FINAL INSTALLATION, OPERATION, AND MAINTENANCE (I.O.M.) MANUAL

SMITHCO JOB NUMBER: S16286

ATLANTIC COAST PIPELINE

PO# 70301548
Item# D2.2C CASE 2
Service: GAS COOLER

Smithco Engineering
9660 Grunwald Rd., Beasley, TX 77417
(281) 396-8243
www.smithco-eng.com

REV	REV DATE	DESCRIPTION	Created by	Checked by
0	18-JULY-18	Issued Final	JB	GHH

THE NATIONAL BOARD
OF
BOILER & PRESSURE VESSEL INSPECTORS

Certificate of Authorization

This is to certify that

Hudson Products Corporation
9660 Grunwald Road
Beasley, Texas 77417
United States

is authorized to use the R Symbol in accordance with the provisions of the National Board.

The scope of Authorization is limited as follows:

Metallic
Repairs and Alterations
At
Shop and Field Locations

In Accordance with the National Board Inspection Code
Part 3

Certification Number: 2574

Issue Date: January 12, 2016

Expiration Date: January 11, 2019

Executive Director

THE NATIONAL BOARD
OF
BOILER & PRESSURE VESSEL INSPECTORS

Certificate of Authorization to Register

This is to certify that

Hudson Products Corporation
9660 Grunwald Road
Beasley, Texas 77417

is authorized to apply the "NB" mark and register boilers, pressure vessels or other pressure retaining items with the National Board.

The scope of Authorization is limited to items manufactured in accordance with:

ASME Designator(s): U, S

Issue Date: **February 1, 2016**

This Certificate of Authorization to Register will remain in effect as long as the manufacturing organization holds a valid Certificate of Authorization issued by the American Society of Mechanical Engineers.

Executive Director

Project Job No : S16286-IOM

CERTIFICATE OF AUTHORIZATION

S

The named company is authorized by the American Society of Mechanical Engineers (ASME) for the scope of activity shown below in accordance with the applicable rules of the ASME Boiler and Pressure Vessel Code. The use of the certification mark and the authority granted by this Certificate of Authorization are subject to the provisions of the agreement set forth in the application. Any construction stamped with this certification mark shall have been built strictly in accordance with the provisions of the ASME Boiler and Pressure Vessel Code.

COMPANY:

Hudson Products Corporation
9660 Grunwald Road
Beasley, Texas 77417

SCOPE:

Manufacture and assembly of power boilers at the above location and field sites controlled by the above location

AUTHORIZED: **February 1, 2016**

EXPIRES: **December 31, 2018**

CERTIFICATE NUMBER: **8,729**

Board Chair, Conformity Assessment

Director, Conformity Assessment

The American Society of Mechanical Engineers

CERTIFICATE OF AUTHORIZATION

The named company is authorized by the American Society of Mechanical Engineers (ASME) for the scope of activity shown below in accordance with the applicable rules of the ASME Boiler and Pressure Vessel Code. The use of the certification mark and the authority granted by this Certificate of Authorization are subject to the provisions of the agreement set forth in the application. Any construction stamped with this certification mark shall have been built strictly in accordance with the provisions of the ASME Boiler and Pressure Vessel Code.

COMPANY:

Hudson Products Corporation
9660 Grunwald Road
Beasley, Texas 77417

SCOPE:

Manufacture of pressure vessels at the above location and field sites controlled by the above location (This authorization does not cover impregnated graphite)

AUTHORIZED:	**February 1, 2016**
EXPIRES:	**December 31, 2018**
CERTIFICATE NUMBER:	**8,728**

Board Chair, Conformity Assessment

Director, Conformity Assessment

The American Society of Mechanical Engineers

SMITHCO

TABLE OF CONTENTS

SECTION (1)

INTRODUCTION

RECEIVING THE EQUIPMENT

The **SMITHCO** Air Cooled heat Exchanger should be inspected thoroughly by receiving personnel. Check the columns, fan drive support, plenum panels, fan ring and guard, and cooling sections for damage. Any damage in transit must be noted on receiving documents presented by the carrier. Prompt claim filing will expedite compensation from the carrier.

The base unit is a shop assembled cooling unit. The columns, braces, walkway supports, and walkways may be shipped disassembled due to shipping limitations. The ship loose items with the part number or piece mark number shown as the Item number. Each ship loose item should be counted and marked as received.

To enable assembly of the components, the appropriate assembly instructions will accompany the shipment.

SHIP LIST

CERTIFIED
APPROVED FOR FABRICATION
6-Nov-2017
SMITHCO ENGINEERING

SMITHCO ENGINEERING INC.

P.O. Box 571330
Tulsa, OK 74157-1330
Phone (918) 446-4406 Fax (918) 445-2857

Ship To:

DOMINION TRANSMISSION
PO BOX 25459
TBD
ATTN: Texas Eastern Transmissi

Date: 11/17/2017
Job #: 2016B286
Cust. PO: 70301548
Shipped Via:

Item #	Qty	Description		Weight(lbs)
	4	SMITHCO Model 1 F60-142-3 Air Cooled Heat Exchanger		297,500 TOTAL 74,375 PER UNIT

UNIT DESCRIPTION: Size(ft)(Length x Width x Height) Weight(lbs)
61.5 x 14.2 x 12.2 72,000 each

SHIPPING BEAMS: 16) 12 X 26 X 170.3750

LOOSE STRUCTURE:
Note: Stubbed Columns

111	16	BOTTOM CENTER COLUMN	{W 6.00 x 15 x 64}	1616
131	64	END COLUMN BRACE	{ L 2.50 x 0.25 x 110}	2368
136	96	SIDE COLUMN BRACE	{ L 2.50 x 0.25 x 110}	3552
132	320	BRACE SPACER	{ 2.50 x 0.25 x 2.50}	320

WALKWAYS:
INLET END:

1311	4	BOTTOM LEFT COLUMN	{W 6.00 x 15 x 64}	404
1316	4	BOTTOM RIGHT COLUMN	{W 6.00 x 15 x 64}	404
1326	8	WALKWAY SUPPORT	{W 6.00 x 15 x 52}	568
1331	16	WALKWAY COLUMN BRACE	{L 3.00 x 0.25 x 70}	432
1336	4	WALKWAY FLOOR	{FLR 31 x 8.00 x 176}	2644
1341	8	WALKWAY OUTSIDE RAIL	{L 44 x 2.50 x 176}	1960

RETURN END:

