Analysis 96BZF

Section A - API-661 Nozzle Loads

Finite Element Analysis Summary

Nozzles for both coolers were checked for 3x API-661 nozzle loads. The resulting von mises stresses were compared to the yield stress for the material at the design temperature, and found to be within the acceptable limits. Both headers (42ZF and 96BZF) can withstand 3xAPI-661 Nozzle loads without modification.



Key
1 fin tubes

Figure 6 — Nozzle loads

Table 4 — Maximum allowable nozzle loads

Nozzle size DN (NPS)	Moments N·m (ft·lbf)			Forces N (lbf)		
	M_x	M_y	M_z	F_x	F_y	F_z
40 (1 1/2)	110 (80)	150 (110)	110 (80)	670 (150)	1 020 (230)	670 (150)
50 (2)	150 (110)	240 (180)	150 (110)	1 020 (230)	1 330 (300)	1 020 (230)
80 (3)	410 (300)	610 (450)	410 (300)	2 000 (450)	1 690 (380)	2 000 (450)
100 (4)	810 (600)	1 220 (900)	810 (600)	3 340 (750)	2 670 (600)	3 340 (750)
150 (6)	2 140 (1 580)	3 050 (2 250)	1 630 (1 200)	4 000 (900)	5 030 (1 130)	5 030 (1 130)
200 (8)	3 050 (2 250)	6 100 (4 500)	2 240 (1 650)	5 690 (1 280)	13 340 (3 000)	8 010 (1 800)
250 (10)	4 070 (3 000)	6 100 (4 500)	2 550 (1 880)	6 670 (1 500)	13 340 (3 000)	10 010 (2 250)
300 (12)	5 080 (3 750)	6 100 (4 500)	3 050 (2 250)	8 360 (1 880)	13 340 (3 000)	13 340 (3 000)
350 (14)	6 100 (4 500)	7 120 (5 250)	3 570 (2 630)	10 010 (2 250)	16 680 (3 750)	16 680 (3 750)

Quality Control Documents

- Weld Procedures
 - P1-P1-10
 - P1-P1-11
 - P1-P8-05
- Tag # AC-5020



AXH air-coolers, LLC
 401 E. Lowry Road
 Claremore, Oklahoma 74017

Welding Procedure Specification (WPS)

WPS No.: P1-P1-10 Date: 8/19/2009 Rev. No.: 0

Page 1 of 2

Supporting PQR(s): P1-P1-10

Welding Process(es) / Type(s): (1) GMAW / Semiautomatic (2) SAW / Machine

Joint Design (QW-402)					
Weld Type: <u>Groove and fillet welds</u>					
Joint Type	Backing	Root Opening	Groove Angle	Root Face	Groove Radius
Single-V groove	No backing	3/16" max	50 deg min	1/8" max	
Single bevel	No backing	3/16" max	45 deg min	1/8" max	
Single-V groove	Gouged & back welded	1/4" max	50 deg min	3/16" max	
Double bevel	Gouged & back welded	1/4" max	45 deg min	3/16" max	
Double-V groove	Gouged & back welded	1/4" max	45 deg min	3/16" max	
Square groove	T-joint	1/32" max			
Square groove	No backing	3/32" max			
Fillet Welds: <u>All fillet sizes on all base metal thicknesses and all diameters.</u>					
Retainers: <u>None</u>					
APP. 28 TESTING: <u>5/8" TO 1", 1-1/4" TO 2", 1-3/4" TO 2-3/4", 2-1/2" TO 3-3/4"</u>					
WELD JOINT DESCRIPTIONS SHOWN ARE NOT INCLUSIVE OF ALL THOSE FOUND ON A JOB. WELD JOINT DESIGN REFERENCE IN AN ENGINEERING SPECIFICATION OR A DESIGN DRAWING SHALL TAKE PRECEDENCE OVER WELD JOINTS SHOWN IN THIS WPS.					
Base Metals (QW-403)					
P-No. <u>1</u> Group No. <u>1, 2</u> Thickness Range: <u>0.375 in. to 0.5813 in.</u>					
to P-No. <u>1</u> Group No. <u>1, 2</u>					
Preheat (QW-406)			Postweld Heat Treatment (QW-407)		
Minimum Preheat Temperature: <u>60</u> °F			PWHT Type: <u>PWHT below lower transformation temperature</u>		
Maximum Interpass Temperature: <u>550</u> °F			PWHT Temperature: <u>1150</u> °F		
Preheat Maintenance: <u>DURING WELDING</u>			PWHT Holding Time: <u>1.0 hr./in., 0.25 hr. min.</u>		
			Total aggregate PWHT time including any repairs CANNOT exceed 3.75 hours.		
Initial and Interpass Cleaning: <u>With wire brush clean 1 inch (25 mm) on both sides of weld joint</u>					
Method of Back Gouging: <u>When required, grind until all defects are removed.</u>					
Minimum preheat must be maintained during thermal cutting, tacking, and welding operations.					
Welds shall be cleaned between each pass. When completed, remove all slag and projections.					

We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Code.

Prepared By: Steve D Little Date: 8/19/2009 QC MANAGER
 STEVE D. LITTLE Date

Welding Procedure Specification (WPS)

WPS No.: P1-P1-10

Rev. No.: 0

Page 2 of 2

First Process:	GMAW	Type:	Semiautomatic
Filler Metal (QW-404)			
Weld Deposit Limits:	0.2063 in. maximum	No Pass Greater Than 1/2" Allowed	
AWS Classification:	ER70S-6	SFA Specification:	5.18 F-No.: 6
A-No. or Chemical Composition:	1	Filler Metal Trade Name:	QUANTUM ARC 6
Filler Metal Product Form:	Bare (Solid)		
Supplemental Filler Metal:	None		
Position (QW-405)		Technique (QW-410)	
Position of Joint:	Flat, Horizontal, & Overhead	Stringer or Weave Bead:	Stringer bead
Weld Progression:	N/A	Nozzle / Gas Cup Size:	3/8" to 5/8"
Gas (QW-408)		Peening:	None
Shielding:	88% Argon, 12% CO2 / 27-36 CFH	Contact Tube to Work Distance:	1/2"
Backing:	None / - CFH	Multiple / Single Pass (per side):	Multipass
Trailing:	None / - CFH		
Electrical Characteristics (QW-409)			
Current Type and Polarity:	DCEP (reverse)		
Transfer Mode:	Short-circuiting arc		
Max. Heat Input (J/in):	39600		

First Process Welding Parameters

Layer(s) and/or Pass(es)	Filler Metal		Current		Wire Feed Speed (in/min)	Voltage Range	Travel Speed Range (in/min)
	AWS Classification	Size (in.)	Type and Polarity	Amperage Range			
Any	ER70S-6	0.045	DCEP (reverse)	110-160	176	16.0-16.5	4-10

Second Process:	SAW	Type:	Machine
Filler Metal (QW-404)			
Weld Deposit Limits:	0.3750 in. maximum	No Pass Greater Than 1/2" Allowed	
AWS Classification:	F7P8-EM14K-H8	SFA Specification:	5.17 F-No.: 6
A-No. or Chemical Composition:	1	Filler Metal Trade Name:	LINCOLN LA-71
Flux Trade Name:	LINCOLN 880M	Flux Type:	Neutral
Supplemental Filler Metal:	None		
Flux from Recrushed Slag:	None		
Position (QW-405)		Technique (QW-410)	
Position of Joint:	Flat & Horizontal	Stringer or Weave Bead:	Stringer bead
Electrical Characteristics (QW-409)		Oscillation:	None
Current Type and Polarity:	DCEP (reverse)	Peening:	None
Max. Heat Input (J/in):	29400	Contact Tube to Work Distance:	1"
		Multiple or Single Electrode(s):	Single electrode
		Electrode Spacing:	N/A
		Multiple / Single Pass (per side):	Multipass

Second Process Welding Parameters

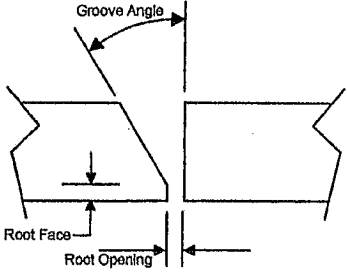
Layer(s) and/or Pass(es)	Filler Metal		Current		Wire Feed Speed (in/min)	Voltage Range	Travel Speed Range (in/min)
	AWS Classification	Size (in.)	Type and Polarity	Amperage Range			
Any	F7P8-EM14K-H8	1/8	DCEP (reverse)	300-350	80	27-28	20-30



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 401 E. Lowry Road
 Claremore, Oklahoma 74017

Procedure Qualification Record (PQR)

PQR No.: P1-P1-10 Date: 8/19/2009 WPS No.: P1-P1-10
 Welding Process(es) / Type(s): (1) GMAW / Semiautomatic (2) SAW / Machine

<p>Joint Design (QW-402) Weld Type: <u>Groove weld</u> Groove Type: <u>Single-bevel groove</u> Backing: <u>Open butt, no back weld</u> Root Opening: <u>1/8</u> in. Root Face: <u>None</u> in. Groove Angle: <u>35</u> °</p> <div style="text-align: center;">  <p>SINGLE BEVEL GROOVE</p> </div>	<p>Base Metals (QW-403) Specification Type and Grade: <u>SA-516, Grade 70 N</u> to <u>SA-516, Grade 70 N</u> P-No. <u>1</u> Group No. <u>2</u> to P-No. <u>1</u> Group No. <u>2</u> Thickness (in.): <u>0.375</u></p> <p>Preheat (QW-406) Minimum Preheat Temperature: <u>60</u> °F Preheat Maintenance: <u>DURING WELDING</u> Maximum Interpass Temperature: <u>550</u> °F</p> <p>Postweld Heat Treatment (QW-407) Type: <u>PWHT performed below lower transformation temp.</u> PWHT Temperature: <u>1150</u> °F PWHT Holding Time: <u>3</u> hr.</p>																								
<p>First Process: <u>GMAW</u> Filler Metals (QW-404) AWS Classification: <u>ER70S-6</u> SFA Specification: <u>5.18</u> F-No.: <u>6</u> A-No. or Chemical Composition: <u>1</u> Filler Metal Trade Name: <u>QUANTUM ARC 6</u> Filler Metal Product Form: <u>Bare (Solid)</u> Supplemental Filler Metal: <u>None</u> Weld Deposit 't' (in.): <u>0.1875</u> Pass Greater Than 1/2": <u>No</u></p> <p>Positions (QW-405) Position of Joint: <u>2G - Horizontal</u> Weld Progression: <u>N/A</u></p> <p>Gas (QW-408) Shielding: <u>88% Argon, 12% CO2</u> / <u>30</u> CFH Backing: <u>None</u> / <u>-</u> CFH Trailing: <u>None</u> / <u>-</u> CFH</p>	<p>Type: <u>Semiautomatic</u> Electrical Characteristics (QW-409) Current Type and Polarity: <u>DCEP (reverse)</u> Transfer Mode: <u>Short-circuiting arc</u></p> <p>Welding Details</p> <table border="1" style="width:100%; border-collapse: collapse;"> <tr> <td>Filler Metal Size (in.):</td> <td><u>0.045</u></td> <td><u>-</u></td> <td><u>-</u></td> </tr> <tr> <td>Amperage Used:</td> <td><u>160</u></td> <td><u>-</u></td> <td><u>-</u></td> </tr> <tr> <td>Wire Feed Speed (in/min):</td> <td><u>176</u></td> <td><u>-</u></td> <td><u>-</u></td> </tr> <tr> <td>Voltage Used:</td> <td><u>16.5</u></td> <td><u>-</u></td> <td><u>-</u></td> </tr> <tr> <td>Travel Speed (in/min):</td> <td><u>4</u></td> <td><u>-</u></td> <td><u>-</u></td> </tr> <tr> <td>Max. Heat Input (J/in):</td> <td colspan="3"><u>39600</u></td> </tr> </table> <p>Technique (QW-410) Thermal Processes: <u>No</u> Stringer or Weave Bead: <u>Stringer bead</u> Nozzle / Gas Cup Size: <u>3/8"</u> Contact Tube to Work Distance: <u>1/2"</u> Multiple / Single Pass (per side): <u>Multipass</u></p>	Filler Metal Size (in.):	<u>0.045</u>	<u>-</u>	<u>-</u>	Amperage Used:	<u>160</u>	<u>-</u>	<u>-</u>	Wire Feed Speed (in/min):	<u>176</u>	<u>-</u>	<u>-</u>	Voltage Used:	<u>16.5</u>	<u>-</u>	<u>-</u>	Travel Speed (in/min):	<u>4</u>	<u>-</u>	<u>-</u>	Max. Heat Input (J/in):	<u>39600</u>		
Filler Metal Size (in.):	<u>0.045</u>	<u>-</u>	<u>-</u>																						
Amperage Used:	<u>160</u>	<u>-</u>	<u>-</u>																						
Wire Feed Speed (in/min):	<u>176</u>	<u>-</u>	<u>-</u>																						
Voltage Used:	<u>16.5</u>	<u>-</u>	<u>-</u>																						
Travel Speed (in/min):	<u>4</u>	<u>-</u>	<u>-</u>																						
Max. Heat Input (J/in):	<u>39600</u>																								

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Procedure Qualification Record (PQR)

PQR No.: P1-P1-10

Page 2 of 3

Second Process:	SAW	Type:	Machine
Filler Metals (QW-404)		Electrical Characteristics (QW-409)	
AWS Classification:	<u>F7P8-EM14K-H8</u>	Current Type and Polarity:	<u>DCEP (reverse)</u>
SFA Specification:	<u>5.17</u> F-No.: <u>6</u>	Welding Details	
A-No. or Chemical Composition:	<u>1</u>	Filler Metal Size (in.):	<u>1/8</u> <u>-</u> <u>-</u>
Filler Metal Trade Name:	<u>LINCOLN LA-71</u>	Amperage Used:	<u>350</u> <u>-</u> <u>-</u>
Supplemental Filler Metal:	<u>None</u>	Wire Feed Speed (in/min):	<u>80</u> <u>-</u> <u>-</u>
Flux Trade Name / Type:	<u>LINCOLN 880M / Neutral</u>	Voltage Used:	<u>28</u> <u>-</u> <u>-</u>
Flux from Recrushed Slag:	<u>None</u>	Travel Speed (in/min):	<u>20</u> <u>-</u> <u>-</u>
Weld Deposit 't' (in.):	<u>0.1875</u>	Max. Heat Input (J/in):	<u>29400</u>
Pass Greater Than 1/2":	<u>No</u>	Technique (QW-410)	
Positions (QW-405)		Thermal Processes:	<u>No</u>
Position of Joint:	<u>1G - Flat</u>	Stringer or Weave Bead:	<u>Stringer bead</u>
		Contact Tube to Work Distance:	<u>1"</u>
		Oscillation:	<u>None</u>
		Multiple or Single Electrode(s):	<u>Single electrode</u>
		Electrode Spacing:	<u>N/A</u>
		Multiple / Single Pass (per side):	<u>Multipass</u>

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Procedure Qualification Record (PQR)

PQR No.: P1-P1-10

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Tensile Test (QW-150)

Specimen No.	Width (in.)	Thickness (in.)	Area (in ²)	Ultimate Total Load (lb)	Ultimate Unit Stress (PSI)	Failure Type and Location
1	0.752	0.325	0.244	18419	75500	Ductile - BM
2	0.751	0.314	0.236	17796	75500	Ductile - BM

Guided Bend Tests (QW-160)

Type and Figure No.	Result	Type and Figure No.	Result
QW-462.2 Side bend	Acceptable	QW-462.2 Side bend	Acceptable
QW-462.2 Side bend	Acceptable	QW-462.2 Side bend	Acceptable

Toughness Tests (QW-170)

Specimen Number	Notch Location	Notch Type	Test Temp. (°F)	Impact Value (ft-lb)	% Shear	Lateral Expansion (Mils)	Drop Weight Break
1	Weld metal	"V"	-50	77-34-48	60-20-25	83-44-58	-
2	HAZ	"V"	-50	68-90-88	45-75-70	73-83-87	-

Hardness Test - Brinell hardness

Location	Readings						
SA-516, Grade 70 N BM	145	145	147				
SA-516, Grade 70 N HAZ	190	157	161				
Weld metal	155	146	154				

Visual Examination: SATISFACTORY

Macro-Examination Test: APP. 28 TESTING: 5/8" TO 1", 1-1/4" TO 2", 1-3/4" TO 2-3/4", 2-1/2" TO 3-3/4"

NOTE: SEE LAB REPORT FOR VICKERS HARDNESS TEST RESULTS PER NACE MR0175 / ISO 15156

Welder's Name: BARK, MICHAEL I.D.: PP Stamp No.: PP

PQR was done and welding of coupon was witnessed by: AXH air-coolers, LLC

Test conducted by: Sherry Laboratories Lab Test No.: 09080271-001-v1

We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Code.

Prepared By: Steve D Little 8/19/2009 QC MANAGER
STEVE D. LITTLE Date



AXH air-coolers, LLC
 401 E. Lowry Road
 Claremore, Oklahoma 74017

Welding Procedure Specification (WPS)

WPS No.: P1-P1-11 Date: 2/12/2010 Rev. No.: 0

Page 1 of 2

Supporting PQR(s): P1-P1-11

Welding Process(es) / Type(s): (1) GMAW / Semiautomatic (2) FCAW / Semiautomatic

Joint Design (QW-402)					
Weld Type: <u>Groove and fillet welds</u>					
Joint Type	Backing	Root Opening	Groove Angle	Root Face	Groove Radius
Single-V groove	No backing	3/16" max	50 deg min	1/8" max	
Single bevel	No backing	3/16" max	45 deg min	1/8" max	
Single-V groove	Gouged & back welded	1/4" max	50 deg min	3/16" max	
Double bevel	Gouged & back welded	1/4" max	45 deg min	3/16" max	
Double-V groove	Gouged & back welded	1/4" max	45 deg min	3/16" max	
Square groove	T-joint	1/32" max			
Square groove	No backing	3/32" max			

Fillet Welds: All fillet sizes on all base metal thicknesses and all diameters.
 Retainers: None

WELD JOINT DESCRIPTIONS SHOWN ARE NOT INCLUSIVE OF ALL THOSE FOUND ON A JOB. WELD JOINT DESIGN REFERENCE IN AN ENGINEERING SPECIFICATION OR A DESIGN DRAWING SHALL TAKE PRECEDENCE OVER WELD JOINTS SHOWN IN THIS WPS.

Base Metals (QW-403)
 P-No. 1 Group No. 1, 2 Thickness Range: 0.375 in. to 0.5813 in.
 to P-No. 1 Group No. 1, 2

Preheat (QW-406)	Postweld Heat Treatment (QW-407)
Minimum Preheat Temperature: <u>60</u> °F	PWHT Type: <u>PWHT below lower transformation temperature</u>
Maximum Interpass Temperature: <u>300</u> °F	PWHT Temperature: <u>1150</u> °F
Preheat Maintenance: <u>DURING WELDING</u>	PWHT Holding Time: <u>1.0 hr./in., 0.25 hr. min.</u>
	Total aggregate PWHT time including any repairs CANNOT exceed 3.75 hours.

Initial and Interpass Cleaning: With wire brush clean 1 inch (25 mm) on both sides of weld joint
 Method of Back Gouging: When required, grind until all defects are removed.
 Minimum preheat must be maintained during thermal cutting, tacking, and welding operations.
 Welds shall be cleaned between each pass. When completed, remove all slag and projections.

We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Code.

Prepared By: Steve D. Little Date: 2/12/2010 QC MANAGER
 STEVE D. LITTLE

Welding Procedure Specification (WPS)

WPS No.: **P1-P1-11**

Rev. No.: **0**

Page 2 of 2

First Process: GMAW		Type: Semiautomatic	
Filler Metal (QW-404)			
Weld Deposit Limits: <u>0.2063 in. maximum</u>		No Pass Greater Than 1/2" Allowed	
AWS Classification: <u>ER70S-6</u>		SFA Specification: <u>5.18</u> F-No.: <u>6</u>	
A-No. or Chemical Composition: <u>1</u>		Filler Metal Trade Name: <u>QUANTUM ARC 6</u>	
Filler Metal Product Form: <u>Bare (Solid)</u>		Supplemental Filler Metal: <u>None</u>	
Position (QW-405)		Technique (QW-410)	
Position of Joint: <u>Flat, Horizontal, & Overhead</u>		Stringer or Weave Bead: <u>Stringer bead</u>	
Weld Progression: <u>N/A</u>		Nozzle / Gas Cup Size: <u>3/8" to 5/8"</u>	
Gas (QW-408)		Peening: <u>None</u>	
Shielding: <u>88% Argon, 12% CO2</u> / <u>27-36</u> CFH		Contact Tube to Work Distance: <u>1/2"</u>	
Backing: <u>None</u> / <u>-</u> CFH		Multiple / Single Pass (per side): <u>Multipass</u>	
Trailing: <u>None</u> / <u>-</u> CFH			
Electrical Characteristics (QW-409)			
Current Type and Polarity: <u>DCEP (reverse)</u>			
Transfer Mode: <u>Short-circuiting arc</u>			
Max. Heat Input (J/in): <u>29409</u>			

First Process Welding Parameters

Layer(s) and/or Pass(es)	Filler Metal		Current		Wire Feed Speed (in/min)	Voltage Range	Travel Speed Range (in/min)
	AWS Classification	Size (in.)	Type and Polarity	Amperage Range			
Any	ER70S-6	0.045	DCEP (reverse)	110-180	230	16.0-17.7	6.5-10

Second Process: FCAW		Type: Semiautomatic	
Filler Metal (QW-404)			
Weld Deposit Limits: <u>0.3750 in. maximum</u>		No Pass Greater Than 1/2" Allowed	
AWS Classification: <u>E71T-12</u>		SFA Specification: <u>5.20</u> F-No.: <u>6</u>	
A-No. or Chemical Composition: <u>1</u>		Filler Metal Trade Name: <u>TRI-MARK TM-910</u>	
Filler Metal Product Form: <u>Flux cored</u>		Supplemental Filler Metal: <u>None</u>	
Position (QW-405)		Technique (QW-410)	
Position of Joint: <u>Flat, Horizontal, & Overhead</u>		Stringer or Weave Bead: <u>Stringer and weave bead</u>	
Weld Progression: <u>N/A</u>		Nozzle / Gas Cup Size: <u>3/8" to 5/8"</u>	
Gas (QW-408)		Peening: <u>None</u>	
Shielding: <u>88% Argon, 12% CO2</u> / <u>26-33</u> CFH		Contact Tube to Work Distance: <u>1/2"</u>	
Backing: <u>None</u> / <u>-</u> CFH		Multiple / Single Pass (per side): <u>Multipass</u>	
Trailing: <u>None</u> / <u>-</u> CFH			
Electrical Characteristics (QW-409)			
Current Type and Polarity: <u>DCEP (reverse)</u>			
Transfer Mode: <u>Spray arc</u>			
Max. Heat Input (J/in): <u>20109</u>			

Second Process Welding Parameters

Layer(s) and/or Pass(es)	Filler Metal		Current		Wire Feed Speed (in/min)	Voltage Range	Travel Speed Range (in/min)
	AWS Classification	Size (in.)	Type and Polarity	Amperage Range			
Any	E71T-12	0.045	DCEP (reverse)	150-215	315	22-26.5	17-20



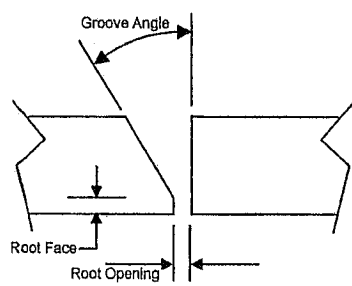
AXH air-coolers, LLC
 401 E. Lowry Road
 Claremore, Oklahoma 74017

Procedure Qualification Record (PQR)

PQR No.: P1-P1-11 Date: 2/12/2010 WPS No.: P1-P1-11

Page 1 of 3

Welding Process(es) / Type(s): (1) GMAW / Semiautomatic (2) FCAW / Semiautomatic

Joint Design (QW-402) Weld Type: <u>Groove weld</u> Groove Type: <u>Single-bevel groove</u> Backing: <u>Open butt, no back weld</u> Root Opening: <u>1/8</u> in. Root Face: <u>None</u> in. Groove Angle: <u>35</u> °		Base Metals (QW-403) Specification Type and Grade: <u>SA-516, Grade 65 N</u> to <u>SA-516, Grade 70 N</u> P-No. <u>1</u> Group No. <u>1</u> to P-No. <u>1</u> Group No. <u>2</u> Thickness (in.): <u>0.375</u> to <u>0.375</u>																									
 <p style="text-align: center;">SINGLE BEVEL GROOVE</p>		Preheat (QW-406) Minimum Preheat Temperature: <u>60</u> °F Preheat Maintenance: <u>DURING WELDING</u> Maximum Interpass Temperature: <u>300</u> °F																									
		Postweld Heat Treatment (QW-407) Type: <u>PWHT performed below lower transformation temp.</u> PWHT Temperature: <u>1150</u> °F PWHT Holding Time: <u>3</u> hr.																									
First Process: <u>GMAW</u> Filler Metals (QW-404) AWS Classification: <u>ER70S-6</u> SFA Specification: <u>5.18</u> F-No.: <u>6</u> A-No. or Chemical Composition: <u>1</u> Filler Metal Trade Name: <u>QUANTUM ARC 6</u> Filler Metal Product Form: <u>Bare (Solid)</u> Supplemental Filler Metal: <u>None</u> Weld Deposit μ (in.): <u>0.1875</u> Pass Greater Than 1/2": <u>No</u>		Type: <u>Semiautomatic</u> Electrical Characteristics (QW-409) Current Type and Polarity: <u>DCEP (reverse)</u> Transfer Mode: <u>Short-circuiting arc</u> Welding Details <table border="1" style="width: 100%;"> <tr> <td>Filler Metal Size (in.):</td> <td><u>0.045</u></td> <td>-</td> <td>-</td> </tr> <tr> <td>Amperage Used:</td> <td><u>180</u></td> <td>-</td> <td>-</td> </tr> <tr> <td>Wire Feed Speed (in/min):</td> <td><u>230</u></td> <td>-</td> <td>-</td> </tr> <tr> <td>Voltage Used:</td> <td><u>17.7</u></td> <td>-</td> <td>-</td> </tr> <tr> <td>Travel Speed (in/min):</td> <td><u>6.5</u></td> <td>-</td> <td>-</td> </tr> <tr> <td>Max. Heat Input (J/in):</td> <td colspan="3"><u>29409</u></td> </tr> </table>		Filler Metal Size (in.):	<u>0.045</u>	-	-	Amperage Used:	<u>180</u>	-	-	Wire Feed Speed (in/min):	<u>230</u>	-	-	Voltage Used:	<u>17.7</u>	-	-	Travel Speed (in/min):	<u>6.5</u>	-	-	Max. Heat Input (J/in):	<u>29409</u>		
Filler Metal Size (in.):	<u>0.045</u>	-	-																								
Amperage Used:	<u>180</u>	-	-																								
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Voltage Used:	<u>17.7</u>	-	-																								
Travel Speed (in/min):	<u>6.5</u>	-	-																								
Max. Heat Input (J/in):	<u>29409</u>																										
Positions (QW-405) Position of Joint: <u>2G - Horizontal</u> Weld Progression: <u>N/A</u>		Technique (QW-410) Thermal Processes: <u>No</u> Stringer or Weave Bead: <u>Stringer bead</u>																									
Gas (QW-408) Shielding: <u>88% Argon, 12% CO2</u> / <u>30</u> CFH Backing: <u>None</u> / <u>-</u> CFH Trailing: <u>None</u> / <u>-</u> CFH		Nozzle / Gas Cup Size: <u>3/8"</u> Contact Tube to Work Distance: <u>1/2"</u> Multiple / Single Pass (per side): <u>Multipass</u>																									

AXH air-coolers, LLC

Procedure Qualification Record (PQR)

PQR No.: P1-P1-11

Page 2 of 3

Second Process: FCAW		Type: Semiautomatic	
Filler Metals (QW-404)		Electrical Characteristics (QW-409)	
AWS Classification:	E71T-12	Current Type and Polarity:	DCEP (reverse)
SFA Specification:	5.20 F-No.: 6	Transfer Mode:	Spray arc
A-No. or Chemical Composition:	1	Welding Details	
Filler Metal Trade Name:	TRI-MARK TM-910	Filler Metal Size (in.):	0.045 - -
Filler Metal Product Form:	Flux cored	Amperage Used:	215 - -
Supplemental Filler Metal:	None	Wire Feed Speed (in/min):	315 - -
Weld Deposit 't' (in.):	0.1875	Voltage Used:	26.5 - -
Pass Greater Than 1/2":	No	Travel Speed (in/min):	17 - -
Positions (QW-405)		Max. Heat Input (J/in):	20109
Position of Joint:	2G - Horizontal	Technique (QW-410)	
Weld Progression:	N/A	Thermal Processes:	No
Gas (QW-408)		Stringer or Weave Bead:	Stringer and weave bead
Shielding:	88% Argon, 12% CO2 / 28 CFH	Nozzle / Gas Cup Size:	5/8"
Backing:	None / - CFH	Contact Tube to Work Distance:	1/2"
Trailing:	None / - CFH	Multiple / Single Pass (per side):	Multipass

AXH air-coolers, LLC

Procedure Qualification Record (PQR)

PQR No.: P1-P1-11

Page 3 of 3

Tensile Test (QW-150)

Specimen No.	Width (in.)	Thickness (in.)	Area (in ²)	Ultimate Total Load (lb)	Ultimate Unit Stress (PSI)	Failure Type and Location
1	0.757	0.298	0.226	16641	74000	Ductile - BM
2	0.757	0.312	0.236	17538	74500	Ductile - BM

Guided Bend Tests (QW-160)

Type and Figure No.	Result	Type and Figure No.	Result
QW-462.2 Side bend	Acceptable	QW-462.2 Side bend	Acceptable
QW-462.2 Side bend	Acceptable	QW-462.2 Side bend	Acceptable

Toughness Tests (QW-170)

Specimen Number	Notch Location	Notch Type	Test Temp. (°F)	Impact Value (ft-lb)	% Shear	Lateral Expansion (Mils)	Drop Weight Break
1	Weld metal	"V"	-50	44-18-31	50-40-45	40-21-29	-
2	HAZ	"V"	-50	68-35-50	50-25-40	67-35-48	-

Hardness Test - Brinell hardness

Location	Readings							
SA-516, Grade 70 N BM	140	146	146					
SA-516, Grade 70 N HAZ	183	194	183					
Weld metal	193	198	189					

Visual Examination: SATISFACTORY

NOTE: SEE LAB REPORT FOR VICKERS HARDNESS TEST RESULTS PER NACE MR0175 / ISO 15156

Welder's Name: FARBRO, ERNIE I.D.: OP Stamp No.: OP

PQR was done and welding of coupon was witnessed by: AXH air-coolers, LLC

Test conducted by: Sherry Laboratories Lab Test No.: 10020180-001-v1

We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Code.

Prepared By: Steve D. Little Date: 2/12/2010 QC MANAGER
STEVE D. LITTLE Date



AXH air-coolers, LLC
 401 E. Lowry Road
 Claremore, Oklahoma 74017

Welding Procedure Specification (WPS)

WPS No.: PI-P8-05 Date: 10/26/2009 Rev. No.: 0

Page 1 of 2

Supporting PQR(s): PI-P8-05

Welding Process(es) / Type(s): (1) GMAW / Semiautomatic

Joint Design (QW-402)					
Weld Type: <u>Groove and fillet welds</u>					
Joint Type	Backing	Root Opening	Groove Angle	Root Face	Groove Radius
Single-V groove	No backing	3/16" max	50 deg min	1/8" max	
Single bevel	No backing	3/16" max	45 deg min	1/8" max	
Single-V groove	Gouged & back welded	1/4" max	50 deg min	3/16" max	
Double bevel	Gouged & back welded	1/4" max	45 deg min	3/16" max	
Double-V groove	Gouged & back welded	1/4" max	45 deg min	3/16" max	
Square groove	T-joint	1/32" max			
Square groove	No backing	3/32" max			

Fillet Welds: All fillet sizes on all base metal thicknesses and all diameters.

Retainers: None

WELD JOINT DESCRIPTIONS SHOWN ARE NOT INCLUSIVE OF ALL THOSE FOUND ON A JOB. WELD JOINT DESIGN REFERENCE IN AN ENGINEERING SPECIFICATION OR A DESIGN DRAWING SHALL TAKE PRECEDENCE OVER WELD JOINTS SHOWN IN THIS WPS.

Base Metals (QW-403)

P-No. 1 Group No. 2 Thickness Range: 0.5 in. to 1.0000 in.
 to P-No. 8 Group No. 1

Preheat (QW-406)

Minimum Preheat Temperature: 60 °F
 Maximum Interpass Temperature: 350 °F
 Preheat Maintenance: DURING WELDING

Postweld Heat Treatment (QW-407)

PWHT Type: PWHT below lower transformation temperature
 PWHT Temperature: 1150 °F
 PWHT Holding Time: 1.0 hr./in., 0.25 hr. min.
 Total aggregate PWHT time including any repairs CANNOT exceed 3.75 hours.

Initial and Interpass Cleaning: With wire brush clean 1 inch (25 mm) on both sides of weld joint

Method of Back Gouging: When required, grind until all defects are removed.

Minimum preheat must be maintained during thermal cutting, tacking, and welding operations.

Welds shall be cleaned between each pass. When completed, remove all slag and projections.

We certify that the statements in this specification are correct and in accordance with the requirements of Section IX of the ASME Code.

Prepared By: Steve D. Little
 STEVE D. LITTLE

10/26/2009 QC MANAGER
 Date

AXH air-coolers, LLC

Welding Procedure Specification (WPS)

WPS No.: P1-P8-05

Rev. No.: 0

Page 2 of 2

First Process:	GMAW	Type:	Semiautomatic
Filler Metal (QW-404)			
Weld Deposit Limits:	1.0000 in. maximum	No Pass Greater Than 1/2" Allowed	
AWS Classification:	ER309L	SFA Specification:	5.9 F-No.: 6
A-No. or Chemical Composition:	8	Filler Metal Trade Name:	SANDVIK
Filler Metal Product Form:	Bare (Solid)		
Supplemental Filler Metal:	None		
Position (QW-405)		Technique (QW-410)	
Position of Joint:	Flat & Horizontal	Stringer or Weave Bead:	Stringer bead
Weld Progression:	N/A	Nozzle / Gas Cup Size:	3/8" to 5/8"
Gas (QW-408)		Peening:	None
Shielding:	75% Argon, 25% CO2 / 26-33 CFH	Contact Tube to Work Distance:	1/2"
Backing:	None / - CFH	Multiple / Single Pass (per side):	Multipass
Trailing:	None / - CFH		
Electrical Characteristics (QW-409)			
Current Type and Polarity:	DCEP (reverse)		
Transfer Mode:	Short-circuiting arc		
Max. Heat Input (J/in):	9516		

First Process Welding Parameters

Layer(s) and/or Pass(es)	Filler Metal		Current		Wire Feed Speed (in/min)	Voltage Range	Travel Speed Range (in/min)
	AWS Classification	Size (in.)	Type and Polarity	Amperage Range			
Any	ER309L	0.045	DCEP (reverse)	110-145	160	16-17.5	16-20



AXH air-coolers, LLC
 401 E. Lowry Road
 Claremore, Oklahoma 74017

Procedure Qualification Record (PQR)

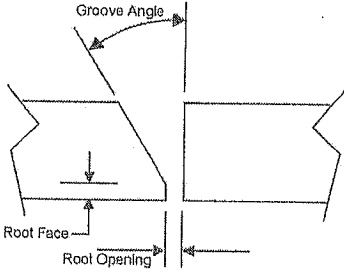
PQR No.: P1-P8-05

Date: 10/26/2009

WPS No.: P1-P8-05

Page 1 of 2

Welding Process(es) / Type(s): (1) GMAW / Semiautomatic

Joint Design (QW-402) Weld Type: Groove weld Groove Type: Single-bevel groove Backing: Open butt, no back weld Root Opening: 1/8 in. Root Face: None in. Groove Angle: 35 °		Base Metals (QW-403) Specification Type and Grade: SA-516, Grade 70 Norm to SA-240, Type 304L P-No. 1 Group No. 2 to P-No. 8 Group No. 1 Thickness (in.): 0.5 to 0.5																									
 <p style="text-align: center;">SINGLE BEVEL GROOVE</p>		Preheat (QW-406) Minimum Preheat Temperature: 60 °F Preheat Maintenance: DURING WELDING Maximum Interpass Temperature: 350 °F																									
		Postweld Heat Treatment (QW-407) Type: PWHT performed below lower transformation temp. PWHT Temperature: 1150 °F PWHT Holding Time: 3 hr.																									
First Process: GMAW		Type: Semiautomatic																									
Filler Metals (QW-404) AWS Classification: ER309L SFA Specification: 5.9 F-No.: 6 A-No. or Chemical Composition: 8 Filler Metal Trade Name: SANDVIK Filler Metal Product Form: Bare (Solid) Supplemental Filler Metal: None Weld Deposit 't' (in.): 0.5 Pass Greater Than 1/2": No		Electrical Characteristics (QW-409) Current Type and Polarity: DCEP (reverse) Transfer Mode: Short-circuiting arc																									
Positions (QW-405) Position of Joint: 2G - Horizontal Weld Progression: N/A		Welding Details <table border="1"> <tr> <td>Filler Metal Size (in.):</td> <td>0.045</td> <td>-</td> <td>-</td> </tr> <tr> <td>Amperage Used:</td> <td>145</td> <td>-</td> <td>-</td> </tr> <tr> <td>Wire Feed Speed (in/min):</td> <td>160</td> <td>-</td> <td>-</td> </tr> <tr> <td>Voltage Used:</td> <td>17.5</td> <td>-</td> <td>-</td> </tr> <tr> <td>Travel Speed (in/min):</td> <td>16</td> <td>-</td> <td>-</td> </tr> <tr> <td>Max. Heat Input (J/in):</td> <td colspan="3">9516</td> </tr> </table>		Filler Metal Size (in.):	0.045	-	-	Amperage Used:	145	-	-	Wire Feed Speed (in/min):	160	-	-	Voltage Used:	17.5	-	-	Travel Speed (in/min):	16	-	-	Max. Heat Input (J/in):	9516		
Filler Metal Size (in.):	0.045	-	-																								
Amperage Used:	145	-	-																								
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Voltage Used:	17.5	-	-																								
Travel Speed (in/min):	16	-	-																								
Max. Heat Input (J/in):	9516																										
Gas (QW-408) Shielding: 75% Argon, 25% CO2 / 28 CFH Backing: None / - CFH Trailing: None / - CFH		Technique (QW-410) Thermal Processes: No Stringer or Weave Bead: Stringer bead Nozzle / Gas Cup Size: 3/8" Contact Tube to Work Distance: 1/2" Multiple / Single Pass (per side): Multipass																									

AXH air-coolers, LLC

Procedure Qualification Record (PQR)

PQR No.: P1-P8-05

Page 2 of 2

Tensile Test (QW-150)

Specimen No.	Width (in.)	Thickness (in.)	Area (in ²)	Ultimate Total Load (lb)	Ultimate Unit Stress (PSI)	Failure Type and Location
1	0.746	0.440	0.328	23645	72000	Ductile - WM
2	0.746	0.414	0.309	22269	72000	Ductile - BM

Guided Bend Tests (QW-160)

Type and Figure No.	Result	Type and Figure No.	Result
QW-462.2 Side bend	Acceptable	QW-462.2 Side bend	Acceptable
QW-462.2 Side bend	Acceptable	QW-462.2 Side bend	Acceptable

Toughness Tests (QW-170)

Specimen Number	Notch Location	Notch Type	Test Temp. (°F)	Impact Value (ft-lb)	% Shear	Lateral Expansion (Mils)	Drop Weight Break
	Weld metal	"V"	-50	42-37-31	99-99-99	30-26-28	-
	HAZ - 304L	"V"	-50	255-299-209	99-99-99	95-88-85	-
	HAZ - GR70	"V"	-50	49-31-52	55-50-35	38-22-38	-

Hardness Test - Brinell hardness

Location	Readings						
SA-240, Type 304L BM	180	177	169				
SA-240, Type 304L HAZ	208	209	221				
SA-516, Grade 70 Norm BM	140	139	141				
SA-516, Grade 70 Norm HAZ	156	154	167				
Weld metal	195	149	212				

Visual Examination: SATISFACTORY

NOTE: SEE LAB REPORT FOR VICKERS HARDNESS TEST RESULTS PER NACE MR0175 / ISO 15156

Welder's Name: FARBRO, ERNIE I.D.: OP Stamp No.: OP

PQR was done and welding of coupon was witnessed by: AXH air-coolers, LLC

Test conducted by: Sherry Laboratories Lab Test No.: 09100771-002-V1

We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Code.

Prepared By: Steve D. Little Date: 10/26/2009 QC MANAGER
STEVE D. LITTLE Date

Quality Control Documents

- Qualifications and Maps
 - Welder Qualifications
 - Weld Map and NIDE Map
- Weld Procedure Summary Form
 - Welders Log
 - Tag # AC-5020

AXH air-coolers, LLC
 401 E. Lowry Road
 Claremore, Oklahoma 74017

Welder or Welding Operator Performance Qualification (WPQ)

Welder's Name: **MENDOZA, THOMAS** Stamp: **EF**

Test WPS No.: **P1-P1-02** Rev.: **0** WPQ No.: **P1-P1-02**

Date: **3/16/2007**

Welding process(es) / type(s) used: **GMAW / Semiautomatic and FCAW / Semiautomatic**

Type of joint welded: **Plate Groove weld** Joint type(s) qualified: **Groove and Fillet Welds**

Base metal(s) welded: **SA-36 to SA-36**

Welder Variables (QW-350)

P- or S-Number to P- or S-Number

Base metal thickness (in.)

Pipe diameter (in.)

Actual Values Used

P-No. 1 to P-No. 1

N/A

Range Qualified

P-1 (thru P-11, P-34 & P-4X)

WPS Limits

2.875" minimum

Backing **

AWS classification

Filler metal specification (SFA)

Filler metal F-No.

Filler metal product form

Consumable insert

Deposit thickness (in.) [≥ 3 layers]

Welding position

Weld progression

Backing gas

GMAW / FCAW transfer mode

GMAW / Semiauto

No backing used

ER70S-6

5.18

6

N/A

N/A

0.375 [N/A]

2G - Horizontal

N/A

No backing gas used

Short-circuiting arc

FCAW / Semiauto

Backing used

E71T-1

5.20

6

N/A

N/A

0.625 [No]

2G - Horizontal

N/A

No backing gas used

Spray arc

GMAW / Semiauto

With or without backing

5.xx

F-No. 6

N/A

N/A

0.4125" maximum

Flat & Horizontal

N/A

W/WO backing gas

Short-circuiting arc

FCAW / Semiauto

With backing only

5.xx

F-No. 6

N/A

N/A

1.2500" maximum

Flat & Horizontal

N/A

W/WO backing gas

Spray, Pulsed, or Globular

Machine Welding Variables (QW-360)

Actual Values Used

Range Qualified

Direct / remote visual control

Automatic voltage control

Automatic joint tracking

Welding position

Consumable insert

Backing **

Single / multiple pass per side

N/A

N/A

N/A

N/A

N/A

N/A

N/A

N/A

N/A

N/A

N/A

N/A

N/A

N/A

N/A

N/A

N/A

N/A

N/A

N/A

N/A

Fillet Welds: Qualified to make fillet welds of any size on all base material thicknesses and pipe diameters of any size.

** Welds with backing include fillets and double-welded groove welds.

Notes:

Guided Bend Test (QW-160)

Figure Number and Type	Result	Figure Number and Type	Result
QW-462.2 Side bend	Satisfactory	QW-462.2 Side bend	Satisfactory
QW-462.2 Side bend	Satisfactory	QW-462.2 Side bend	Satisfactory
None		None	

Visual examination results: Visual exam satisfactory per QW-302.4 and QW-194

Radiographic test results: None

Welding test conducted by: **AXH air-coolers, LLC**

Mechanical/Radiographic tests conducted by: **AXH AIR-COOLERS**

Lab test no.: **N/A**

We certify that the statements in this record are correct and that the test coupons were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME code.

Certified By:


 JAMES HORN

Organization: **AXH air-coolers, LLC**

3/16/2007 QC MANAGER

Date

AXH air-coolers, LLC
 401 E. Lowry Road
 Claremore, Oklahoma 74017

Welder or Welding Operator Performance Qualification (WPQ)

Welder's Name: **MENDOZA, THOMAS** Stamp: **EF**

Test WPS No.: **P1-P1-03** Rev.: **0** WPQ No.: **P1-P1-03**

Date: **3/16/2007**

Welding process(es) / type(s) used: **GMAW / Semiautomatic and SMAW / Manual**

Type of joint welded: **Plate Groove weld** Joint type(s) qualified: **Groove and Fillet Welds**

Base metal(s) welded: **SA-36 to SA-36**

Welder Variables (QW-350)

P- or S-Number to P- or S-Number

Actual Values Used

P-No. 1 to P-No. 1

Range Qualified

P-1 thru P-11, P-34 & P-4X

Base metal thickness (in.)

N/A

WPS Limits

Pipe diameter (in.)

N/A

2.875" minimum

Backing **

GMAW / Semiauto
No backing used

SMAW / Manual
Backing used

GMAW / Semiauto
With or without backing

SMAW / Manual
With backing only

AWS classification

ER70S-6

E7018

5.xx

5.xx

Filler metal specification (SFA)

5.18

5.1

F-No. 6

F-No. 1 to F-No. 4

Filler metal F-No.

6

4

Filler metal product form

N/A

N/A

N/A

N/A

Consumable insert

N/A

N/A

N/A

N/A

Deposit thickness (in.) [≥ 3 layers]

0.375 [N/A]

0.625 [No]

0.4125" maximum

1.2500" maximum

Welding position

1G - Flat

2G - Horizontal

Flat only

Flat & Horizontal

Weld progression

N/A

N/A

N/A

N/A

Backing gas

No backing gas used

N/A

W/WO backing gas

N/A

GMAW / FCAW transfer mode

Short-circuiting arc

N/A

Short-circuiting arc

N/A

Machine Welding Variables (QW-360)

Actual Values Used

Range Qualified

Direct / remote visual control

N/A

N/A

N/A

N/A

Automatic voltage control

N/A

N/A

N/A

N/A

Automatic joint tracking

N/A

N/A

N/A

N/A

Welding position

N/A

N/A

N/A

N/A

Consumable insert

N/A

N/A

N/A

N/A

Backing **

N/A

N/A

N/A

N/A

Single / multiple pass per side

N/A

N/A

N/A

N/A

Fillet Welds: Qualified to make fillet welds of any size on all base material thicknesses and pipe diameters of any size.

**** Welds with backing include fillets and double-welded groove welds.**

Notes:

Guided Bend Test (QW-160)

Figure Number and Type	Result	Figure Number and Type	Result
QW-462.2 Side bend	Satisfactory	QW-462.2 Side bend	Satisfactory
QW-462.2 Side bend	Satisfactory	QW-462.2 Side bend	Satisfactory
None		None	

Visual examination results: Visual exam satisfactory per QW-302.4 and QW-194

Radiographic test results: None

Welding test conducted by: AXH air-coolers, LLC

Mechanical/Radiographic tests conducted by: AXH AIR-COOLERS

Lab test no.: N/A

We certify that the statements in this record are correct and that the test coupons were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME code.

Certified By:


 JAMES HORN

Organization: AXH air-coolers, LLC

3/16/2007 QC MANAGER

Date



AXH air-coolers, LLC
401 E. Lowry Road
Claremore, Oklahoma 74017

Welder or Welding Operator Performance Qualification (WPQ)

Welder's Name: CUNNINGHAM, JERRY Stamp: J

Test WPS No.: P1-P1-02 Rev.: 0 WPQ No.: P1-P1-02

Date: 7/11/2007

Welding process(es) / type(s) used: GMAW / Semiautomatic and FCAW / Semiautomatic

Type of joint welded: Plate Groove weld Joint type(s) qualified: Groove and Fillet Welds

Base metal(s) welded: SA-36 to SA-36

Welder Variables (QW-350)	Actual Values Used		Range Qualified	
	P-No. 1 to P-No. 1		P-1 thru P-11, P-34 & P-4X	
P- or S-Number to P- or S-Number	1		WPS Limits	
Base metal thickness (in.)	N/A		2.875" minimum	
Pipe diameter (in.)	GMAW / Semiauto	FCAW / Semiauto	GMAW / Semiauto	FCAW / Semiauto
	No backing used	Backing used	With or without backing	With backing only
Backing **	ER70S-6	E71T-1		
AWS classification	5.18	5.20	5.xx	5.xx
Filler metal specification (SFA)	6	6	F-No. 6	F-No. 6
Filler metal F-No.	N/A	N/A	N/A	N/A
Filler metal product form	N/A	N/A	N/A	N/A
Consumable insert	N/A	N/A	N/A	N/A
Deposit thickness (in.) [\geq 3 layers]	0.375 [N/A]	0.625 [Yes]	0.4125" maximum	WPS Limits
Welding position	2G - Horizontal	2G - Horizontal	Flat & Horizontal	Flat & Horizontal
Weld progression	N/A	N/A	N/A	N/A
Backing gas	No backing gas used	No backing gas used	W/WO backing gas	W/WO backing gas
GMAW / FCAW transfer mode	Short-circuiting arc	Spray arc	Short-circuiting arc	Spray, Pulsed, or Globular

Machine Welding Variables (QW-360)	Actual Values Used		Range Qualified	
Direct / remote visual control	N/A	N/A	N/A	N/A
Automatic voltage control	N/A	N/A	N/A	N/A
Automatic joint tracking	N/A	N/A	N/A	N/A
Welding position	N/A	N/A	N/A	N/A
Consumable insert	N/A	N/A	N/A	N/A
Backing **	N/A	N/A	N/A	N/A
Single / multiple pass per side	N/A	N/A	N/A	N/A

Fillet Welds: Qualified to make fillet welds of any size on all base material thicknesses and pipe diameters of any size.
**** Welds with backing include fillets and double-welded groove welds.**
Notes: MACRO ETCH ACCEPTABLE PER ASME SECTION VIII DIV. 1, APP. 28
 RANGE: 5/8" TO 1"

Guided Bend Test (QW-160)

Figure Number and Type	Result	Figure Number and Type	Result
QW-462.2 Side bend	Satisfactory	QW-462.2 Side bend	Satisfactory
None		None	
None		None	

Visual examination results: Visual exam satisfactory per QW-302.4 and QW-194

Radiographic test results: None

Welding test conducted by: AXH air-coolers, LLC

Mechanical/Radiographic tests conducted by: AXH air-coolers, LLC

Lab test no.: 7/11/2007

We certify that the statements in this record are correct and that the test coupons were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME code.

Certified By: Steve D. Little
 STEVE D. LITTLE

Organization: AXH air-coolers, LLC

7/11/2007 QC MANAGER
 Date



AXH air-coolers, LLC
401 E. Lowry Road
Claremore, Oklahoma 74017

Welder or Welding Operator Performance Qualification (WPQ)

Welder's Name: CUNNINGHAM, JERRY Stamp: J

Test WPS No.: P1-P1-03 Rev.: 0 WPQ No.: P1-P1-03

Date: 7/27/2007

Welding process(es) / type(s) used: GMAW / Semiautomatic and SMAW / Manual

Type of joint welded: Plate Groove weld Joint type(s) qualified: Groove and Fillet Welds

Base metal(s) welded: SA-36 to SA-36

Welder Variables (QW-350) P- or S-Number to P- or S-Number	Actual Values Used		Range Qualified	
	P-No. 1 to P-No. 1		P-1 thru P-11, P-34 & P-4X	
Base metal thickness (in.)	1		WPS Limits	
Pipe diameter (in.)	N/A		2.875" minimum	
	GMAW / Semiauto	SMAW / Manual	GMAW / Semiauto	SMAW / Manual
Backing **	No backing used	Backing used	With or without backing	With backing only
AWS classification	ER70S-6	E7018		
Filler metal specification (SFA)	5.18	5.1	5.xx	5.xx
Filler metal F-No.	6	4	F-No. 6	F-No. 1 to F-No. 4
Filler metal product form	N/A	N/A	N/A	N/A
Consumable insert	N/A	N/A	N/A	N/A
Deposit thickness (in.) [≥ 3 layers]	0.375 [N/A]	0.625 [Yes]	0.4125" maximum	WPS Limits
Welding position	2G - Horizontal	2G - Horizontal	Flat & Horizontal	Flat & Horizontal
Weld progression	N/A	N/A	N/A	N/A
Backing gas	No backing gas used	N/A	W/WO backing gas	N/A
GMAW / FCAW transfer mode	Short-circuiting arc	N/A	Short-circuiting arc	N/A

Machine Welding Variables (QW-360)	Actual Values Used		Range Qualified	
	Direct / remote visual control	N/A	N/A	N/A
Automatic voltage control	N/A	N/A	N/A	N/A
Automatic joint tracking	N/A	N/A	N/A	N/A
Welding position	N/A	N/A	N/A	N/A
Consumable insert	N/A	N/A	N/A	N/A
Backing **	N/A	N/A	N/A	N/A
Single / multiple pass per side	N/A	N/A	N/A	N/A

Fillet Welds: Qualified to make fillet welds of any size on all base material thicknesses and pipe diameters of any size.

** Welds with backing include fillets and double-welded groove welds.

Notes:

Guided Bend Test (QW-160)

Figure Number and Type	Result	Figure Number and Type	Result
QW-462.2 Side bend	Satisfactory	QW-462.2 Side bend	Satisfactory
None		None	
None		None	

Visual examination results: Visual exam satisfactory per QW-302.4 and QW-194

Radiographic test results: None

Welding test conducted by: AXH air-coolers, LLC

Mechanical/Radiographic tests conducted by: AXH air-coolers, LLC

Lab test no.: 7/11/2007

We certify that the statements in this record are correct and that the test coupons were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME code.

Certified By:

Steve D. Little
STEVE D. LITTLE

Organization: AXH air-coolers, LLC

7/11/2007 QC MANAGER

Date



AXH air-coolers, LLC
 401 E. Lowry Road
 Claremore, Oklahoma 74017

Welder or Welding Operator Performance Qualification (WPQ)

Welder's Name: CUNNINGHAM, JERRY Stamp: J

Test WPS No.: P1-P1-02 Rev.: 0 WPQ No.: P1-P1-02

Date: 12/21/2010

Welding process(es) / type(s) used: GMAW / Semiautomatic and FCAW / Semiautomatic

Type of joint welded: Pipe Groove weld Joint type(s) qualified: Groove and Fillet Welds

Base metal(s) welded: SA-106, Grade B to SA-106, Grade B

Welder Variables (QW-350)	Actual Values Used		Range Qualified	
	P-No. 1 to P-No. 1		P-1 thru P-15F, P-34 & P-4X	
P- or S-Number to P- or S-Number	0.375		WPS Limits	
Base metal thickness (in.)	2.875		1.00" minimum	
Pipe diameter (in.)	<u>GMAW / Semiauto</u>	<u>FCAW / Semiauto</u>	<u>GMAW / Semiauto</u>	<u>FCAW / Semiauto</u>
	No backing used	Backing used	With or without backing	With backing only
Backing **	ER70S-6	E71T-1		
AWS classification	5.18	5.20	5.xx	5.xx
Filler metal specification (SFA)	6	6	F-No. 6	F-No. 6
Filler metal F-No.	N/A	N/A	N/A	N/A
Filler metal product form	N/A	N/A	N/A	N/A
Consumable insert	0.1875 [N/A]	0.1875 [N/A]	0.2063" maximum	0.3750" maximum
Deposit thickness (in.) [\geq 3 layers]	1GR - Rotated	1GR - Rotated	Flat only	Flat only
Welding position	N/A	N/A	N/A	N/A
Weld progression	No backing gas used	No backing gas used	W/WO backing gas	W/WO backing gas
Backing gas	Short-circuiting arc	Spray arc	Short-circuiting arc	Spray, Pulsed, or Globular
GMAW / FCAW transfer mode				

Machine Welding Variables (QW-360)	Actual Values Used		Range Qualified	
	Direct / remote visual control	N/A	N/A	N/A
Automatic voltage control	N/A	N/A	N/A	N/A
Automatic joint tracking	N/A	N/A	N/A	N/A
Welding position	N/A	N/A	N/A	N/A
Consumable insert	N/A	N/A	N/A	N/A
Backing **	N/A	N/A	N/A	N/A
Single / multiple pass per side	N/A	N/A	N/A	N/A

Fillet Welds: Qualified to make fillet welds of any size on all base material thicknesses and pipe diameters of any size.

** Welds with backing include fillets and double-welded groove welds.

Notes:

Guided Bend Test (QW-160)

Figure Number and Type	Result	Figure Number and Type	Result
QW-462.3(a) Face bend	Satisfactory	QW-462.3(a) Root bend	Satisfactory
None		None	
None		None	

Visual examination results: Visual exam satisfactory per QW-302.4 and QW-194

Radiographic test results: None

Welding test conducted by: AXH air-coolers, LLC

Mechanical/Radiographic tests conducted by: Shery Laboratories

Lab test no.: 10120648-005-v1

We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Code.

Certified By: _____

Steve D. Little
 STEVE D. LITTLE

Organization: AXH air-coolers, LLC

12/21/2010 QC MANAGER
 Date



AXH air-coolers, LLC
 401 E. Lowry Road
 Claremore, Oklahoma 74017

Welder or Welding Operator Performance Qualification (WPQ)

Welder's Name: EGLESTON, ETHAN Stamp: IJ

Test WPS No.: P1-P1-02 Rev.: 0 WPQ No.: P1-P1-02

Date: 8/24/2011

Welding process(es) / type(s) used: GMAW / Semiautomatic and FCAW / Semiautomatic

Type of joint welded: Plate Groove weld Joint type(s) qualified: Groove and Fillet Welds

Base metal(s) welded: SA-516, Grade 70 to SA-516, Grade 70

Welder Variables (QW-350)	Actual Values Used		Range Qualified	
	P-No. 1 to P-No. 1		P-1 thru P-15F, P-34 & P-4X	
P- or S-Number to P- or S-Number	1		WPS Limits	
Base metal thickness (in.)	N/A		2.875" minimum	
Pipe diameter (in.)	<u>GMAW / Semiauto</u>	<u>FCAW / Semiauto</u>	<u>GMAW / Semiauto</u>	<u>FCAW / Semiauto</u>
	No backing used	Backing used	With or without backing	With backing only
Backing **				
AWS classification	<u>ER70S-6</u>	<u>E71T-1</u>		
Filler metal specification (SFA)	<u>5.18</u>	<u>5.20</u>	<u>5.xx</u>	<u>5.xx</u>
Filler metal F-No.	<u>6</u>	<u>6</u>	<u>F-No. 6</u>	<u>F-No. 6</u>
Filler metal product form	<u>N/A</u>	<u>N/A</u>	<u>N/A</u>	<u>N/A</u>
Consumable insert	<u>N/A</u>	<u>N/A</u>	<u>N/A</u>	<u>N/A</u>
Deposit thickness (in.) [≥ 3 layers]	<u>0.25 [N/A]</u>	<u>0.75 [Yes]</u>	<u>0.2750" maximum</u>	<u>WPS Limits</u>
Welding position	<u>2G - Horizontal</u>	<u>2G - Horizontal</u>	<u>Flat & Horizontal</u>	<u>Flat & Horizontal</u>
Weld progression	<u>N/A</u>	<u>N/A</u>	<u>N/A</u>	<u>N/A</u>
Backing gas	<u>No backing gas used</u>	<u>No backing gas used</u>	<u>W/WO backing gas</u>	<u>W/WO backing gas</u>
GMAW / FCAW transfer mode	<u>Short-circuiting arc</u>	<u>Spray arc</u>	<u>Short-circuiting arc</u>	<u>Spray, Pulsed, or Globular</u>

Machine Welding Variables (QW-360)	Actual Values Used		Range Qualified	
	Direct / remote visual control	<u>N/A</u>	<u>N/A</u>	<u>N/A</u>
Automatic voltage control	<u>N/A</u>	<u>N/A</u>	<u>N/A</u>	<u>N/A</u>
Automatic joint tracking	<u>N/A</u>	<u>N/A</u>	<u>N/A</u>	<u>N/A</u>
Welding position	<u>N/A</u>	<u>N/A</u>	<u>N/A</u>	<u>N/A</u>
Consumable insert	<u>N/A</u>	<u>N/A</u>	<u>N/A</u>	<u>N/A</u>
Backing **	<u>N/A</u>	<u>N/A</u>	<u>N/A</u>	<u>N/A</u>
Single / multiple pass per side	<u>N/A</u>	<u>N/A</u>	<u>N/A</u>	<u>N/A</u>

Fillet Welds: Qualified to make fillet welds of any size on all base material thicknesses and pipe diameters of any size.

** Welds with backing include fillets and double-welded groove welds.

Notes:

Guided Bend Test (QW-160)

Figure Number and Type	Result	Figure Number and Type	Result
<u>QW-462.2 Side bend</u>	<u>Satisfactory</u>	<u>QW-462.2 Side bend</u>	<u>Satisfactory</u>
<u>None</u>		<u>None</u>	
<u>None</u>		<u>None</u>	

Visual examination results: Visual exam satisfactory per QW-302.4 and QW-194

Volumetric test results: None

Welding test conducted by: AXH air-coolers, LLC

Mechanical/Radiographic tests conducted by: AXH air-coolers, LLC

Lab test no.: 8/24/2011

We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Code.

Organization: AXH air-coolers, LLC

Certified By:

Steve D. Little
 STEVE D. LITTLE

8/24/2011 QC MANAGER

Date



AXH air-coolers, LLC
 401 E. Lowry Road
 Claremore, Oklahoma 74017

Welder or Welding Operator Performance Qualification (WPQ)

Welder's Name: ROY, DEON Stamp: 7A

Test WPS No.: P1-P1-02 Rev.: 0 WPQ No.: P1-P1-02

Date: 8/5/2010

Welding process(es) / type(s) used: GMAW / Semiautomatic and FCAW / Semiautomatic

Type of joint welded: Plate Groove weld Joint type(s) qualified: Groove and Fillet Welds

Base metal(s) welded: SA-516, Grade 70 to SA-516, Grade 70

Welder Variables (QW-350)	Actual Values Used		Range Qualified	
	P-No. 1 to P-No. 1		P-1 thru P-15F, P-34 & P-4X	
P- or S-Number to P- or S-Number	1		WPS Limits	
Base metal thickness (in.)	N/A		2.875" minimum	
Pipe diameter (in.)	N/A		2.875" minimum	
	GMAW / Semiauto	FCAW / Semiauto	GMAW / Semiauto	FCAW / Semiauto
Backing **	No backing used	Backing used	With or without backing	With backing only
AWS classification	ER70S-6	E71T-1		
Filler metal specification (SFA)	5.18	5.20	5.xx	5.xx
Filler metal F-No.	6	6	F-No. 6	F-No. 6
Filler metal product form	N/A	N/A	N/A	N/A
Consumable insert	N/A	N/A	N/A	N/A
Deposit thickness (in.) [\geq 3 layers]	0.25 [N/A]	0.75 [Yes]	0.2750" maximum	WPS Limits
Welding position	2G - Horizontal	2G - Horizontal	Flat & Horizontal	Flat & Horizontal
Weld progression	N/A	N/A	N/A	N/A
Backing gas	No backing gas used	No backing gas used	W/WO backing gas	W/WO backing gas
GMAW / FCAW transfer mode	Short-circuiting arc	Spray arc	Short-circuiting arc	Spray, Pulsed, or Globular

Machine Welding Variables (QW-360)	Actual Values Used		Range Qualified	
Direct / remote visual control	N/A	N/A	N/A	N/A
Automatic voltage control	N/A	N/A	N/A	N/A
Automatic joint tracking	N/A	N/A	N/A	N/A
Welding position	N/A	N/A	N/A	N/A
Consumable insert	N/A	N/A	N/A	N/A
Backing **	N/A	N/A	N/A	N/A
Single / multiple pass per side	N/A	N/A	N/A	N/A

Fillet Welds: Qualified to make fillet welds of any size on all base material thicknesses and pipe diameters of any size.

** Welds with backing include fillets and double-welded groove welds.

Notes:

Guided Bend Test (QW-160)

Figure Number and Type	Result	Figure Number and Type	Result
QW-462.2 Side bend	Satisfactory	QW-462.2 Side bend	Satisfactory
None		None	
None		None	

Visual examination results: Visual exam satisfactory per QW-302.4 and QW-194

Radiographic test results: None

Welding test conducted by: AXH air-coolers, LLC

Mechanical/Radiographic tests conducted by: AXH air-coolers, LLC

Lab test no.: 8/5/2010

We certify that the statements in this record are correct and that the test coupons were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME code.

Organization: AXH air-coolers, LLC

Certified By: _____

Steve D. Little
 STEVE D. LITTLE

8/5/2010

Date

QC MANAGER



AXH air-coolers, LLC
 401 E. Lowry Road
 Claremore, Oklahoma 74017

Welder or Welding Operator Performance Qualification (WPO)

Welder's Name: ROY, DEON Stamp: 7A

Test WPS No.: P1-P1-02 Rev.: 0 WPQ No.: P1-P1-02

Date: 3/14/2011

Welding process(es) / type(s) used: GMAW / Semiautomatic and FCAW / Semiautomatic

Type of joint welded: Pipe Groove weld Joint type(s) qualified: Groove and Fillet Welds

Base metal(s) welded: SA-106, Grade B to SA-106, Grade B

Welder Variables (QW-350)

P- or S-Number to P- or S-Number
 Base metal thickness (in.)
 Pipe diameter (in.)

Actual Values Used

P-No. 1 to P-No. 1

0.375

2.875

Range Qualified

P-1 thru P-15F, P-34 & P-4X

WPS Limits

1.00" minimum

Backing **

AWS classification

Filler metal specification (SFA)

Filler metal F-No.

Filler metal product form

Consumable insert

Deposit thickness (in.) [≥ 3 layers]

Welding position

Weld progression

Backing gas

GMAW / FCAW transfer mode

	Actual Values Used		Range Qualified	
	P-No. 1 to P-No. 1		P-1 thru P-15F, P-34 & P-4X	
	0.375		WPS Limits	
	2.875		1.00" minimum	
	GMAW / Semiauto	FCAW / Semiauto	GMAW / Semiauto	FCAW / Semiauto
	No backing used	Backing used	With or without backing	With backing only
Backing **	ER70S-6	E71T-1		
AWS classification	5.18	5.20	5.xx	5.xx
Filler metal specification (SFA)	6	6	F-No. 6	F-No. 6
Filler metal F-No.	N/A	N/A	N/A	N/A
Filler metal product form	N/A	N/A	N/A	N/A
Consumable insert	N/A	N/A	N/A	N/A
Deposit thickness (in.) [≥ 3 layers]	0.1875 [N/A]	0.1875 [N/A]	0.2063" maximum	0.3750" maximum
Welding position	IGR - Rotated	IGR - Rotated	Flat only	Flat only
Weld progression	N/A	N/A	N/A	N/A
Backing gas	No backing gas used	No backing gas used	W/WO backing gas	W/WO backing gas
GMAW / FCAW transfer mode	Short-circuiting arc	Spray arc	Short-circuiting arc	Spray, Pulsed, or Globular

Machine Welding Variables (QW-360)

Direct / remote visual control

Automatic voltage control

Automatic joint tracking

Welding position

Consumable insert

Backing **

Single / multiple pass per side

	Actual Values Used		Range Qualified	
Direct / remote visual control	N/A	N/A	N/A	N/A
Automatic voltage control	N/A	N/A	N/A	N/A
Automatic joint tracking	N/A	N/A	N/A	N/A
Welding position	N/A	N/A	N/A	N/A
Consumable insert	N/A	N/A	N/A	N/A
Backing **	N/A	N/A	N/A	N/A
Single / multiple pass per side	N/A	N/A	N/A	N/A

Fillet Welds: Qualified to make fillet welds of any size on all base material thicknesses and pipe diameters of any size.

**** Welds with backing include fillets and double-welded groove welds.**

Notes:

Guided Bend Test (QW-160)

Figure Number and Type	Result	Figure Number and Type	Result
QW-462.3(a) Face bend	Satisfactory	QW-462.3(a) Root bend	Satisfactory
None		None	
None		None	

Visual examination results: Visual exam satisfactory per QW-302.4 and QW-194

Volumetric test results: None

Welding test conducted by: AXH air-coolers, LLC

Mechanical/Radiographic tests conducted by: Sherry Laboratories

Lab test no.: 11030472-003-v1

We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Code.

Certified By:

Steve D. Little
 STEVE D. LITTLE

Organization: AXH air-coolers, LLC

3/14/2011 QC MANAGER
 Date



AXH air-coolers, LLC
401 E. Lowry Road
Claremore, Oklahoma 74017

Welder or Welding Operator Performance Qualification (WPQ)

Welder's Name: ROY, DEON Stamp: 7A
 Test WPS No.: P1-P1-03 Rev.: 0 WPQ No.: P1-P1-03 Date: 10/25/2010
 Welding process(es) / type(s) used: SMAW / Manual
 Type of joint welded: Plate Groove weld Joint type(s) qualified: Groove and Fillet Welds
 Base metal(s) welded: SA-516, Grade 70 to SA-516, Grade 70

Welder Variables (QW-350)	Actual Values Used	Range Qualified
P- or S-Number to P- or S-Number	P-No. 1 to P-No. 1	P-1 thru P-15F, P-34 & P-4X
Base metal thickness (in.)	0.75	WPS Limits
Pipe diameter (in.)	N/A	2.875" minimum
	SMAW / Manual	SMAW / Manual
Backing **	No backing used	With or without backing
AWS classification	E7018-1	
Filler metal specification (SFA)	5.1	5.xx
Filler metal F-No.	4	F 4 (F 1 - F 3 w/backing)
Filler metal product form	N/A	N/A
Consumable insert	N/A	N/A
Deposit thickness (in.) [\geq 3 layers]	0.75 [Yes]	WPS Limits
Welding position	2G - Horizontal	Flat & Horizontal
Weld progression	N/A	N/A
Backing gas	N/A	N/A

Machine Welding Variables (QW-360)	Actual Values Used	Range Qualified
Direct / remote visual control	N/A	N/A
Automatic voltage control	N/A	N/A
Automatic joint tracking	N/A	N/A
Welding position	N/A	N/A
Consumable insert	N/A	N/A
Backing **	N/A	N/A
Single / multiple pass per side	N/A	N/A

Fillet Welds: Qualified to make fillet welds of any size on all base material thicknesses and pipe diameters of any size.
 ** Welds with backing include fillets and double-welded groove welds.
 Notes:

Guided Bend Test (QW-160)

Figure Number and Type	Result	Figure Number and Type	Result
None		None	
None		None	
None		None	

Visual examination results: Visual exam satisfactory per QW-302.4 and QW-194
 Radiographic test results: Acceptable Per QW-302.2 and QW-191
 Welding test conducted by: AXH air-coolers, LLC
 Mechanical/Radiographic tests conducted by: IRIS NDT Lab test no.: 10/25/2010

We certify that the statements in this record are correct and that the test coupons were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME code.

Certified By: Steve D. Little Organization: AXH air-coolers, LLC
 STEVE D. LITTLE Date: 10/25/2010 QC MANAGER



AXH air-coolers, LLC
401 E. Lowry Road
Claremore, Oklahoma 74017

Welder or Welding Operator Performance Qualification (WPQ)

Welder's Name: GARTRELL, MIKE Stamp: QR

Test WPS No.: P1-P1-02 Rev.: 0 WPQ No.: P1-P1-02

Date: 10/6/2010

Welding process(es) / type(s) used: GMAW / Semiautomatic and FCAW / Semiautomatic

Type of joint welded: Plate Groove weld Joint type(s) qualified: Groove and Fillet Welds

Base metal(s) welded: SA-516, Grade 70 to SA-516, Grade 70

Welder Variables (QW-350)

P- or S-Number to P- or S-Number

Actual Values Used

P-No. 1 to P-No. 1

Range Qualified

P-1 thru P-15F, P-34 & P-4X

Base metal thickness (in.)

1

WPS Limits

Pipe diameter (in.)

N/A

2.875" minimum

Backing **

GMAW / Semiauto

FCAW / Semiauto

GMAW / Semiauto

FCAW / Semiauto

AWS classification

No backing used

Backing used

With or without backing

With backing only

Filler metal specification (SFA)

ER70S-6

E71T-1

5.xx

5.xx

Filler metal F-No.

6

6

F-No. 6

F-No. 6

Filler metal product form

N/A

N/A

N/A

N/A

Consumable insert

N/A

N/A

N/A

N/A

Deposit thickness (in.) [≥ 3 layers]

0.25 [N/A]

0.75 [Yes]

0.2750" maximum

WPS Limits

Welding position

2G - Horizontal

2G - Horizontal

Flat & Horizontal

Flat & Horizontal

Weld progression

N/A

N/A

N/A

N/A

Backing gas

No backing gas used

No backing gas used

W/WO backing gas

W/WO backing gas

GMAW / FCAW transfer mode

Short-circuiting arc

Spray arc

Short-circuiting arc

Spray, Pulsed, or Globular

Machine Welding Variables (QW-360)

Actual Values Used

Range Qualified

Direct / remote visual control

N/A

N/A

N/A

N/A

Automatic voltage control

N/A

N/A

N/A

N/A

Automatic joint tracking

N/A

N/A

N/A

N/A

Welding position

N/A

N/A

N/A

N/A

Consumable insert

N/A

N/A

N/A

N/A

Backing **

N/A

N/A

N/A

N/A

Single / multiple pass per side

N/A

N/A

N/A

N/A

Fillet Welds: Qualified to make fillet welds of any size on all base material thicknesses and pipe diameters of any size.

**** Welds with backing include fillets and double-welded groove welds.**

Notes:

Guided Bend Test (QW-160)

Figure Number and Type	Result	Figure Number and Type	Result
QW-462.2 Side bend	Satisfactory	QW-462.2 Side bend	Satisfactory
None		None	
None		None	

Visual examination results: Visual exam satisfactory per QW-302.4 and QW-194

Radiographic test results: None

Welding test conducted by: AXH air-coolers, LLC

Mechanical/Radiographic tests conducted by: AXH air-coolers, LLC

Lab test no.: 10/6/2010

We certify that the statements in this record are correct and that the test coupons were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME code.

Organization: AXH air-coolers, LLC

Certified By: _____

Steve D. Little
STEVE D. LITTLE

10/6/2010

Date

QC MANAGER



AXH air-coolers, LLC
401 E. Lowry Road
Claremore, Oklahoma 74017

Welder or Welding Operator Performance Qualification (WPQ)

Welder's Name: GARTRELL, MIKE Stamp: QR
 Test WPS No.: P1-P1-02 Rev.: 0 WPQ No.: P1-P1-02 Date: 3/14/2011
 Welding process(es) / type(s) used: GMAW / Semiautomatic and FCAW / Semiautomatic
 Type of joint welded: Pipe Groove weld Joint type(s) qualified: Groove and Fillet Welds
 Base metal(s) welded: SA-106, Grade B to SA-106, Grade B

Welder Variables (QW-350)	Actual Values Used		Range Qualified	
	P-No. 1 to P-No. 1		P-1 thru P-15F,P-34 & P-4X	
P- or S-Number to P- or S-Number	0.375		WPS Limits	
Base metal thickness (in.)	2.875		1.00" minimum	
Pipe diameter (in.)				
	GMAW / Semiauto	FCAW / Semiauto	GMAW / Semiauto	FCAW / Semiauto
Backing **	No backing used	Backing used	With or without backing	With backing only
AWS classification	ER70S-6	E71T-1		
Filler metal specification (SFA)	5.18	5.20	5.xx	5.xx
Filler metal F-No.	6	6	F-No. 6	F-No. 6
Filler metal product form	N/A	N/A	N/A	N/A
Consumable insert	N/A	N/A	N/A	N/A
Deposit thickness (in.) [≥ 3 layers]	0.1875 [N/A]	0.1875 [N/A]	0.2063" maximum	0.3750" maximum
Welding position	1GR - Rotated	1GR - Rotated	Flat only	Flat only
Weld progression	N/A	N/A	N/A	N/A
Backing gas	No backing gas used	No backing gas used	W/WO backing gas	W/WO backing gas
GMAW / FCAW transfer mode	Short-circuiting arc	Spray arc	Short-circuiting arc	Spray, Pulsed, or Globular

Machine Welding Variables (QW-360)	Actual Values Used		Range Qualified	
Direct / remote visual control	N/A	N/A	N/A	N/A
Automatic voltage control	N/A	N/A	N/A	N/A
Automatic joint tracking	N/A	N/A	N/A	N/A
Welding position	N/A	N/A	N/A	N/A
Consumable insert	N/A	N/A	N/A	N/A
Backing **	N/A	N/A	N/A	N/A
Single / multiple pass per side	N/A	N/A	N/A	N/A

Fillet Welds: Qualified to make fillet welds of any size on all base material thicknesses and pipe diameters of any size.

** Welds with backing include fillets and double-welded groove welds.

Notes:

Guided Bend Test (QW-160)

Figure Number and Type	Result	Figure Number and Type	Result
QW-462.3(a) Face bend	Satisfactory	QW-462.3(a) Root bend	Satisfactory
None		None	
None		None	

Visual examination results: Visual exam satisfactory per QW-302.4 and QW-194

Volumetric test results: None

Welding test conducted by: AXH air-coolers, LLC

Mechanical/Radiographic tests conducted by: Sherry Laboratories

Lab test no.: 11030472-001-v1

We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Code.

Certified By: Steve D. Little
STEVE D. LITTLE

Organization: AXH air-coolers, LLC

3/14/2011 QC MANAGER
Date



AXH air-coolers, LLC
401 E. Lowry Road
Claremore, Oklahoma 74017

Welder or Welding Operator Performance Qualification (WPQ)

Welder's Name: DIXON, GREG Stamp: P

Test WPS No.: P1-P1-01 Rev.: 0 WPQ No.: P1-P1-01

Date: 4/6/2010

Welding process(es) / type(s) used: SAW / Machine

Type of joint welded: Plate Groove weld Joint type(s) qualified: Groove and Fillet Welds

Base metal(s) welded: SA-516, Grade 70 to SA-516, Grade 70

Welder Variables (QW-350)

	Actual Values Used	Range Qualified
P- or S-Number to P- or S-Number	P-No. 1 to P-No. 1	All base metals
Base metal thickness (in.)	0.75	WPS Limits
Pipe diameter (in.)	N/A	All diameters
	SAW / Machine	SAW / Mach. and Auto.
Backing **	N/A	N/A
AWS classification	N/A	N/A
Filler metal specification (SFA)	N/A	N/A
Filler metal F-No.	N/A	N/A
Filler metal product form	N/A	N/A
Consumable insert	N/A	N/A
Weld deposit thickness (in.)	N/A	N/A
Welding position	N/A	N/A
Weld progression	N/A	N/A
Backing gas	N/A	N/A

Machine Welding Variables (QW-360)

	Actual Values Used	Range Qualified
Direct / remote visual control	Direct control used	Direct control required
Automatic voltage control	N/A	N/A
Automatic joint tracking	Manual tracking	With or Without auto tracking
Welding position	1G - Flat	Flat only
Consumable insert	N/A	N/A
Backing **	Backing used	With backing only
Single / multiple pass per side	Multipass	Single or multipass

Fillet Welds: Qualified to make fillet welds of any size on all base material thicknesses and pipe diameters of any size.

** Welds with backing include fillets and double-welded groove welds.

Notes: MACRO ETCH ACCEPTABLE PER ASME SECTION VIII DIV. 1, APP. 28

RANGE: 5/8" TO 1", 1-1/4" TO 2", 1-3/4" TO 2-3/4", 2-1/2" TO 3-3/4"

Guided Bend Test (QW-160)

Figure Number and Type	Result	Figure Number and Type	Result
None		None	
None		None	
None		None	

Visual examination results: Visual exam satisfactory per QW-302.4 and QW-194

Radiographic test results: Acceptable Per QW-302.2 and QW-191

Welding test conducted by: AXH air-coolers, LLC

Mechanical/Radiographic tests conducted by: IRIS NDT

Lab test no.: 4/6/2010

We certify that the statements in this record are correct and that the test coupons were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME code.

Certified By:

Steve D. Little
STEVE D. LITTLE

Organization: AXH air-coolers, LLC

4/6/2010 QC MANAGER
Date

AXH air-coolers, LLC
 401 E. Lowry Road
 Claremore, Oklahoma 74017

Welder or Welding Operator Performance Qualification (WPQ)

Welder's Name: WELLS, JEREMY Stamp: LL

Test WPS No.: P1-P1-02 Rev.: 0 WPQ No.: P1-P1-02

Date: 8/25/2008

Welding process(es) / type(s) used: GMAW / Semiautomatic

Type of joint welded: Plate Groove weld Joint type(s) qualified: Groove and Fillet Welds

Base metal(s) welded: SA-516, Grade 70 to SA-516, Grade 70

Welder Variables (QW-350)	Actual Values Used	Range Qualified
P- or S-Number to P- or S-Number	P-No. 1 to P-No. 1	P-1 thru P-11, P-34 & P-4X
Base metal thickness (in.)	0.375	WPS Limits
Pipe diameter (in.)	N/A	2.875" minimum
	GMAW / Semiauto	GMAW / Semiauto
Backing **	No backing used	With or without backing
AWS classification	ER70S-6	
Filler metal specification (SFA)	5.18	5.xx
Filler metal F-No.	6	F-No. 6
Filler metal product form	N/A	N/A
Consumable insert	N/A	N/A
Deposit thickness (in.) [≥ 3 layers]	0.375 [N/A]	0.4125" maximum
Welding position	2G - Horizontal	Flat & Horizontal
Weld progression	N/A	N/A
Backing gas	No backing gas used	With or Without backing gas
GMAW / FCAW transfer mode	Short-circuiting arc	Short-circuiting arc

Machine Welding Variables (QW-360)	Actual Values Used	Range Qualified
Direct / remote visual control	N/A	N/A
Automatic voltage control	N/A	N/A
Automatic joint tracking	N/A	N/A
Welding position	N/A	N/A
Consumable insert	N/A	N/A
Backing **	N/A	N/A
Single / multiple pass per side	N/A	N/A

Fillet Welds: Qualified to make fillet welds of any size on all base material thicknesses and pipe diameters of any size.
**** Welds with backing include fillets and double-welded groove welds.**
Notes: FIT-UP ONLY

Guided Bend Test (QW-160)

Figure Number and Type	Result	Figure Number and Type	Result
QW-462.2 Side bend	Satisfactory	QW-462.2 Side bend	Satisfactory
None		None	
None		None	

Visual examination results: Visual exam satisfactory per QW-302.4 and QW-194

Radiographic test results: None

Welding test conducted by: AXH air-coolers, LLC

Mechanical/Radiographic tests conducted by: AXH air-coolers, LLC

Lab test no.: 8/25/08

We certify that the statements in this record are correct and that the test coupons were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME code.

Certified By: Steve D. Little
 STEVE LITTLE

Organization: AXH air-coolers, LLC

8/6/2008 QC MANAGER
 Date

AXH air-coolers, LLC
401 E. Lowry Road
Claremore, Oklahoma 74017

Welder or Welding Operator Performance Qualification (WPQ)

Welder's Name: WELLS, JEREMY Stamp: LL

Test WPS No.: P1-P1-02 Rev.: 0 WPQ No.: P1-P1-02

Date: 3/5/2009

Welding process(es) / type(s) used: GMAW / Semiautomatic and FCAW / Semiautomatic

Type of joint welded: Plate Groove weld Joint type(s) qualified: Groove and Fillet Welds

Base metal(s) welded: SA-516, Grade 70 to SA-516, Grade 70

Welder Variables (QW-350)

P- or S-Number to P- or S-Number
Base metal thickness (in.)
Pipe diameter (in.)

Actual Values Used

P-No. 1 to P-No. 1

1

N/A

Range Qualified

P-1 thru P-11, P-34 & P-4X

WPS Limits

2.875" minimum

Backing **

AWS classification

Filler metal specification (SFA)

Filler metal F-No.

Filler metal product form

Consumable insert

Deposit thickness (in.) [\geq 3 layers]

Welding position

Weld progression

Backing gas

GMAW / FCAW transfer mode

GMAW / Semiauto

No backing used

ER70S-6

5.18

6

N/A

N/A

0.25 [N/A]

2G - Horizontal

N/A

No backing gas used

Short-circuiting arc

FCAW / Semiauto

Backing used

E71T-1

5.20

6

N/A

N/A

0.75 [No]

2G - Horizontal

N/A

No backing gas used

Spray arc

GMAW / Semiauto

With or without backing

5.xx

F-No. 6

N/A

N/A

0.2750" maximum

Flat & Horizontal

N/A

W/WO backing gas

Short-circuiting arc

FCAW / Semiauto

With backing only

5.xx

F-No. 6

N/A

N/A

1.5000" maximum

Flat & Horizontal

N/A

W/WO backing gas

Spray, Pulsed, or Globular

Machine Welding Variables (QW-360)

Direct / remote visual control

Automatic voltage control

Automatic joint tracking

Welding position

Consumable insert

Backing **

Single / multiple pass per side

Actual Values Used

N/A

N/A

N/A

N/A

N/A

N/A

N/A

Range Qualified

N/A

N/A

N/A

N/A

N/A

N/A

N/A

Fillet Welds: Qualified to make fillet welds of any size on all base material thicknesses and pipe diameters of any size.

**** Welds with backing include fillets and double-welded groove welds.**

Notes:

Guided Bend Test (QW-160)

Figure Number and Type	Result	Figure Number and Type	Result
QW-462.2 Side bend	Satisfactory	QW-462.2 Side bend	Satisfactory
None		None	
None		None	

Visual examination results: Visual exam satisfactory per QW-302.4 and QW-194

Radiographic test results: None

Welding test conducted by: AXH air-coolers, LLC

Mechanical/Radiographic tests conducted by: AXH air-coolers, LLC

Lab test no.: N/A

We certify that the statements in this record are correct and that the test coupons were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME code.

Organization: AXH air-coolers, LLC

Certified By: _____

Steve D. Little
STEVE D. LITTLE

3/5/2009

Date

QC MANAGER



AXH air-coolers, LLC
401 E. Lowry Road
Claremore, Oklahoma 74017

Welder or Welding Operator Performance Qualification (WPQ)

Welder's Name: WELLS, JEREMY Stamp: LL

Test WPS No.: P1-P1-03 Rev.: 0 WPQ No.: P1-P1-03

Date: 5/10/2011

Welding process(es) / type(s) used: SMAW / Manual

Type of joint welded: Plate Groove weld Joint type(s) qualified: Groove and Fillet Welds

Base metal(s) welded: SA-516, Grade 70 to SA-516, Grade 70

Welder Variables (QW-350)

	Actual Values Used	Range Qualified
P- or S-Number to P- or S-Number	P-No. 1 to P-No. 1	P-1 thru P-15F, P-34 & P-4X
Base metal thickness (in.)	0.75	WPS Limits
Pipe diameter (in.)	N/A	2.875" minimum
	SMAW / Manual	SMAW / Manual
Backing **	No backing used	With or without backing
AWS classification	E7018-1	
Filler metal specification (SFA)	5.1	5.xx
Filler metal F-No.	4	F 4 (F 1 - F 3 w/backing)
Filler metal product form	N/A	N/A
Consumable insert	N/A	N/A
Deposit thickness (in.) [≥ 3 layers]	0.75 [Yes]	WPS Limits
Welding position	2G - Horizontal	Flat & Horizontal
Weld progression	N/A	N/A
Backing gas	N/A	N/A

Machine Welding Variables (QW-360)

	Actual Values Used	Range Qualified
Direct / remote visual control	N/A	N/A
Automatic voltage control	N/A	N/A
Automatic joint tracking	N/A	N/A
Welding position	N/A	N/A
Consumable insert	N/A	N/A
Backing **	N/A	N/A
Single / multiple pass per side	N/A	N/A

Fillet Welds: Qualified to make fillet welds of any size on all base material thicknesses and pipe diameters of any size.

** Welds with backing include fillets and double-welded groove welds.

Notes:

Guided Bend Test (QW-160)

Figure Number and Type	Result	Figure Number and Type	Result
None		None	
None		None	
None		None	

Visual examination results: Visual exam satisfactory per QW-302.4 and QW-194

Volumetric test results: Acceptable Per QW-302.2 and QW-191

Welding test conducted by: AXH air-coolers, LLC

Mechanical/Radiographic tests conducted by: IRIS NDT

Lab test no.: 5/10/2011

We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Code.

Certified By:

Steve D. Little
STEVE D. LITTLE

Organization: AXH air-coolers, LLC

5/10/2011 QC MANAGER
Date



AXH air-coolers, LLC
401 E. Lowry Road
Claremore, Oklahoma 74017

Welder or Welding Operator Performance Qualification (WPQ)

Welder's Name: FARBRO, ERNIE Stamp: OP

Test WPS No.: PI-PI-01 Rev.: 0 WPQ No.: PI-PI-01

Date: 3/5/2009

Welding process(es) / type(s) used: SAW / Machine

Type of joint welded: Plate Groove weld Joint type(s) qualified: Groove and Fillet Welds

Base metal(s) welded: SA-516, Grade 70 to SA-516, Grade 70

Welder Variables (QW-350)	Actual Values Used	Range Qualified
P- or S-Number to P- or S-Number	P-No. 1 to P-No. 1	All base metals
Base metal thickness (in.)	0.875	WPS Limits
Pipe diameter (in.)	N/A	All diameters
	SAW / Machine	SAW / Mach. and Auto.
Backing **	N/A	N/A
AWS classification	N/A	N/A
Filler metal specification (SFA)	N/A	N/A
Filler metal F-No.	N/A	N/A
Filler metal product form	N/A	N/A
Consumable insert	N/A	N/A
Weld deposit thickness (in.)	N/A	N/A
Welding position	N/A	N/A
Weld progression	N/A	N/A
Backing gas	N/A	N/A

Machine Welding Variables (QW-360)	Actual Values Used	Range Qualified
Direct / remote visual control	Direct control used	Direct control required
Automatic voltage control	N/A	N/A
Automatic joint tracking	Manual tracking	With or Without auto tracking
Welding position	IG - Flat	Flat only
Consumable insert	N/A	N/A
Backing **	Backing used	With backing only
Single / multiple pass per side	Multipass	Single or multipass

Fillet Welds: Qualified to make fillet welds of any size on all base material thicknesses and pipe diameters of any size.
**** Welds with backing include fillets and double-welded groove welds.**
Notes: MACRO ETCH ACCEPTABLE PER ASME SECTION VIII DIV. 1, APP. 28
 RANGE: 5/8" TO 1", 1-1/4" TO 2", 1-3/4" TO 2-3/4", 2-1/2" TO 3-3/4"

Guided Bend Test (QW-160)			
Figure Number and Type	Result	Figure Number and Type	Result
None		None	
None		None	
None		None	

Visual examination results: Visual exam satisfactory per QW-302.4 and QW-194

Radiographic test results: Acceptable Per QW-302.2 and QW-191

Welding test conducted by: AXH air-coolers, LLC

Mechanical/Radiographic tests conducted by: IRIS NDT

Lab test no.: 3/5/09

We certify that the statements in this record are correct and that the test coupons were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME code.

Certified By:

Steve D. Little
STEVE D. LITTLE

Organization: AXH air-coolers, LLC

3/5/2009 QC MANAGER

Date



AXH air-coolers, LLC
401 E. Lowry Road
Claremore, Oklahoma 74017

Welder or Welding Operator Performance Qualification (WPQ)

Welder's Name: FARBRO, ERNIE Stamp: OP

Test WPS No.: P1-P1-02 Rev.: 0 WPQ No.: P1-P1-02

Date: 5/5/2006

Welding process(es) / type(s) used: GMAW / Semiautomatic and FCAW / Semiautomatic

Type of joint welded: Plate Groove weld Joint type(s) qualified: Groove and Fillet Welds

Base metal(s) welded: SA-36 to SA-36

Welder Variables (QW-350)

P- or S-Number to P- or S-Number
Base metal thickness (in.)
Pipe diameter (in.)

	Actual Values Used		Range Qualified	
	P-No. 1 to P-No. 1		P-1 thru P-11, P-34 & P-4X	
	N/A		WPS Limits 2.875" minimum	
	GMAW / Semiauto	FCAW / Semiauto	GMAW / Semiauto	FCAW / Semiauto
	No backing used	Backing used	With or without backing	With backing only
Backing **	ER70S-6	E71T-1		
AWS classification	5.18	5.20	5.xx	5.xx
Filler metal specification (SFA)	6	6	F-No. 6	F-No. 6
Filler metal F-No.	N/A	N/A	N/A	N/A
Filler metal product form	N/A	N/A	N/A	N/A
Consumable insert	0.375 [N/A]	0.625 [Yes]	0.4125" maximum	WPS Limits
Deposit thickness (in.) [≥ 3 layers]	2G - Horizontal	2G - Horizontal	Flat & Horizontal	Flat & Horizontal
Welding position	N/A	N/A	N/A	N/A
Weld progression	No backing gas used	No backing gas used	W/WO backing gas	W/WO backing gas
Backing gas	Short-circuiting arc	Spray arc	Short-circuiting arc	Spray, Pulsed, or Globular
GMAW / FCAW transfer mode				

Machine Welding Variables (QW-360)

Direct / remote visual control
Automatic voltage control
Automatic joint tracking
Welding position
Consumable insert
Backing **
Single / multiple pass per side

	Actual Values Used		Range Qualified	
Direct / remote visual control	N/A	N/A	N/A	N/A
Automatic voltage control	N/A	N/A	N/A	N/A
Automatic joint tracking	N/A	N/A	N/A	N/A
Welding position	N/A	N/A	N/A	N/A
Consumable insert	N/A	N/A	N/A	N/A
Backing **	N/A	N/A	N/A	N/A
Single / multiple pass per side	N/A	N/A	N/A	N/A

Fillet Welds: Qualified to make fillet welds of any size on all base material thicknesses and pipe diameters of any size.

** Welds with backing include fillets and double-welded groove welds.

Notes: MACRO ETCH ACCEPTABLE PER ASME SECTION VIII DIV. 1, APP. 28

RANGE: 5/8" TO 1"

Guided Bend Test (QW-160)

Figure Number and Type	Result	Figure Number and Type	Result
QW-462.2 Side bend	Satisfactory	QW-462.2 Side bend	Satisfactory
None		None	
None		None	

Visual examination results: Visual exam satisfactory per QW-302.4 and QW-194

Radiographic test results: None

Welding test conducted by: AXH air-coolers, LLC

Mechanical/Radiographic tests conducted by: Bennett Testing

Lab test no.: 5/5/2006

We certify that the statements in this record are correct and that the test coupons were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME code.

Certified By:

Steve D. Little
STEVE D. LITTLE

Organization: AXH air-coolers, LLC

5/5/2006

QC MANAGER

Date



AXH air-coolers, LLC
 401 E. Lowry Road
 Claremore, Oklahoma 74017

Welder or Welding Operator Performance Qualification (WPQ)

Welder's Name: FARBRO, ERNIE Stamp: OP

Test WPS No.: P1-P1-02 Rev.: 0 WPQ No.: P1-P1-02

Date: 5/14/2010

Welding process(es) / type(s) used: GMAW / Semiautomatic and FCAW / Semiautomatic

Type of joint welded: Pipe Groove weld Joint type(s) qualified: Groove and Fillet Welds

Base metal(s) welded: SA-106, Grade B to SA-106, Grade B

Welder Variables (QW-350)

P- or S-Number to P- or S-Number
 Base metal thickness (in.)
 Pipe diameter (in.)

Actual Values Used

P-No. 1 to P-No. 1

0.358

1.315

Range Qualified

P-1 thru P-15F, P-34 & P-4X

WPS Limits

1.00" minimum

Backing **

AWS classification

Filler metal specification (SFA)

Filler metal F-No.

Filler metal product form

Consumable insert

Deposit thickness (in.) [≥ 3 layers]

Welding position

Weld progression

Backing gas

GMAW / FCAW transfer mode

	Actual Values Used		Range Qualified	
	P-No. 1 to P-No. 1		P-1 thru P-15F, P-34 & P-4X	
	0.358		WPS Limits	
	1.315		1.00" minimum	
	GMAW / Semiauto	FCAW / Semiauto	GMAW / Semiauto	FCAW / Semiauto
	No backing used	Backing used	With or without backing	With backing only
Backing **	ER70S-6	E71T-1		
AWS classification	5.18	5.20	5.xx	5.xx
Filler metal specification (SFA)	6	6	F-No. 6	F-No. 6
Filler metal F-No.	N/A	N/A	N/A	N/A
Filler metal product form	N/A	N/A	N/A	N/A
Consumable insert	N/A	N/A	N/A	N/A
Deposit thickness (in.) [≥ 3 layers]	0.125 [N/A]	0.233 [N/A]	0.1375" maximum	0.4660" maximum
Welding position	IGR - Rotated	IGR - Rotated	Flat only	Flat only
Weld progression	N/A	N/A	N/A	N/A
Backing gas	No backing gas used	No backing gas used	W/WO backing gas	W/WO backing gas
GMAW / FCAW transfer mode	Short-circuiting arc	Spray arc	Short-circuiting arc	Spray, Pulsed, or Globular

Machine Welding Variables (QW-360)

Direct / remote visual control

Automatic voltage control

Automatic joint tracking

Welding position

Consumable insert

Backing **

Single / multiple pass per side

Actual Values Used

N/A

N/A

N/A

N/A

N/A

N/A

N/A

N/A

Range Qualified

N/A

N/A

N/A

N/A

N/A

N/A

N/A

N/A

Fillet Welds: Qualified to make fillet welds of any size on all base material thicknesses and pipe diameters of any size.

** Welds with backing include fillets and double-welded groove welds.

Notes:

Guided Bend Test (QW-160)

Figure Number and Type	Result	Figure Number and Type	Result
QW-462.3(a) Face bend	Satisfactory	QW-462.3(a) Root bend	Satisfactory
None		None	
None		None	

Visual examination results: Visual exam satisfactory per QW-302.4 and QW-194

Radiographic test results: None

Welding test conducted by: AXH air-coolers, LLC

Mechanical/Radiographic tests conducted by: Sherry Laboratories

Lab test no.: 10050504-001-v1

We certify that the statements in this record are correct and that the test coupons were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME code.

Certified By:

Steve D. Little
 STEVE D. LITTLE

Organization: AXH air-coolers, LLC

5/14/2010 QC MANAGER

Date



AXH air-coolers, LLC
 401 E. Lowry Road
 Claremore, Oklahoma 74017

Welder or Welding Operator Performance Qualification (WPQ)

Welder's Name: FARBRO, ERNIE Stamp: OP

Test WPS No.: P1-P1-03 Rev.: 0 WPQ No.: P1-P1-03

Date: 5/5/2006

Welding process(es) / type(s) used: GMAW / Semiautomatic and SMAW / Manual

Type of joint welded: Plate Groove weld Joint type(s) qualified: Groove and Fillet Welds

Base metal(s) welded: SA-36 to SA-36

Welder Variables (QW-350)

P- or S-Number to P- or S-Number

Base metal thickness (in.)

Pipe diameter (in.)

Actual Values Used

P-No. 1 to P-No. 1

1

N/A

Range Qualified

P-1 thru P-11, P-34 & P-4X

WPS Limits

2.875" minimum

Backing **

AWS classification

Filler metal specification (SFA)

Filler metal F-No.

Filler metal product form

Consumable insert

Deposit thickness (in.) [≥ 3 layers]

Welding position

Weld progression

Backing gas

GMAW / FCAW transfer mode

GMAW / Semiauto

No backing used

ER70S-6

5.18

6

N/A

N/A

N/A

0.375 [N/A]

2G - Horizontal

N/A

No backing gas used

Short-circuiting arc

SMAW / Manual

Backing used

E7018

5.1

4

N/A

N/A

N/A

0.625 [Yes]

2G - Horizontal

N/A

N/A

N/A

GMAW / Semiauto

With or without backing

5.xx

F-No. 6

N/A

N/A

N/A

0.4 [25" maximum]

Flat & Horizontal

N/A

W/WO backing gas

Short-circuiting arc

SMAW / Manual

With backing only

5.xx

F-No. 1 to F-No. 4

N/A

N/A

N/A

WPS Limits

Flat & Horizontal

N/A

N/A

N/A

Machine Welding Variables (QW-360)

Direct / remote visual control

Automatic voltage control

Automatic joint tracking

Welding position

Consumable insert

Backing **

Single / multiple pass per side

Actual Values Used

N/A

N/A

N/A

N/A

N/A

N/A

N/A

Range Qualified

N/A

N/A

N/A

N/A

N/A

N/A

N/A

Fillet Welds: Qualified to make fillet welds of any size on all base material thicknesses and pipe diameters of any size.

** Welds with backing include fillets and double-welded groove welds.

Notes:

Guided Bend Test (QW-160)

Figure Number and Type	Result	Figure Number and Type	Result
QW-462.2 Side bend	Satisfactory	QW-462.2 Side bend	Satisfactory
None		None	
None		None	

Visual examination results: Visual exam satisfactory per QW-302.4 and QW-194

Radiographic test results: None

Welding test conducted by: AXH air-coolers, LLC

Mechanical/Radiographic tests conducted by: Bennett Testing

Lab test no.: 5/5/2006

We certify that the statements in this record are correct and that the test coupons were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME code.

Certified By:

Steve D. Little
 STEVE D. LITTLE

Organization: AXH air-coolers, LLC

5/5/2006 QC MANAGER

Date



AXH air-coolers, LLC
 401 E. Lowry Road
 Claremore, Oklahoma 74017

Welder or Welding Operator Performance Qualification (WPQ)

Welder's Name: FARBRO, ERNIE Stamp: OP

Test WPS No.: P1-P1-14 Rev.: 0 WPQ No.: P1-P1-14

Date: 2/18/2009

Welding process(es) / type(s) used: GTAW / Manual

Type of joint welded: Plate Groove weld Joint type(s) qualified: Groove and Fillet Welds

Base metal(s) welded: SA-516, Grade 70 to SA-516, Grade 70

Welder Variables (QW-350)

	Actual Values Used	Range Qualified
P- or S-Number to P- or S-Number	P-No. 1 to P-No. 1	P-1 thru P-11, P-34 & P-4X
Base metal thickness (in.)	0.375	WPS Limits
Pipe diameter (in.)	N/A	2.875" minimum
	GTAW / Manual	GTAW / Manual
Backing **	No backing used	With or without backing
AWS classification	ER70S-6	
Filler metal specification (SFA)	5.18	5.xx
Filler metal F-No.	6	F-No. 6
Filler metal product form	Bare (Solid)	Bare / metal cored
Consumable insert	No insert used	Without insert only
Deposit thickness (in.) [≥ 3 layers]	0.375 [N/A]	0.7500" maximum
Welding position	2G - Horizontal	Flat & Horizontal
Weld progression	N/A	N/A
Backing gas	No backing gas used	With or Without backing gas
GTAW welding current / polarity	DCEN (straight)	DCEN (straight)

Machine Welding Variables (QW-360)

	Actual Values Used	Range Qualified
Direct / remote visual control	N/A	N/A
Automatic voltage control	N/A	N/A
Automatic joint tracking	N/A	N/A
Welding position	N/A	N/A
Consumable insert	N/A	N/A
Backing **	N/A	N/A
Single / multiple pass per side	N/A	N/A

Fillet Welds: Qualified to make fillet welds of any size on all base material thicknesses and pipe diameters of any size.

** Welds with backing include fillets and double-welded groove welds.

Notes: (n3) Also qualifies without backing gas for fillets and butt joints with backing.

Guided Bend Test (QW-160)

Figure Number and Type	Result	Figure Number and Type	Result
None		None	
None		None	
None		None	

Visual examination results: Visual exam satisfactory per QW-302.4 and QW-194

Radiographic test results: Acceptable Per QW-302.2 and QW-191

Welding test conducted by: AXH air-coolers, LLC

Mechanical/Radiographic tests conducted by: IRIS NDT

Lab test no.: 2/18/09

We certify that the statements in this record are correct and that the test coupons were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME code.

Certified By:

Steve D. Little
 STEVE D. LITTLE

Organization: AXH air-coolers, LLC

2/18/2009 QC MANAGER
 Date



AXH air-coolers, LLC
401 E. Lowry Road
Claremore, Oklahoma 74017

Welder or Welding Operator Performance Qualification (WPQ)

Welder's Name: YANG, TOUA Stamp: 5D

Test WPS No.: P1-P1-02 Rev.: 0 WPQ No.: P1-P1-02

Date: 2/12/2011

Welding process(es) / type(s) used: GMAW / Semiautomatic and FCAW / Semiautomatic

Type of joint welded: Plate Groove weld Joint type(s) qualified: Groove and Fillet Welds

Base metal(s) welded: SA-516, Grade 70 to SA-516, Grade 70

Welder Variables (QW-350)

P- or S-Number to P- or S-Number

Base metal thickness (in.)

Pipe diameter (in.)

Backing **

AWS classification

Filler metal specification (SFA)

Filler metal F-No.

Filler metal product form

Consumable insert

Deposit thickness (in.) [≥ 3 layers]

Welding position

Weld progression

Backing gas

GMAW / FCAW transfer mode

Actual Values Used

P-No. 1 to P-No. 1

1

N/A

GMAW / Semiauto

No backing used

ER70S-6

5.18

6

N/A

N/A

0.25 [N/A]

2G - Horizontal

N/A

No backing gas used

Short-circuiting arc

FCAW / Semiauto

Backing used

E71T-1

5.20

6

N/A

N/A

0.75 [Yes]

2G - Horizontal

N/A

No backing gas used

Spray arc

Range Qualified

P-1 thru P-15F, P-34 & P-4X

WPS Limits

2.875" minimum

GMAW / Semiauto

With or without backing

5.xx

F-No. 6

N/A

N/A

0.2750" maximum

Flat & Horizontal

N/A

W/WO backing gas

Short-circuiting arc

FCAW / Semiauto

With backing only

5.xx

F-No. 6

N/A

N/A

WPS Limits

Flat & Horizontal

N/A

W/WO backing gas

Spray, Pulsed, or Globular

Machine Welding Variables (QW-360)

Direct / remote visual control

Automatic voltage control

Automatic joint tracking

Welding position

Consumable insert

Backing **

Single / multiple pass per side

Actual Values Used

N/A

N/A

N/A

N/A

N/A

N/A

N/A

Range Qualified

N/A

N/A

N/A

N/A

N/A

N/A

N/A

Fillet Welds: Qualified to make fillet welds of any size on all base material thicknesses and pipe diameters of any size.

**** Welds with backing include fillets and double-welded groove welds.**

Notes:

Guided Bend Test (QW-160)

Figure Number and Type	Result	Figure Number and Type	Result
QW-462.2 Side bend	Satisfactory	QW-462.2 Side bend	Satisfactory
None		None	
None		None	

Visual examination results: Visual exam satisfactory per QW-302.4 and QW-194

Volumetric test results: None

Welding test conducted by: AXH air-coolers, LLC

Mechanical/Radiographic tests conducted by: AXH air-coolers, LLC

Lab test no.: 2/12/2011

We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Code.

Organization: AXH air-coolers, LLC

Certified By: _____

Steve D. Little
STEVE D. LITTLE

2/12/2011

Date

QC MANAGER



AXH air-coolers, LLC
401 E. Lowry Road
Claremore, Oklahoma 74017

Welder or Welding Operator Performance Qualification (WPQ)

Welder's Name: YANG, TOUA Stamp: 5D

Test WPS No.: P1-P1-03 Rev.: 0 WPQ No.: P1-P1-03

Date: 6/10/2011

Welding process(es) / type(s) used: SMAW / Manual

Type of joint welded: Plate Groove weld Joint type(s) qualified: Groove and Fillet Welds

Base metal(s) welded: SA-516, Grade 70 to SA-516, Grade 70

Welder Variables (QW-350)

	Actual Values Used	Range Qualified
P- or S-Number to P- or S-Number	P-No. 1 to P-No. 1	P-1 thru P-15F, P-34 & P-4X
Base metal thickness (in.)	0.75	WPS Limits
Pipe diameter (in.)	N/A	2.875" minimum
	SMAW / Manual	SMAW / Manual
Backing **	No backing used	With or without backing
AWS classification	E7018-1	
Filler metal specification (SFA)	5.1	5.xx
Filler metal F-No.	4	F 4 (F 1 - F 3 w/backing)
Filler metal product form	N/A	N/A
Consumable insert	N/A	N/A
Deposit thickness (in.) [≥ 3 layers]	0.75 [Yes]	WPS Limits
Welding position	2G - Horizontal	Flat & Horizontal
Weld progression	N/A	N/A
Backing gas	N/A	N/A

Machine Welding Variables (QW-360)

	Actual Values Used	Range Qualified
Direct / remote visual control	N/A	N/A
Automatic voltage control	N/A	N/A
Automatic joint tracking	N/A	N/A
Welding position	N/A	N/A
Consumable insert	N/A	N/A
Backing **	N/A	N/A
Single / multiple pass per side	N/A	N/A

Fillet Welds: Qualified to make fillet welds of any size on all base material thicknesses and pipe diameters of any size.

** Welds with backing include fillets and double-welded groove welds.

Notes:

Guided Bend Test (QW-160)

Figure Number and Type	Result	Figure Number and Type	Result
None		None	
None		None	
None		None	

Visual examination results: Visual exam satisfactory per QW-302.4 and QW-194

Volumetric test results: Acceptable Per QW-302.2 and QW-191

Welding test conducted by: AXH air-coolers, LLC

Mechanical/Radiographic tests conducted by: IRIS NDT

Lab test no.: 6/10/2011

We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Code.

Certified By: _____

Steve D. Little
STEVE D. LITTLE

Organization: AXH air-coolers, LLC

6/10/2011 QC MANAGER
Date



AXH air-coolers, LLC
401 E. Lowry Road
Claremore, Oklahoma 74017

Welder or Welding Operator Performance Qualification (WPQ)

Welder's Name: YANG, TOUA Stamp: 5D

Test WPS No.: P1-P1-14 Rev.: 0 WPQ No.: P1-P1-14

Date: 7/16/2011

Welding process(es) / type(s) used: GTAW / Manual

Type of joint welded: Plate Groove weld Joint type(s) qualified: Groove and Fillet Welds

Base metal(s) welded: SA-516, Grade 70 to SA-516, Grade 70

Welder Variables (QW-350)	Actual Values Used	Range Qualified
P- or S-Number to P- or S-Number	P-No. 1 to P-No. 1	P-1 thru P-15F,P-34 & P-4X
Base metal thickness (in.)	0.375	WPS Limits
Pipe diameter (in.)	N/A	2.875" minimum
	GTAW / Manual	GTAW / Manual
Backing **	No backing used	With or without backing
AWS classification	ER70S-6	
Filler metal specification (SFA)	5.18	5.xx
Filler metal F-No.	6	F-No. 6
Filler metal product form	Bare (Solid)	Bare / metal cored
Consumable insert	No insert used	Without insert only
Deposit thickness (in.) [≥ 3 layers]	0.375 [N/A]	0.7500" maximum
Welding position	2G - Horizontal	Flat & Horizontal
Weld progression	N/A	N/A
Backing gas	No backing gas used	With or Without backing gas
GTAW welding current / polarity	DCEN (straight)	DCEN (straight)

Machine Welding Variables (QW-360)	Actual Values Used	Range Qualified
Direct / remote visual control	N/A	N/A
Automatic voltage control	N/A	N/A
Automatic joint tracking	N/A	N/A
Welding position	N/A	N/A
Consumable insert	N/A	N/A
Backing **	N/A	N/A
Single / multiple pass per side	N/A	N/A

Fillet Welds: Qualified to make fillet welds of any size on all base material thicknesses and pipe diameters of any size.

** Welds with backing include fillets and double-welded groove welds.

Notes: (n3) Also qualifies without backing gas for fillets and butt joints with backing.

Guided Bend Test (QW-160)

Figure Number and Type	Result	Figure Number and Type	Result
None		None	
None		None	
None		None	

Visual examination results: Visual exam satisfactory per QW-302.4 and QW-194

Volumetric test results: Acceptable Per QW-302.2 and QW-191

Welding test conducted by: AXH air-coolers, LLC

Mechanical/Radiographic tests conducted by: IRIS NDT

Lab test no.: 7/16/2011

We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Code.

Certified By: Steve D. Little
STEVE D. LITTLE

Organization: AXH air-coolers, LLC

7/16/2011 QC MANAGER
Date



AXH air-coolers, LLC
401 E. Lowry Road
Claremore, Oklahoma 74017

Welder or Welding Operator Performance Qualification (WPQ)

Welder's Name: GILLILAND, MIKE Stamp: 1E

Test WPS No.: P1-P1-02 Rev.: 0 WPQ No.: P1-P1-02

Date: 8/30/2011

Welding process(es) / type(s) used: GMAW / Semiautomatic and FCAW / Semiautomatic

Type of joint welded: Plate Groove weld Joint type(s) qualified: Groove and Fillet Welds

Base metal(s) welded: SA-516, Grade 70 to SA-516, Grade 70

Welder Variables (QW-350)	Actual Values Used		Range Qualified	
	P-No. 1 to P-No. 1		P-1 thru P-15F, P-34 & P-4X	
P- or S-Number to P- or S-Number	0.75		WPS Limits	
Base metal thickness (in.)	N/A		2.875" minimum	
Pipe diameter (in.)	N/A		2.875" minimum	
	GMAW / Semiauto	FCAW / Semiauto	GMAW / Semiauto	FCAW / Semiauto
Backing **	No backing used	Backing used	With or without backing	With backing only
AWS classification	ER70S-6	E71T-1		
Filler metal specification (SFA)	5.18	5.20	5.xx	5.xx
Filler metal F-No.	6	6	F-No. 6	F-No. 6
Filler metal product form	N/A	N/A	N/A	N/A
Consumable insert	N/A	N/A	N/A	N/A
Deposit thickness (in.) [\geq 3 layers]	0.25 [N/A]	0.5 [Yes]	0.2750" maximum	WPS Limits
Welding position	2G - Horizontal	2G - Horizontal	Flat & Horizontal	Flat & Horizontal
Weld progression	N/A	N/A	N/A	N/A
Backing gas	No backing gas used	No backing gas used	W/WO backing gas	W/WO backing gas
GMAW / FCAW transfer mode	Short-circuiting arc	Spray arc	Short-circuiting arc	Spray, Pulsed, or Globular

Machine Welding Variables (QW-360)	Actual Values Used		Range Qualified	
Direct / remote visual control	N/A	N/A	N/A	N/A
Automatic voltage control	N/A	N/A	N/A	N/A
Automatic joint tracking	N/A	N/A	N/A	N/A
Welding position	N/A	N/A	N/A	N/A
Consumable insert	N/A	N/A	N/A	N/A
Backing **	N/A	N/A	N/A	N/A
Single / multiple pass per side	N/A	N/A	N/A	N/A

Fillet Welds: Qualified to make fillet welds of any size on all base material thicknesses and pipe diameters of any size.

** Welds with backing include fillets and double-welded groove welds.

Notes:

Guided Bend Test (QW-160)

Figure Number and Type	Result	Figure Number and Type	Result
QW-462.2 Side bend	Satisfactory	QW-462.2 Side bend	Satisfactory
None		None	
None		None	

Visual examination results: Visual exam satisfactory per QW-302.4 and QW-194

Volumetric test results: None

Welding test conducted by: AXH air-coolers, LLC

Mechanical/Radiographic tests conducted by: AXH air-coolers, LLC

Lab test no.: 8/30/2011

We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Code.

Certified By:

Steve D. Little
STEVE D. LITTLE

Organization: AXH air-coolers, LLC

8/30/2011 QC MANAGER

Date



AXH air-coolers, LLC
401 E. Lowry Road
Claremore, Oklahoma 74017

Welder or Welding Operator Performance Qualification (WPQ)

Welder's Name: GILLILAND, MIKE Stamp: 1E
 Test WPS No.: P1-P1-03 Rev.: 0 WPQ No.: P1-P1-03 Date: 10/28/2011
 Welding process(es) / type(s) used: SMAW / Manual
 Type of joint welded: Plate Groove weld Joint type(s) qualified: Groove and Fillet Welds
 Base metal(s) welded: SA-516, Grade 70 to SA-516, Grade 70

Welder Variables (QW-350)	Actual Values Used	Range Qualified
P- or S-Number to P- or S-Number	P-No. 1 to P-No. 1	P-1 thru P-15F, P-34 & P-4X
Base metal thickness (in.)	0.75	WPS Limits
Pipe diameter (in.)	N/A	2.875" minimum
	SMAW / Manual	SMAW / Manual
Backing **	No backing used	With or without backing
AWS classification	E7018-1	
Filler metal specification (SFA)	5.1	5.xx
Filler metal F-No.	4	F 4 (F 1 - F 3 w/backing)
Filler metal product form	N/A	N/A
Consumable insert	N/A	N/A
Deposit thickness (in.) [≥ 3 layers]	0.75 [Yes]	WPS Limits
Welding position	2G - Horizontal	Flat & Horizontal
Weld progression	N/A	N/A
Backing gas	N/A	N/A

Machine Welding Variables (QW-360)	Actual Values Used	Range Qualified
Direct / remote visual control	N/A	N/A
Automatic voltage control	N/A	N/A
Automatic joint tracking	N/A	N/A
Welding position	N/A	N/A
Consumable insert	N/A	N/A
Backing **	N/A	N/A
Single / multiple pass per side	N/A	N/A

Fillet Welds: Qualified to make fillet welds of any size on all base material thicknesses and pipe diameters of any size.
**** Welds with backing include fillets and double-welded groove welds.**
Notes:

Guided Bend Test (QW-160)

Figure Number and Type	Result	Figure Number and Type	Result
None		None	
None		None	
None		None	

Visual examination results: Visual exam satisfactory per QW-302.4 and QW-194
 Volumetric test results: Acceptable Per QW-302.2 and QW-191
 Welding test conducted by: AXH air-coolers, LLC
 Mechanical/Radiographic tests conducted by: IRIS NDT Lab test no.: 10/28/2011

We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Code.

Certified By: Steve D. Little Organization: AXH air-coolers, LLC
 STEVE D. LITTLE Date: 10/28/2011 QC MANAGER

Quality Control Documents

- NDE Testing and Hydro Testing
- NDE Testing - *see previous section*
 - Hydrostatic Test Report
 - Tag # AC-5020



HYDROSTATIC TEST REPORT

MANUFACTURED FOR MURPHY OIL CORPORATION

AXH JOB NUMBER 118455

VESSEL TESTED 118455.1 BF WATER

TEST PRESSURE 333 PSI

HYDRO TEST HELD FOR 1 HR.

**THIS REPORT IS TO CERTIFY THAT THE AFOREMENTIONED
VESSEL (OR) VESSELS WERE HYDROSTATIC TESTED IN
ACCORDANCE WITH ASME SECTION VIII DIV 1.**

CUSTOMER WITNESS _____

DATE 3.20.2012 BY Renee Weeks
QUALITY CONTROL DEPARTMENT

Review ONLY

WISco
W <input type="checkbox"/> R <input checked="" type="checkbox"/>
Initials: <u>RP</u>
Date: <u>3-20-12</u>
117

Quality Control Documents

- Material Records
 - Flanges
 - Pipe
 - Plate
 - Tubes
 - Tag # AC-5020

11/23/2011


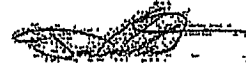
P.O.# : 2683

Item : 2 (4 PC) " X 2-1/4" DIAMETER X 137-1/2" LG

S.O.# : 406163

AA PL# : 2.25734603

11-28-11

 <p>Material Test Report</p> <p>CMC IMPACT METALS PENNSYLVANIA 1024 Kittanning Pike Chloota PA 16025-2030 888-692-7897 www.cmcimpactmetals.com</p>					<p>Production Date 05.27.2011</p>  <p>Tom Carter, Technical Director</p>				
<p>Sold To: CMC Comets Steel 6565 N MacArthur Blvd IRVING TX 75039-6283 US</p>					<p>Ship To:</p>				
<p>Customer PO No. 66269 SO 67379</p>					<p>BOL No.</p>	<p>Delivery No.</p>		<p>Sales Order No.</p>	
<p>Customer Part No.</p>					<p>0000419228</p>	<p>0080538934</p>		<p>0000579721</p>	
<p>Product Description ROUND:SBQ 2-1/4" 20R 1022M, 1022M/1518M A105/A350 LF2 Norm</p>					<p>Alternate Grades: ASTM/ASME A/SA 105-10, ASTM A596-90A GR C ASTM/ASME A/SA 350-07 GR. LF2 CLASS 1 ASTM/ASME A/SA 675-03 GR 70, NACE MR0175-03 EN 10204:04 3.1</p>				
<p>Processing Normalize, RND - Straigten 1/8" in 5 ft</p>									

2-1/4" Dia. SA-350 LF2 SA-675-70
 SA-105 SA-696-C
 A-696-C
 DICK
 GARDEN
 HH. 7346038 WHITE
 78A

CHEMICAL ANALYSIS												
Heat No.	C (%)	Mn (%)	P (%)	S (%)	Si (%)	Cu (%)	Cr (%)	Ni (%)	Mo (%)	V (%)	Cb (Nb) (%)	Al (%)
7946038	0.22	1.15	0.010	0.005	0.23	0.02	0.14	0.02	0.010	0.003	0.001	0.030
Batch No.	Ti (%)	B (%)	As (%)	Pb (%)	Sb (%)	Zr (%)	N2 (ppm)	O2 (ppm)	H2 (ppm)	DI (in.)	CE (%)	
3460381765											0.44	

THERMAL PROCESSING								
Furnace No.	Austenitizing Temp. (°F)	Austenitizing Time (min)	Tempering Temp. (°F)	Tempering Time (min)	Normalizing Temp. (°F)	Normalizing Time (min)	Quench Media	Quench Temp. (°F)
11765					1740	12		

Notes: Certified a true copy of the original, retained in our file. *AL 11-16-12*

Test	Tensile Test						Hardness Test					
	Yield (ksi)	Tensile (ksi)	Elongation (%)	Reduction of Area (%)	Yield at 0.5% Elongation Under Load (ksi)	Yield at 0.02% (ksi)	Test Orientation	Test Location	Brinell (BHN)	Test Location	Rockwell	Test Location
1	50.4	80.1	35	69			Longitudinal	Mid Radius	149	Surface		
2									156	Mid Radius		
3												
4												
5												
6												
7												
8												

JOMINY RESULTS (HRC)												
Distance (In)												
Test	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12
1	J13	J14	J15	J16	J18	J20	J22	J24	J25	J28	J30	J32

1/25/2011 From: TO:
 P.O.# :2683 S.O.# :406163 AA/PH# 2-257-14003
 Item :2 (4 PC) X 2-1/4" DIAMETER X 137-1/2" LG



CMC IMPACT METALS PENNSYLVANIA
 1024 Kittinging Pike
 Chicora PA 16015-2030
 888-682-7337
 www.cmcimpactmetals.com

Material Test Report

Production Data 08/27/2011
 Heat No. 78A0039
 Furnace No. 10765
 Tom Carter, Technical Director

CHARPY IMPACT TESTS														
Test	Average*	Specimen 1*	Shear	Lateral Expansion	Specimen 2*	Shear	Lateral Expansion	Specimen 3*	Shear	Lateral Expansion	Test Temp.	Size	Location	Orientation
	Btu	ft-lb	%	In.	ft-lb	%	In.	ft-lb	%	In.	°F			
1	49.3	50.5	27	0.036	42.5	27	0.033	55.0	33	0.033	-50	Full	Mtd Radius	Longitudinal
2														
3														
4														
5														
6														
7														
8														

*Absorbed energy values converted from sub-size results (ref. ASTM A370) when applicable.

INCLUSION RATING								
Method								
Test	Thin (T)	Heavy (H)	Thin (T)	Heavy (H)	Thin (T)	Heavy (H)	Thin (T)	Heavy (H)
1								
2								
3								

BEND TESTS				
Test	P/n Radius (In.)	Orientation	Result	Final Bend Angle
1				
2				

Certified a true copy of the original, retained in our file.

AG 7-11-11

OTHER TESTS				
Type of Test	Method			
Grain Size	ASTM E112	Grain Size:	5	
Ballistic Test 1		Req'd Velocity:		Observed Velocity: Result:
Ballistic Test 2		Req'd Velocity:		Observed Velocity: Result:
Ultrasonic Test		Criteria:		Result:
Decarburization				
Macro Test	ASTM E381	SRC		
Reduction Ratio		9:1		

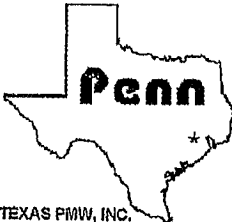
Additional Comments

AXH

Order # 38770
 Qty 100
 Production # 53039

Country of Origin: United States

PRODUCTION MFG, TULSA, OKLA.
 CUSTOMER MATISCO
 P.O.# 53039-9
 ITEM 1" 6200 # x 2 3/8" TOE COPING
 LEAT CODE 78A



TEXAS PMW, INC.
316 NORTH WAYSIDE DRIVE HOUSTON, TX 77020
(713) 678-7800 - FAX (713) 678-7020

Penn
MACHINE
Since 1931

PENNSYLVANIA MACHINE WORKS, INC.
201 BETHEL AVENUE ASTON, PA 19014
(610) 487-3300 - FAX (610) 497-3325



US DROP FORGE CO.
P.O. BOX 184 - ROUTE 561
1898 AUBURN ROAD SVEDSBORO, NJ 08085
(856) 467-0508 - FAX (856) 467-4598

CERTIFIED MATERIAL TEST REPORT

MATTISCO SUPPLY COMPANY
P.O. BOX 2925
TULSA, OK 74101

P.O. 544259
ORDER # 03 206788
3/06/12

36-1 1/4X3/4 6M TOL LF2 QTY: 4

HEAT CODE: 6U1S-A MATERIAL: LF2
SPECIFICATION: A350 SPEC. YEAR: 02 SPEC. REV: A
HEAT TREATMENT: QUENCHED & TEMPERED
UNS NUMBER: K03011

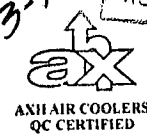
CHEMICAL ANALYSIS										
C	MN	P	S	SI	NI	CR	MO	CU	V	CB
.200	1.040	.011	.025	.230	.080	.070	.026	.170	.003	.002
AL	CB	SN								
.028	.002	.009								

PHYSICAL ANALYSIS								
YS (PSI)	TS (PSI)	%EL 4D	%RA	HARDNESS (HB)	CHARPY1 FT/LBS	CHARPY2 FT/LBS	CHARPY3 FT/LBS	CHARPY AVG
51500	77500	34.00	79.00	152	236.000	221.000	238.000	231.666

TESTED@ QUENCHED TEMP C.E=
TEMP (F) (F) (F)
-50 1625 1200 .41

MATERIAL I/A/W ASME-SEC.II SA SPECIFICATION-CERTIFICATE I/A/W EN10204 TYPE 3.1
THE ABOVE MATERIAL IS A350-LF2 CLASS 1 AND MATERIAL MEETS NACE-MRO175 (2003 EDITION) AND NACE-MRO-2003
MATERIAL MEETS NACE-MRO103-2007
CHARPY IMPACT SPECIMEN SIZE : 10 BY 10 (MM) AND IMPACT TEST TEMPERATURE STATED IN NEGATIVE DEGREES F.
DURING THE MANUFACTURE AND PROCESSING OF THIS PRODUCT, IT DID NOT COME IN DIRECT CONTACT WITH MERCURY
OR ANY OF ITS COMPOUNDS NOR WITH ANY MERCURY CONTAINING DEVICE THAT EMPLOYED A SINGLE BOUNDARY OF CONTAINMENT.
NO WELD REPAIRED MATERIAL - MADE IN THE U.S.A

JG
3-13-12
Customer # 39862
Item # 1
Mattisco File # 54425



WE HEREBY CERTIFY THAT THE REPORTED FIGURES ARE CORRECT AS CONTAINED IN THE RECORDS OF THE CORPORATION.

James B. Friant
JAMES B. FRIANT
QUALITY MANAGER



MANUFACTURERS OF **Penn FORGED** PIPE FITTINGS
QUALITY • SERVICE • PARTNERSHIP
www.pennusa.com



PO # 39862



NATIONAL FLANGE & FITTING CO.

4420 CREEKMONT ST.
 P. O. BOX 924149
 HOUSTON, TEXAS 77292 - 4149
 (713) 688 - 2515
 FAX (713) 688 - 0205

SOLD TO MATTSCO SUPPLY CO
 5740 E. ADMIRAL PLACE
 TULSA, OK 74115

MILL TEST REPORT

INVOICE NUMBER: 02119500
 DATE: 10/19/11

CUSTOMER'S ORDER NO: 867-S-12

ITEM	QTY	DESCRIPTION	MATERIAL	H CODE
1	25	2" 150# WN RF S/160	SA-350-LF2 N	LOP-09
2	20	3" 150# WN RF S/160	SA-350-LF2 N	LSW-05
3	25	4" 150# WN RF S/160	SA-350-LF2 N	LJY-06
4	10	6" 150# WN RF S/160	SA-350-LF2 N	LEA-11
5	20	3" 300# WN RF XXH	SA-350-LF2 N	LZK-05
6	40	4" 300# WN RF S/160	SA-350-LF2 N	LHK-11
7	5	3" 600# WN RF S/160	SA-350-LF2 N	LZK-05
8	10	3" 900# WN RF S/160	SA-350-LF2 N&T	LTE-05
9	5	4" 900# WN RF S/160	SA-350-LF2 N	LEH-10

ITM	H CODE	CAR	MAN	PHOS	SUL	NIC	CHR	MOL	SIL	CU	VA	NB
1	LOP-09	.202	.931	.024	.021	.034	.043	.008	.217	.061	.002	.001
TEN:	79,477 YLD:	49,021 EL:	32.00	RED:	66.82	CVN@-50F	26/28/29	BHN:	146/149			
2	LSW-05	.195	1.090	.012	.012	.060	.100	.010	.220	.170	.021	.002
TEN:	77,012 YLD:	54,532 EL:	30.00	RED:	59.00	CVN@-50F	45/42/43	BHN:	159/162			
3	LJY-06	.180	1.120	.026	.014	.010	.020	.006	.220	.010	.005	.001
TEN:	73,531 YLD:	49,746 EL:	36.00	RED:	70.32	CVN@-50F	57/60/42	BHN:	150/153			
4	LEA-11	.225	1.170	.030	.018	.040	.140	.015	.260	.033	.016	.005
TEN:	81,194 YLD:	52,196 EL:	28.00	RED:	57.48	CVN@-50F	22/20/22	BHN:	163,159			
5	LZK-05	.250	1.200	.013	.012	.070	.050	.020	.260	.160	.000	.000
TEN:	80,348 YLD:	54,677 EL:	31.71	RED:	69.68	CVN@-50F	24/25/30	BHN:	149/159			
6	LHK-11	.170	1.120	.010	.011	.007	.060	.020	.220	.220	.000	.002
TEN:	72,500 YLD:	56,550 EL:	35.80	RED:	64.95	CVN@-50F	44/47/50	BHN:	146/152			
7	LZK-05	.250	1.200	.013	.012	.070	.050	.020	.260	.160	.000	.000
TEN:	80,348 YLD:	54,677 EL:	31.71	RED:	69.68	CVN@-50F	24/25/30	BHN:	149/159			
8	LTE-05	.260	1.240	.013	.012	.070	.050	.020	.260	.160	.000	.000
TEN:	78,607 YLD:	54,387 EL:	31.42	RED:	68.65	CVN@-50F	28/54/47	BHN:	149/167			
9	LEH-10	.208	.820	.016	.010	.035	.080	.011	.160	.010	.001	.001
TEN:	79,477 YLD:	49,021 EL:	32.00	RED:	66.82	CVN@-50F	20/22/23	BHN:	146/149			

COMMENT: ITEM 1: NORMALIZED @ 1724F FOR 1 HR/INCH/THICKNESS, AIR COOL. ITEMS 2&3: NORMALIZED @ 1650F FOR 1 HR/INCH/THICKNESS, AIR COOL. ITEM 4: NORMALIZED @ 1650F FOR 4 HRS, AIR COOL. ITEMS 5&7: NORMALIZED @ 1650F FOR 2 HRS, AIR COOL. ITEM 6: NORMALIZED @ 1670F FOR 1 MIN/MILLIMETER/THICKNESS, AIR COOL. ITEM 8: NORMALIZED @ 1670F FOR 2.3 HRS, AIR COOL. TEMPERED @ 1220F FOR 4 HRS, AIR COOL. ITEM 9: NORMALIZED @ 1670F FOR 1 HR/INCH/THICKNESS, AIR COOL.

THIS IS TO CERTIFY THAT THE MATERIAL FURNISHED ON THIS ORDER COMPLIES IN ALL RESPECT WITH THE SPECIFICATIONS INDICATED IN DESCRIPTION. WE FURTHER CERTIFY THIS PRODUCT WAS MANUFACTURED IN THE UNITED STATES.

NATIONAL FLANGE & FITTING COMPANY

BY: *avicknan*



js
2-20-12

P# 38797



MATERIAL TRACEABILITY RECORD

JOB NO. 118455

PIPES PLATES TUBES BY JW DATE 2-27-12 CUSTOMER _____

MTL. P.O. NO. SECTION NO.	MATERIAL DESCRIPTION	HEAT OR CERTIFICATION NO.
BF WATER	1. 3" SCH 160, SA-333-GR. 6 - (2 pcs)	320369
	2.	
	3.	
	1.	
	2.	
	3.	
	1.	
	2.	
	3.	
	1.	
	2.	
	3.	
	1.	
	2.	
	3.	



NOTE: ALL MATERIAL OF SAME DESCRIPTION IN A SECTION MUST BE OF SAME HEAT NO.

AXH air-coolers • 401 E Lowery Road • Claremore, OK 74017 • (918) 283-9200

JW
2-28-12

AXH AIR COOLERS
QC CERTIFIED

3" SA333 Sch 160
GR 6 320369

V&M FRANCE (A01) TUBERIE SAINT SAULVE SAINT SAULVE ZONE INDUSTRIELLE 89880 SAINT SAULVE 	 VALLOUREC & MANNESMANN TUBES Vallourec Group	MATERIAL TEST REPORT - INSPECTION CERTIFICATE 3.1 EN 10204 : 2004 No. : 183285v07 (A02) Page: 1 / 5 Date: 31.10.2007
--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	----------------------------------------------------------------------------------------------------------------------------------------------	-----------------------------------------------------------------------------------------------------------------------------------------

(A01) V&M FRANCE	(A03) V&M-Order-No. VL0810 (A03) Suborder 858/4818 7
(A05) Customer LEE SUPPLY	(A07) Order-No. 41-046815
(A02) Orderer V & M TUBES CORPORATION / 77058 HOUSTON (TEXAS) 77058	(A07) Order-No. 41-046815 Date 08.09.2007 (A07) Order-No. F3032000
(001, 002, 004) Description of the product	Hot finished seamless pipes for low-temperature service Ends bevelled, angle 30° (+5/-0), root face 1.6 mm (± 0.8) Inside without rust protection - Outside dry varnish ASTM A 333 - 04 A ASTM A 999 - 04 A ASME SA 333, Edition 2004 ASME SA 999, Edition 2004, Addenda 2005 ASME Boiler and Pressure Vessel Code, Sect. II, Part. A, Edition 2004, Addenda 2005 Nace MR 0175 / ISO 15169-2:2003 / COR.12006 / EN ISO 15158-2:2003, Annex A.2.1.2 Spec. Wuis-2, Rev. F, dated 04.2008 Grade 6 Grade 1 ROCKWELL C HARDNESS ≤ 22 GUARANTEED MERCHANDISE IS FREE OF MERCURY CONTAMINATION AND NO WELD REPAIR WAS PERFORMED

(A13) V&M Item	(A05) Cust. Item	(014) Item text	(004) Dimensions	(010) Single length
4			NPS 3 SCH 160 OD-Tolerance + 0.031 in - 0.031 in WT-Tolerance + 15% - 12.5%	Random length from 38 to 42 Ft

(A13) V&M Item	(A05) Cust. Item	(007.1) Heat	(000) Quantity	(011) Total length ft	(012) Weight lb
4		320369	62	1,000.29	28,720

(071)
HEAT CHEMICAL ANALYSIS

<p>V&M FRANCE TUBERIE SAINT SAULVE SAINT SAULVE ZONE INDUSTRIELLE</p> <p>66880 SAINT SAULVE</p> 	 V&M VALLOUREC & MANNESMANN TUBES Vallourec Group	<p>MATERIAL TEST REPORT - INSPECTION CERTIFICATE 3.1 EN 10204 : 2004</p> <hr/> <p>No. : 163285v07 Page: 2 / 5 Date: 31.10.2007</p>
---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	--------------------------------------------------------------------------------------------------------------------------------------------------------	----------------------------------------------------------------------------------------------------------------------------------------------------

(071)
HEAT CHEMICAL ANALYSIS

For each reduction of 0,01% carbon below 0,30 %, an increase of 0,05% manganese above 1,00 % would be permitted to a maximum of 1,35% manganese.

(007.1) Heat	(010) Process	C %	Si %	Mn %	P %	S %	Cr %	Mo %	Ni %	Cu %	V %
min	-	-	0,10	0,40	-	-	-	-	-	-	-
max	-	0,22	-	1,05	0,025	0,025	-	-	-	-	-
320389	Oxygen (BOF)	0,19	0,17	1,02	0,011	0,002	0,110	0,010	0,030	0,020	0,004

(007.1) Heat	1003 %									
min	-									
max	0,40									
320389	0,33									

1003 $CE = C + Mn/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15$

Heats fully killed

(007)
HEAT TREATMENT
NORMALIZED CONDITION ASN 820°C (1508 F) COOLING AIR

TENSILE TEST RESULTS

Type (01a.1)	Tube strip specimen
Test temperature (021)	Room temperature
Direction (022)	longitudinal

VAN FRANCE TUBERIE SAINT SAULVE SAINT SAULVE ZONE INDUSTRIELLE 59880 SAINT SAULVE 	 VALLOUREC & MANNESMANN TUBES Vallourec Group	MATERIAL TEST REPORT - INSPECTION CERTIFICATE 3.1 EN 10204 : 2004 No. : 16328Sv07 Page: 3 / 5 Date: 31.10.2007
--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	---------------------------------------------------------------------------------------------------------------------------------------------------------	-----------------------------------------------------------------------------------------------------------------------------------

TENSILE TEST RESULTS

(col.1) Heat	(col.1) Test Piece	(col.2) Dimension	(col.1) Y _{0.2}	(col.1) T _{0.2}	(col.2) Elong.					
		ln / eq ln	R _{p0.2} psi	R _m psi	2° %					
min		-	34984	80063	38					
max		-	-	-	-					
320389	D1MM697	0,74x0,42 0,31	41783	85888	41					
320389	D2MM697	0,74x0,43 0,32	42073	85592	41					
320389	D3MM697	0,74x0,47 0,35	42073	86011	42					

(col.2) Dimension	Test piece dimensions Test piece area
----------------------	------------------------------------------

IMPACT TEST RESULTS

Type (col.1)	Charpy V
Test temperature (col.1)	-60 °F
Direction (col.1)	longitudinal

(col.1) Heat	(col.1) Test Piece	(col.1) Dimension	(col.1) Impact1	(col.1) Impact2	(col.1) Impact3	(col.1) Moan	(col.2) Shear fr1	(col.2) Shear fr2	(col.2) Shear fr3		
		ln / eq ln	ft-lbf	ft-lbf	ft-lbf	ft-lbf	%	%	%		
min		-	10,3	10,3	10,3	13,3	-	-	-		
max		-	-	-	-	-	-	-	-		
320389	D1MM697	0,38x0,38 0,12	203,4	222,5	244,1	225,0	100	100	100		

<p>V&M FRANCE TUBERIE SAINT SAULVE SAINT SAULVE ZONE INDUSTRIELLE</p> <p>59880 SAINT SAULVE</p> 	 VALLBOUREC & MANNESMANN TUBES Vallourec Group	<p>MATERIAL TEST REPORT - INSPECTION CERTIFICATE 3.1 EN 10204 : 2004</p> <p>No. : 183285v07 Page: 4 / 5 Date: 31.10.2007</p>
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IMPACT TEST RESULTS

(001.1) Heat	(002.1) Test Piece	(041) Dimension	(042.1) L.Exp1	(042.2) L.Exp2	(042.3) L.Exp3						
		in / sq in	mm	mm	mm						
		min	-	-	-						
		max	-	-	-						
320369	01MM897	0,39x0,39 0,12	1,3	1,6	1,7						

(040) Dimension	Test piece dimensions Test piece area
--------------------	------------------------------------------

(007)

TECHNOLOGICAL AND OTHER TESTS ON SPECIMENS

Test	Conditions	Test rate	Result
Flattening test			Satisfactory


(034)

OTHER TESTS ON PIPE

Test	Conditions	Test rate	Result
Hydrostatic test	2500 PSI	5 SEC	Satisfactory
Appearance & Dimensions		100% each lot	Satisfactory

(034, 004)

MARKING, IDENTIFICATION

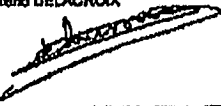
Paint stenciled on one side	 V & M FRANCE A/SAS33 1+6 HF 6CH 180 S LT 60 F 3 0.438 HT HEAT NUMBER 41-046815 F3033010
-----------------------------	--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

(001)

The supplied products are in compliance with the requirements of the order

<p>V&M FRANCE TUBERIE SAINT SAULVE SAINT SAULVE ZONE INDUSTRIELLE</p> <p>69880 SAINT SAULVE</p> 	 VALLOUREC & MANNESMANN TUBES Vallourec Group	<p>MATERIAL TEST REPORT - INSPECTION CERTIFICATE 3.1 EN 10204 : 2004</p> <hr/> <p>No. : 163285v07 Page: 5 / 5 Date: 31.10.2007</p>
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(ANS. 2002. 2003)

Date	31.10.2007
Validated by	Inspection Representative Valérie DELACROIX
	
☐	+ (33) 3 27 23 14 56
☐	+ (33) 3 27 23 19 25
☐	valerie.delacroix@vmtubes.fr
Stamp	

This technical and certification respectively may neither be modified nor used for other products. Changes are regarded as re-issuance of documents and will be subject to external presentation.

171895

USIMINAS U USINAS SIDERÚRGICAS DE MINAS GERAIS S.A. USINA JOSE BONIFÁCIO DE ANDRADA E SILVA - CUBATÃO/SP/BRASIL SEDE: BELLO HORIZONTE - MG - BRASIL R. PROF. JOSE VIEIRA DE MENDONÇA, 3011 BAIRRO ENGENHO NOGUEIRA - CP 896 - CEP: 31310-260 CNPJ: 00.894.710/0003-08 INSCRIÇÃO ESTADUAL: 0283421983115	INSPECTION CERTIFICATE/PACKING LIST CERTIFICADO DE INSPEÇÃO STEEL PLATE CHAPA GROSSA DO LCG	Customer-Cliente: THIRD COAST INTERNATIONAL TRADING I	Lot Lote 926636	Date of Issue Data de Emissão 24/05/2011
		Tolerances - Tolerâncias Thickness-Espessura Width-Largura	-0.25/+1.78 mm -6.00/+25.00mm -6.00/+47.00mm	Sale Order Ordem de Venda N° 00213897

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Quality - Qualidade ASTM-A516-10-70-MT. ASME-SA516-10-70-MT	Nominal Dimensions - Dimensões Nominais 1x96x480 inch	
-----------------------------------------------------------------------	-----------------------------------------------------------------	--

Packages	Pieces per Packages	Net Weight	Gross Weight	Heat	Sample	Packages	Pieces per Packages	Net Weight	Gross Weight	Heat	Sample
Volumes	Pecas por Volume	Peso Líquido	Peso Bruto		Amostra	Volumes	Pecas por Volume	Peso Líquido	Peso Bruto	Corrida	Amostra
14409002	1	5,527	5,927	171895	24717	14409002	1	5,527	5,927	171895	24717
14409002	1	5,527	5,927	171895	24717	14409002	1	5,527	5,927	171895	24717
14409002	1	5,527	5,927	171895	24717	14409002	1	5,527	5,927	171895	24717

Total Gross Weight - Peso Bruto Total = 35.562 MT - Total Net Weight - Peso Líquido Total = 35.562 MT - Packages - Volumes = 5 - Pieces - Pecas = 6

Tensile Test - Ensaio de Tração						Charpy Test - Ensaio do Charpy						
Sample	Pos	Dir	YS	TS	EL(%)	Sample	Dir	Temp	KE1	KE2	KE3	KE4
24717	TR	T	341,5	506,1	47	24717	L	-45	39	39	43	40
24717	TR	T	345,3	512,5	47	24717	R	-45	42	46	46	41
24717	TR	T	329,1	510,3	44	24717	L	-45	42	47	48	42

Tensile Test - Ensaio de Tração
 SM = TSG 30 Tension Unit - Unidade de Tensão - MPA
 C = PRISMATIC
 Specimen Location-Pos. Retir. CP = SUPERIOR

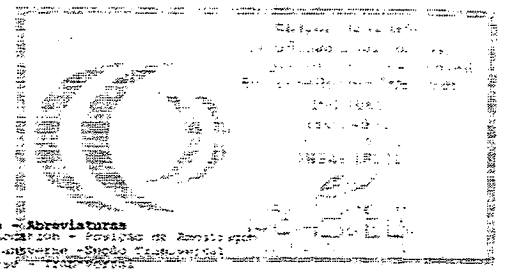
Charpy Test - Ensaio do Charpy
 Size - Dimensão (mm) - 10 X 10 Temp - °C
 Notch - Cavidade (mm) - 02 V Unit - Unidade - J

Chemical Composition (% Weight) - Composição Química (% Peso)													
Analysis	C	Mn	P	S	Si	Al	Cu	Mo	Cr	Ni	Nb	V	Ti
171895	0,28	1,05	0,015	0,004	0,397	0,261	0,009	0,003	0,248	0,018	0,012	0,007	0,016

Summary Condition - Condição de Forno

Temp - T	Heat	HT	ST	FT
940 +/- 10°C	MR	TR	TR	TT
		41	10	41

Abbreviations - Abreviaturas TR - Tensile Test - Ensaio de Tração M - Ladder-Subida Dir - Orientation - Direção Temp - Temperature - Temperatura HT - Heating Time - TR - Tempo Aquecimento ST - Soaking Time - TR - minutos-minutos FT - Furnace Time - TR - Tempo Total de forno	Abbreviations - Abreviaturas TR - Temp. at edge - Temperatura da borda SM - Sample Length - Base Média L - Longitudinal RE - Absorbed Energy - EA - Energia Absorvida Heating Time - Tempo Aquecimento - minutos-minutos FT - Furnace Time - TR - Tempo Total de forno	Abbreviations - Abreviaturas Pos - Test Location - Posição de Amostragem S - Cross Transverse - Superfície Transversal C - Transverse Loc. MS - Cooling-Mold Location - Posição de Molde ST - Soaking Time - TR - minutos-minutos Furnace Time - Tempo total de forno - minutos-minutos
----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------



P# 35915

Paulo Loyola de Souza

SUPERINTENDÊNCIA DE GARANTIA DA QUALIDADE
QUALITY ASSURANCE MANAGEMENT

Remarks - Observações
 MSDS - Material Safety Data Sheet N° 03 available at Usiminas Extranet
 FDS - Ficha de Dados de Segurança do Produto número 03, disponível na Extranet da Usiminas

Signature
 ANV AIR COOLERS
QC CERTIFIED

3/8 516 10/10

E1B176

SSAB

Test Certificate

Form TCI: Revision 1: Date 31 Oct 2000

12400 Highway 43 North, Axis, Alabama 36505

Customer: STEEL SERVICE COMPANY 24412 AMAH PARKWAY CLAREMORE OK 74019		Customer P.O. No.: 33430		Mill Order No.: 41-295826-01		Shipping Manifest: AR113857														
Product Description: ASTM A516-70(06)/ASME SA516-70(09A) LCVN 15/12 FT.LBS.@-40F/A673-P				Ship Date: 23 Mar 11 Cert Date: 23 Mar 11		Cert No: 081271221 (Page 1 of 1)														
NORMALIZED				Size: <u>Q.375</u> X 96.00 X 480.0 (IN)																
Tested Pieces			Tensiles				Charpy Impact Tests													
Heat Id	Piece Id	Piece Dimensions	Tst Loc	YS (PSI)	UTS (PSI)	%RA	Elong 2in / 5in	Tst Dir	Average Hardness	Abs. Energy(FTLB)			% Shear			Tst Tmp	Tst Dir	Tst Siz (mm)	BDWTT Tmp %Str	
E1B176	D37	0.375 X 96.00 (DISCRT)	C	54000	75000		37	T		92	124	129	115.0				60F	L	7.5	
Heat Id	Chemical Analysis															ORGN				
E1B176	C	Mn	P	S	Si	Tot Al	SeI Al	Cu	Ni	Cr	Mo	Cb	V	Ti	CEV	USA				
	.19	1.12	.011	.005	.19	.027	.025	.25	.14	.10	.04	.001	.006	.016	.43					

MERCURY IS NOT A METALLURGICAL COMPONENT OF THE STEEL AND NO MERCURY WAS INTENTIONALLY ADDED DURING THE MANUFACTURE OF THIS PRODUCT
KILLED STEEL, PRODUCED TO A FINE GRAIN PRACTICE
CEV (IIW) = C + MN/6 + (CR+MO+V)/5 + (NI+CU)/15
MTR DIN EN10204:2004 TYPE 3.1 COMPLIANT
100% MELTED AND MANUFACTURED IN THE USA.
CHARPY FULL SIZE EQUIVALENT = ABSORBED ENERGY AVG X 10 / TEST SIZE IN MM
NORMALIZED PLATES, HEATED AT 1650F FOR 19 MINUTES.

PRODUCTS SHIPPED:

E1B176 D37	6220664	PCES:	1,	WGT:	4969	E1B176 D37	6220662	PCES:	1,	WGT:	4956
E1B176 D37	6220661	PCES:	1,	WGT:	4956	E1B176 D37	6220660	PCES:	1,	WGT:	4959

Cust Part #: _____

WE HEREBY CERTIFY THAT THIS MATERIAL WAS TESTED IN ACCORDANCE WITH, AND MEETS THE REQUIREMENTS OF, THE APPROPRIATE SPECIFICATION

Jason Thomas
SENIOR METALLURGIST

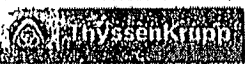
JT
10-10-11
AMH AIR COOLERS
QC CERTIFIED

D# 316079

SO# 388493 SO LINE# 1
 Customer PO # 36575 Pc. Count 1
 Tag # Job #

1/4
 522170
 5A 240
 304

ACCL 2.2019

Hersteller / Manufacturer / Works (Date production)  ThyssenKrupp Nirosa		Art der Prüfungsanordnung / Type of inspection document / Type of document ABNAHMEPRUEFZEUGNIS INSPECTION CERTIFICATE CERTIFICAT DE RECEPTION nach / according to / suivant EN 10204-3.1		Dokumentsnummer / Document Number / Numéro de document 1000300469 / 1 Seite / Page / Page: 1 / 2							
Oberflächenstrasse 18, 47807 Krefeld 1/4" Plate T-304/L HT# 522170			Besteller / Empfänger / Customer / Client / Adresse / Adresse client THYSSENKRUPP NIROSTA, BANNOCKBURN, Kundenbestell-Nr. / Customer's order number / Numéro de la commande du client 51002715 - PO L31739 Werkbestell-Nr. / Manufacturer's work order no. / N° de la commande de l'usine productrice 900408992 / 004 Lieferantengr. Nr. / Delivery Note No. / Avis d'expédition N° B7316104 / 040 Erzeugnis / Product / Produit BLRCH / SHEET / TOLA								
Lieferbedingungen / Terms of delivery / Conditions de livraison ASTM A 240/A 240M ASME SA 240/SA 240M Sec. II Part A Ed 2010 SAE AMS 5511 H ASTM A 888-03 SAE AMS 5513 J ASTM A 480/A 480M ASME SA 480/SA 480M Sec. II Part A Ed 2010 acc. to PED B7/3/VEG NACE STANDARD MR0175 (ONLY ANALYSIS)			Stahlserie und Gütegruppe / Steel grade and quality / Nuance de l'acier TYPE 304 L / 304								
Kundenmaterial-Nr. Customer's material number N° de matière du client		Maße des Erzeugnisses (Dicke / Dicke / Länge) Product's dimensions (Thickness / Width / Length) Dimensions du produit (Epaisseur / Largeur / Longueur)		Hersteller- Identifizierung Mode d'atelier	Ausführung Finish Fini						
		0.2520Inch x 60.0000Inch x 120.0000Inch		AOD	IJa / ID / No.1						
Positiv- Positioning- N° Positiv	Gewicht No. of pieces N° de pièces	VZ-Gewicht Actual weight Masse actuelle	Ident-Nr. Erzeugnis Ident. no. of product Ident. N° du produit	Dokument-Nr. Doc. number N° de la doc.	Probe-Nr. Sample no. Échantillon prélevement	Probe-Nr. Sample no. Échantillon prélevement					
8263971	7	3.532 lbs	228523	522170	1002460150	1002460151					
8263972	7	3.532 lbs	228523	522170	1002460150	1002460151					
8263975	7	3.554 lbs	228523	522170	1002460150	1002460151					
8263979	7	3.527 lbs	228523	522170	1002460150	1002460151					
8263985	7	3.532 lbs	228523	522170	1002460150	1002460151					
8263990	7	3.527 lbs	228523	522170	1002460150	1002460151					
8263997	7	3.527 lbs	228523	522170	1002460150	1002460151					
8263999	7	3.532 lbs	228523	522170	1002460150	1002460151					
8264001	6	3.025 lbs	228523	522170	1002460150	1002460151					
8264005	6	3.029 lbs	228523	522170	1002460150	1002460151					
		34.317 lbs									
Chemische Zusammensetzung / Chemical composition / Composition chimique % C % Si % Mn % P % S % Cr % Ni % N % Cu % Mo											
522170		0.022	0.31	1.25	0.028	0.0030	18.19	8.09	0.063	0.32	0.30
Physikalische Eigenschaften / Physical properties / Propriétés physiques Y00, 2% Y01, 0 TR R1, A2 HRB PSI PSI PSI %											
1002460150		50906	56853	90645	55.8	87.0					
1002460151		50761	56998	91370	55.3	89.0					
Beständig gegen Ritzkorrosion / Resistant to Intergranular Corrosion / Résistant à la corrosion interstitielle EN ISO 3651-2 I.O. I.O. I.O.											
Wärmebehandlung / 1050 GRAD C / LUFT WAERMEBEHANDLUNG 1050 GRAD C / LUFT											
Aussteller der Bescheinigung / Issuer of the Document / Auteur du document ThyssenKrupp Nirosa GmbH Dieses Zeugnis wurde maschinell erstellt Werk Krefeld Abnahme			Butzon Abnahmebeauftragter Inspector / Expert Tel. 02151-832447 Fax: 02151-834108		Datum der Ausstellung und Bescheinigung Date of issue and certification date d'émission et vérification 20.05.2011						

AS AIR COOLERS
 QC CERTIFIED


P# 21.5.170

SO# 388493 SO LINE# 1
 Customer PO # 36575 Pc. Count 1
 Tag # Job #

ACCI 001.50

<p>Herstellerwerk / Manufacture's works / Usine productive</p>  <p>ThyssenKrupp Nirosta</p>	<p>Art der Prüfbescheinigung / Type of inspection document / Type de document</p> <p>ABNAHMEPRUEFZEUGNIS INSPECTION CERTIFICATE CERTIFICAT DE RECEPTION nach / according to / suivant EN 10204-3.1</p>	<p>Bescheinigungs- / Document / Numéro de document 20032011 1000300489 / 1</p> <p>Seite / Page / Page: 2 / 2</p>
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TRAITEMENT THERMIQUE : 1050 GRAD C / AIR
 HEAT - TREATMENT : 1050 DEGREE / AIR
 NO WELD REPAIR
 Frei von Quecksilber / free of mercury
 ASTM A 362 PRACTICE E LO.
 No Ni of Cuban Origin, RoHS - Compliant
 "DFARS compliant"

<p>Aussteller der Bescheinigung / Originator of the document / Auteur du document</p> <p>ThyssenKrupp Nirosta GmbH Dieses Zeugnis wurde maschinell erstellt Werk Krefeld Abnahme</p>	<p>Ort / Location / Lieu</p> <p>Butzen</p> <p>Abnahmebeauftragter Inspector / Expert Tel: 02161-832447 Fax: 02161-834106</p>	<p>Stempel des (der) Abnahmebeauftragten Recording agent's stamp Polycopie de l'agent habilité(e)</p>  <p>Datum der Ausstellung und Verfertigung Date of issue and fabrication date d'impression et usinage</p> <p>20.05.2011</p>
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air-coolers

MATERIAL TRACEABILITY RECORD

JOB NO. 118455

PIPES PLATES TUBES BY KS/FP/JM DATE 3/6/12 CUSTOMER _____

MTL. P.O. NO. SECTION NO.	MATERIAL DESCRIPTION	HEAT OR CERTIFICATION NO.
<u>BF WATER</u> <u>PO # 30142</u> <u>212 TUBES</u>	1. <u>5/8 X .065 X 16' L9</u>	<u>202574</u>
	2. <u>SA - 179</u>	
	3.	
	1.	
	2.	
	3.	
	1.	
	2.	
	3.	
	1.	
	2.	
	3.	
	1.	
	2.	
	3.	

NOTE: ALL MATERIAL OF SAME DESCRIPTION IN A SECTION MUST BE OF SAME HEAT NO.

AXH air-coolers • 401 E Lowery Road • Claremore, OK 74017 • (918) 283-9200



Rw 3/7/12

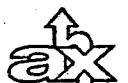
Benteler Steel/Tube GmbH
 Postfach 13 40
 33043 Paderborn
 Deutschland
 Tel.: +49.5254.81-0 Fax: +49.5254.13666

BENTELER 
 Steel/Tube

ABNAHMEPRÜFZEUGNIS EN 10204-3.1
INSPECTION CERTIFICATE EN 10204-3.1
CERTIFICAT DE RECEPTION EN 10204-3.1
 EN 10204:2005-01

Benteler Steel/Tube GmbH - Postfach 1340 - 33043 Paderborn - Deutschland

Tubes Inc.
 900 E. Pecan
 SAND SPRINGS OK 74063
 USA



AXH AIR COOLERS
 QC CERTIFIED

Rw 5.10.11

Dokument-Nr.: 41-628522/001/P
 Document No.:
 No. du document:

Kunden-Bestell-Nr.: BST 10-9955 / Tubes Inc. T-43144-20
 Purchase Order No.:
 No. de commande du client:

Benteler Auftrags-Nr.: 1560219
 Benteler Order No.:
 No. de commande Benteler:

Versandanzeigen-Nr.: 4150819
 Dispatch Note No.:
 No. d'avis d'expédition:

Produkt: NAHTLOSE STAHLROHRE
 Product: SEAMLESS STEEL TUBES
 Produit: TUBES D'ACIER SANS SOUDURE

Prüf-Nr.:
 Inspection No.:
 Nö. du certificat:

Hersteller: Warmrohrwerk/Zieherei
 Manufacturer: ISO/TS 16949 (ISO 9001) TÜV CERT 44111090381-002
 Producteur: PED 97/23/EC TÜV CERT 07-202-5635 WZ-0806/0H

Herstellerzeichen:
 Manufacturer's brand:
 Marque du producteur:



Stempel des Abnahmebeauftragten: WA
 Stamp of the inspection representative:
 Poinçon du contrôleur:

Stahlerschmelzungsverfahren: ELEKTROSTAHL
 Steelmaking process: ELECTRIC FURNACE
 Procédé d'élaboration de l'acier: FOUR ELECTRIQUE

Blatt: 1 / 4
 Page:
 Page:

Lieferbedingungen: ASTM-A 179-1990a, ASME SA-179, ASME Section II Part A Edition 2010

Terms of delivery:

Conditions de livraison:

Maße - Toleranzen: ASME SA-450-CFS, ASME Section II Part A Edition 2010, ASTM-A 450-2007-CD

Dimensions-tolerances:

Dimensions-tolérances:

Stahlsorte: A 179, SA 179

Steel grade:

Nuance d'acier:

Lieferzustand: Normalized

Delivery condition:

État de livraison:

Produktkennzeichnung: FSD: BENTELER A179-SA179 HEAT-NO. DIMENSIONS MADE IN GERMANY WEEK/YEAR WA A 179/SA 179

Product marking: BST 10-9955 / Tubes Inc. T-43144-20

Marquage du produit:

AEZ = Ätztintenbeschriftung, Etching ink marking, Gravure à l'encre | FK = Farbkennzeichnung, colour marking, marquage par couleur | FS = Farbschablonierung, paint stencilling, marquage par peinture | FSD = Farbstrahlendruck, Colour jet printer, imprimante à jet d'encre de c | LK = Laserkennzeichnung, Laser marking, Marquage laser | PKE = Etikettenkennzeichnung, tag marking, marquage sur étiquette | PS = Prägestempel, die stamp, marquage par poinçonnage | TS = Tintenstrahlkennzeichnung, Ink jet spray marking, imprimante à jet d'encre

Pos.	Stück	Maße	Länge	Gewicht	Schmelzen-Nr.	Prüfdruck	Rohr-Nr.-Gruppe	Vielfachlängen
Item	Number	Dimensions	Length	Weight	Heat No.	Test pressure	Tube number group	Multiple lengths
Poste	Nombre	Dimensions	Longueur	Poids	No. de coulée	Pression d'épreuve	Série de no. des tubes	Longueurs multiples
			feet	lbs				
0001	1675	0.625" O.D. * 0.065" MW	48 FT 1 "	80539,57	33292	202574		
0002	1918	0.750" O.D. * 0.065" MW	36 FT 1 "	69207,91	35095	202922		

TUBES, INC.
 1-888-537-8880
 THESE TEST REPORTS APPLY TO:
 YOUR P.O. NO. 30142
 JOB NUMBER 30142-STOCK

ABNAHMEPRÜFZEUGNIS EN 10204-3.1
 INSPECTION CERTIFICATE EN 10204-3.1
 CERTIFICAT DE RECEPTION EN 10204-3.1

Dokument-Nr.: 41-628522/001/P
 Document No.:
 No. du document:

Prüf-Nr.:
 Inspection No.:
 No. du certificat:

Blatt: 2 / 4
 Page:
 Page:

Schmelzenanalyse [%] / Heat analysis [%] / Analyse sur coulée [%]

Pos. Item Poste	Schmelzen-Nr. Heat No. No. de coulée	C	SI	MN	P	S
0001	202574	0,100	0,158	0,47	0,008	0,003
0002	202922	0,100	0,195	0,47	0,012	0,004

Prüfresultate / Test results / Résultats des essais

Die Rohre sind auf Dichtheit geprüft durch: The tubes have been submitted to a leak tightness test by: Les tubes ont passé un contrôle d'étanchéité par:	Hydrostatic test: eddy current testing instead of hydrostatic test	PASSED
Die Rohre wurden zerstörungsfrei geprüft: The tubes are non destructive tested: Les tubes ont passé un essai non destructif:	ET-test: acc. to ASME SA-450, ASTM-A 450; acc. to ASTM-E 309; for imperfections	PASSED
Augensichtkontrolle: Visual inspection: Examen visuel:	Aufweitversuch: Drift expanding/flare test: Essai d'évasement:	PASSED PASSED PASSED
Maßkontrolle: Dimensions examination: Vérification des dimensions:		PASSED
Ringfaltversuch: Flattening test: Essai d'aplatissement:		PASSED

Ergebnisse der mechanischen Prüfung / Results of mechanical testing / Résultats des essais mécaniques

Die Probennahme erfolgte an Vielfachlängen.
 The sampling was carried out on multiple lengths.
 L'échantillonnage était réalisé aux longueurs multiples.

Benteler Steel/Tube GmbH
 Postfach 13 40
 33043 Paderborn
 Deutschland
 Tel.: +49.5254.81-0 Fax: +49.5254.13666

BENTELER 
 Steel/Tube

ABNAHMEPRÜFZEUGNIS EN 10204-3.1
 INSPECTION CERTIFICATE EN 10204-3.1
 CERTIFICAT DE RECEPTION EN 10204-3.1

Dokument-Nr.: 41-628522/001/P
 Document No.:
 No. du document:

Prüf-Nr.:
 Inspection No.:
 No. du certificat:

Blatt: 3 / 4
 Page:
 Page:

Härteprüfung / Hardness test / Essai de dureté

Pos. Item Poste	Proben-Nr. Specimen No. No. de l'éprouv.	Schmelzen-Nr. Heat No. No. de coulée	Härte Hardness Dureté	HRC	HB	HV	HRB	HBW
Anforderungen Requirements Exigences							MAX 72	
0001	000001	202574					067 /	
0001	000002	202574					067 /	
0001	000003	202574					067 /	
0001	000004	202574					067 /	
0001	000005	202574					067 /	
0001	000006	202574					067 /	
0001	000007	202574					067 /	
0001	000008	202574					067 /	
0001	000009	202574					067 /	
0001	000010	202574					067 /	
0001	000011	202574					067 /	
0001	000012	202574					067 /	
0001	000013	202574					067 /	
0001	000014	202574					067 /	
0002	000001	202922					067 /	
0002	000002	202922					066 /	
0002	000003	202922					067 /	
0002	000004	202922					066 /	
0002	000005	202922					067 /	
0002	000006	202922					066 /	
0002	000007	202922					068 /	
0002	000008	202922					067 /	
0002	000009	202922					067 /	

Benteler Steel/Tube GmbH
Postfach 13 40
33043 Paderborn
Deutschland
Tel.: +49.5254.81-0 Fax: +49.5254.13666

BENTELER 
Steel/Tube

ABNAHMEPRÜFZEUGNIS EN 10204-3.1
INSPECTION CERTIFICATE EN 10204-3.1
CERTIFICAT DE RECEPTION EN 10204-3.1

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0002	000010	202922					068	/
0002	000011	202922					067	/
0002	000012	202922					066	/
0002	000013	202922					068	/
0002	000014	202922					067	/
0002	000015	202922					067	/
0002	000016	202922					068	/
0002	000017	202922					067	/
0002	000018	202922					067	/

Vermerk / Remark / Remarque

Certificate remarks: fully killed fine grained steel, Country of origin of the material and heat: Germany

Verkäufer(in) / Salesman/woman in charge / Personne chargée : Mr Höke, Tel.: 05254/81-4263, Fax: 4269

Paderborn Schloß Neuhaus, 21.02.2011, TEL.: 05254.81-1767 FAX: 05254.81-1752

Abnahmebeauftragter
Inspection representative
Contrôleur
THOMAS GOLLAN / TEM

Es wird bestätigt, daß die gelieferten Erzeugnisse den techn. Lieferbedingungen des Auftrages entsprechen. Dieses Dokument wurde mittels EDV erstellt und ist ohne Unterschrift rechtsgültig.
We certify that the supplied products comply with the order specification. This document was prepared by means of electronic data processing and is valid without signature.
Nous attestons que les produits livrés sont conformes aux stipulations de la commande. Ce document a été établi par traitement électronique de l'information et est valide sans signature.

Quality Control Documents

- Travel Sheets
- Box Header Inspection Checklists
- Section Inspection Checklist
- Final Inspection Checklist
 - Tag # AC-5020

**BOX HEADER IN PROCESS
INSPECTION CHECKLIST**



CUSTOMER: MURPHY OIL CORPORATION ASME SECTION VIII, DIV. 1
 JOB / SECTION NUMBER: 118455.1 BF WATER FRONT
 UNIT:

	FITTER	PROD.	LEAD	Q.C.	A.I.
VERIFY ALL MATERIALS ARE PER DRAWINGS AND SPECIFICATIONS AT INITIAL BOX FITUP	3-7-12 VV	IS VV	X		
NOZZLE LAYOUT AND FIT-UP OF PASS PLATES CHECKED	3-7-12 EF	3-12-12 EF	X	MS 3-12	X
FLANGE / PIPE / FITTINGS PER DRAWING					
NOZZLE FIT-UP AND FLANGE FACING INSPECTION		7A 3-13	X	TB 3-13	X
ROOT PENETRATION OF PLATE / PIPE / FITTINGS	3-8-12 7A / EF	7A 3-13	X	RP 3/13/12	X
MT - NOZZLE & CPLG HOLE OPENINGS					
PT - NOZZLE & CPLG HOLE OPENINGS SEE J.I. NOTE				RP 3/13/12	X
MT - ALL NOZZLE & CPLG ROOT PASSES					
PT - ALL NOZZLE & CPLG ROOT PASSES					
MAGNETIC PARTICLE INSPECTION (BEFORE FIT-UP) (AFTER WELDING)				LS 2-29 RP 3/13/12	X
RADIOGRAPHY SEE J.I. NOTE				LS 3-12-12	X
ULTRASONIC EXAM					
PWHT (VERIFY CHART TIME AND TEMPERATURE) SEE J.I. NOTE				LS 3-15-12	X
HARDNESS TESTING SEE J.I. NOTE				LS 3-15-12	X
WELD PROCEDURES			TB 3-13	X R.W. 2/9/2012	X
WELDERS STAMPS EF, II, P, QR		7A 3-13	X	TB 3-13	X
FINAL INSPECTION BEFORE MACHINING		7A 3-13	X	RP 3/13/12	X
HEADER / MACHINING INTERNALS			TH 3-15-12	X RP 3-15-12	X

OFFICE		MATERIAL TRACEABILITY			
	Q.C.	A.I.	DESCRIPTION	THICKNESS / GRADE	HEAT NUMBER
CALCULATION REVIEW	R.W. 2/8/2012	IS	Tube & Plug	1" SA 516-70W	171895
MTRS	Rw 3-19-12	IS	Wrap parts end blocks	1/2" SA 516-70W	E7D144
		IS	Pass Plates	3/8" SA 516-70W	E1B176
DATA REPORTS	Rw 3-21-12	IS	2 couplings	1-6000 Full-SA 352	78A
		IS	2 couplings	5A 350-LF2	6V15-A
		IS	2 couplings	5/8" 1A 350-LF2	LSW

COMMENTS: 3RD PARTY INSPECTION REQUIRED. SEE J.I. INSPECTION TEST PLAN MUST BE SIGNED OFF! WELD MAP IS REQUIRED. MTRS FOR ALL PRESSURE RETAINING COMPONENTS. Plug mtrs - NONE REQ'D.

WISco
 W O R D
 Initials: RP
 Date: 3-28-12
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**BOX HEADER IN PROCESS
INSPECTION CHECKLIST**



CUSTOMER:	MURPHY OIL CORPORATION	ASME SECTION VIII, DIV. 1
JOB / SECTION NUMBER:	118455.1 BF WATER BACK	
UNIT:		

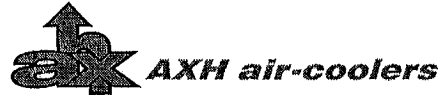
	FITTER	CO-FITTER	PROD.	LEAD	Q.C.	A.I.
VERIFY ALL MATERIALS ARE PER DRAWINGS AND SPECIFICATIONS AT INITIAL BOX FITUP	3-8-12 IJ	3-8-12 IE	X			
NOZZLE LAYOUT AND FIT-UP OF PASS PLATES CHECKED			X	X		
FLANGE / PIPE / FITTINGS PER DRAWING			LL 3-9-12	JK 3-9-12		
NOZZLE FIT-UP AND FLANGE FACING INSPECTION						
ROOT PENETRATION OF PLATE / PIPE / FITTINGS SD			LL 3-9-12		TW 3-9-12	X
MT - NOZZLE & CPLG HOLE OPENINGS						
PT - NOZZLE & CPLG HOLE OPENINGS SEE J.I. NOTE					AM 9-9-12	X
MT - ALL NOZZLE & CPLG ROOT PASSES						
PT - ALL NOZZLE & CPLG ROOT PASSES						
MAGNETIC PARTICLE INSPECTION (BEFORE FIT-UP) (AFTER WELDING)					VS 2-29 TW 3-9-12	X
RADIOGRAPHY SEE J.I. NOTE					VS 3-12-12	X
ULTRASONIC EXAM						
PWHT (VERIFY CHART TIME AND TEMPERATURE) SEE J.I. NOTE					VS 3-13-12	X
HARDNESS TESTING SEE J.I. NOTE					VS 3-13-12	X
WELD PROCEDURES			LL 3-9-12	MS 3-9	X	
WELDERS STAMPS SD, O, OP, LH, etc.			LL 3-9-12	MS 3-9	X	
FINAL INSPECTION BEFORE MACHINING			LL 3-9-12		TW 3-9-12	X
HEADER / MACHINING INTERNALS				MA 3-14	VS 3-14	X

			MATERIAL TRACEABILITY		
			DESCRIPTION	THICKNESS / GRADE	HEAT NUMBER
			tube 28 leg	1" SA516-70N	171895
			w/caps	1/2" SA516-70N	E1D144
			end blocks	3/8" SA516-70N	E1B176
			Pass Plate	1/4" 304-SS	S22170
			Cplgs 1" 6000# Full (x2)	SA-350-LFA	78A

COMMENTS: 3RD PARTY INSPECTION REQUIRED. SEE J.I. INSPECTION TEST PLAN MUST BE SIGNED OFF! WELD MAP IS REQUIRED. MTRS FOR ALL PRESSURE RETAINING COMPONENTS. Plug mtrs - NONE REQ'D.

WISco
WORLD
Initials: [Signature]
Date: 3/27/12
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**SECTION IN PROCESS
INSPECTION CHECKLIST**



CUSTOMER: MURPHY OIL CORPORATION **ASME SECTION VIII, DIV. 1**
JOB / SECTION NUMBER: 118455.1 BF WATER FRONT/BACK
UNIT:

	PROD.	LEAD	Q.C.	A.I.
SIDEFRAME LENGTH / WIDTH / SQUARE / HOLE LAYOUT	3/16 X			
HEADERS PER DRAWING	3/16 X		3/16 X	
NOZZLE ALIGNMENT / FLANGE FACING INSPECTION	3/16 X		3/16 X	
TUBE SPACER STRIPS	3/16 X			
TUBE SUPPORT ARRANGEMENT	3/16 X			
WELDING CHECKED	3/16 X		3/16 X	
CLEANING OF SIDEFRAMES	3/16 X		3/16 X	
PRECOAT INSPECTION FOR GALVANIZING / METALIZING (SIDEFRAMES AND/OR HEADERS)	3/16 X	JH 2-25-12	3/16 X 2/29/12	
RELEASE TO MOVE	3/16 X	JH 3-16-12	3/16 X 3/16	
PAINT INSPECTION BEFORE TUBES ARE INSTALLED		Rm 3-16-12		
TUBES PER DRAWING		Rm 3-16-12	3/16 X	
VERIFICATION OF TUBE PROJECTION		J.O 3-19-12	Ivy 3-20	hwp 3/20/12
VERIFICATION OF ACCELERATORS / RETARDERS				
PLUGS / GASKETS PER DRAWING	DT 3-20-12	BR 3-20-12	3/20 X	
HYDROTEST GAUGE NO. #102	BR 3-20-12		3/20 X	
HYDROTEST CHART REC NO.				
HYDROTEST HOLD FOR 1 HOUR 4:28		BR 3-20-12	3/20 X 3-20	hwp 3/20/12
CLEANING OF HEADERS	DAT 3-20-12	Rm 3-20-12	3/20 X	
INSPECTION OF TUBES / FINS AFTER ROLLING	J.O 3-18-12	J.O 3-19-12	Ivy 3-19	
NAMEPLATE INSPECTION & ATTACHMENT	DAT 3-20-12	Rm 3-20-12	3/20 X 3-21	
INSPECTION OF FLANGE FACING AFTER HYDRO	DAT 3-20-12	Rm 3-20-12	3/20 X	
RELEASE TO MOVE (MISC. PLUGS OR BLINDS INSTALLED, ETC.)		Rm 3-20-12		

COMMENTS: 3RD PARTY INSPECTION REQUIRED. SEE J.I. INSPECTION TEST PLAN MUST BE SIGNED OFF! WISCO

Back Headers m 3-15-12 - Ivy 3-15-12 BK

Fit. Hd A 3-16-12

WISCO
Initials: <i>[Signature]</i>
Date: 3-20-12
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**FINAL IN PROCESS
INSPECTION CHECKLIST**



CUSTOMER:	MURPHY OIL CORPORATION
JOB / MODEL NUMBER:	118455 / 96BZF-R
UNIT:	

	PROD.	LEAD	Q.C.	CUST.
NOZZLE ARRANGEMENT AND FLANGE FACING	JL X 3-21-12	DS X 3-21-12	JL X 3-21	
RUST PREVENTION OF NOZZLE FACES	KP X 3-22-12			
RUST PREVENTION OF SHAFTS	JL X 3-12-12			
DIMENSIONAL INSPECTION OF SUBCOLUMNS <i>Pics taken</i>	JL X 3-12-12	DS X 3-21-12	JL X 3-21	
DIMENSIONAL INSPECTION OF BASE HOLES				
TORQUING OF FAN HUB & BLADES	JP X 3/12/12	C.V. X 3-20-12		
CHECK FAN BLADE CLEARANCE AND PITCH <i>16.9 °</i>	JP X 3/12/12	C.V. X 3-20-12	KP X 3-21-12	
PARAFLEX CPLG, FAN BUSHING, AND BEARINGS SECURED	JL X 3-12-12	C.V. X 3-20-12	KP X 3-21-12	
BEARINGS GREASED	JL X 3-12-12		KP X 3-21-12	
IDLER ALIGNMENT				
ELECTRIC MOTOR / SHEAVE ALIGNMENT	JL X 3-12-12	C.V. X 3-12-12	KP X 3-21	
MANUAL AND/OR AIR MOTORS	JL X 3-21-12		JL X 3-21	
SHUTTERS OPERATE CORRECTLY, <u>PICTURES TAKEN</u>	JL X 3-21-12	C.V. X 3-21-12	JL X 3-21	
SIDE FLAP INSTALLATION (FRONT HEADER END) (BACK HEADER END)				
FINAL FINISH AVG. MIL.				
CLEANING OF GALVANIZED PARTS AS REQUIRED	BC X 3-22-12			
HAIL GUARD, FAN GUARD, AND/OR BUGSCREENS	RB X 3-12-12	SRW 3-12-12		
UNIT / MISC NAMEPLATE INSPECTION & ATTACHMENT	JP X 3/12/12	DS X 3-21-12	JL X 3-21	
TEST FIT OF LADDERS / PLATFORMS <u>PICTURES TAKEN</u>	DP RB X 3-12-12		JL X 3-21	
PARTS SHIPPING LOOSE	BC X 3-22-12	C.V. X 3-22-12	KP X 3-21-12	
VIBRATION SWITCH	DP X 3-12-12	SRW 3-12-12	KP X 3-21-12	
ELECTRIC MOTOR VERIFICATION	G.C. X 3-12-12	C.V. X 3-12-12	KP X 3-21	
RUN TEST AND VIBRATION CHECK		DS 3-21-12	JL X 3-21	KP 3/21/12
VERIFY WEIGHT	BC X 3-22-12			



Q.C. RELEASE FOR SHIPMENT: KP 3-22-12

COMMENTS: 3RD PARTY INSPECTION REQUIRED. SEE J.I. INSPECTION TEST PLAN MUST BE SIGNED OFF!

THIS COOLER HAS A WARM AIR RECIRC. SYSTEM.
*Pics taken of section shutters. 3-21-12 KP
Rollover & Recirc top shutters.*

WISec
W <input type="checkbox"/> R <input type="checkbox"/>
Initials: KP
Date: 3-28-12
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Quality Control Documents

- Bill of Materials/Packing Slips
 - Bill of Lading
- Packing List (located at the bottom of the page)
 - Tag # AC-5020

Bill of Lading

SHIPPER'S NO.

118455A

CARRIER **STONE TRUCKING**

CARRIER'S NO.

RECEIVED, subject to the classifications and tariffs in effect on the date of the issue of this Bill of Lading

AT **Claremore, Oklahoma** APRIL 12 2012 FROM **AXH air-coolers**

The property described below, in apparent good order, except as noted (contents and condition of contents of packages unknown), marked, consigned, and destined as indicated below, which said carrier (the word carrier being understood throughout this contract as meaning any person or corporation in possession of the property under the contract) agrees to carry to its usual place of delivery at said destination, if on its route, otherwise to deliver to another carrier on the route to said destination. It is mutually agreed, as to each carrier of all or any of said property over all or any portion of said route to destination, and as to each party at any time interested in all or any of said property, that every service to be performed hereunder shall be subject to all terms and conditions of the Uniform Domestic Straight Bill of Lading set forth (1) in Uniform Freight Classification in effect on the date hereof, if this is a rail or rail-water shipment, or (2) in the applicable motor carrier classification or tariff if this is a motor carrier shipment. Shipper hereby certifies that he is familiar with all the terms & conditions of the said bill of lading, including those on the back thereof, set forth in the classification or tariff which governs the transportation of this shipment, and said terms and conditions are hereby agreed to by the shipper and accepted for himself and his assigns. (Mail or street address of consignee - For purposes of notification only.)

CONSIGNED TO **STONE TRUCKING**

DESTINATION **KEIFER, OK**

DELIVERY ADDRESS • (To be filled in only when shipper desires and governing tariffs provide for delivery thereat)

ROUTE

DELIVERING CARRIER CAR OR VEHICLE INITIALS NO.

NO. PKGS	KIND OF PACKAGE, DESCRIPTION OF ARTICLES, SPECIAL MARKS AND EXCEPTIONS	WT. (SUB TO COR)	CLASS OR RATE	CK COL	Subject to Section 7 of conditions of applicable bill of lading. If this shipment is to be delivered to the consignee without recourse on the consignor the consignor shall sign the following statement. The carrier shall not make delivery of this shipment without payment of freight and all other lawful charges.
1	96BZF-R AIR COOLED HEAT EXCHANGER AXH JOB# (118455A)				(Signature of Consignor)
	WEIGHT - 13,100#				
	HOLD UNTIL RELEASED BY CUSTOMER				If charges are to be prepaid, write or stamp here "To Be Prepaid"
					Received \$ _____ to apply in prepayment of the charges on the property described hereon
					Agent or Cashier
					Per _____ (The signature here acknowledges only the amount prepaid)
<p>*If the shipment moves between two ports by a carrier by water, the law requires that the bill of lading shall state whether it is carrier's or shipper's weight.</p> <p>NOTE: Where the rate is dependent on value, shippers are required to state specifically in writing the agreed or declared value of the property. The agreed or declared value of the property is hereby specifically stated by the shipper to be not exceeding _____ per _____</p> <p>†The fibre boxes used for this shipment conform to the specifications set forth in the box maker's certificate thereon, and all other requirements of Uniform Freight Classification.</p> <p>‡Shipper's imprint in lieu of stamp; not a part of bill of lading approved by the Interstate Commerce Commission.</p>					Charges Advanced: \$ _____

AXH air-coolers

SHIPPER, PER

AGENT, PER

Permanent post office address of shipper: 401 E Lowry Road, Claremore, Oklahoma 74017

(This Bill of Lading is to be signed by the shipper and the agent of the carrier issuing same.)

PACKING LIST

SOLD TO:

ITEM	QTY ORDERED	QTY SHIPPED	DESCRIPTION
1	1	1	96BZF-R Air Cooled Heat Exchanger \ AXH JOB# (118455A)
2	1	1	Box of Soft Bug Screens
3	2	2	Durastroke 1500 Air Motors
4	2	2	Buckets of Bolts
5	1	1	Ground Level Operator
6	2	2	Long Braces (strapped on motor mount)
7	1 crate	1 crate	With (4) Side Shutters (CRATE 1\4)
8	1 crate	1 crate	With (1) Front Hood Shutter (CRATE 2\4)
9	1 crate	1 crate	With (1) Top Hood Shutter (CRATE 3\4)
10	1 pallet	1 pallet	With (4) Legs, (8) Braces, (2) Blank panels, (3) Recirc panels, (2) Short Braces, (1) Ladder (CRATE 4\4)

SHIPPED COMPLETE

APR 12 2012

AXH AIR-COOLERS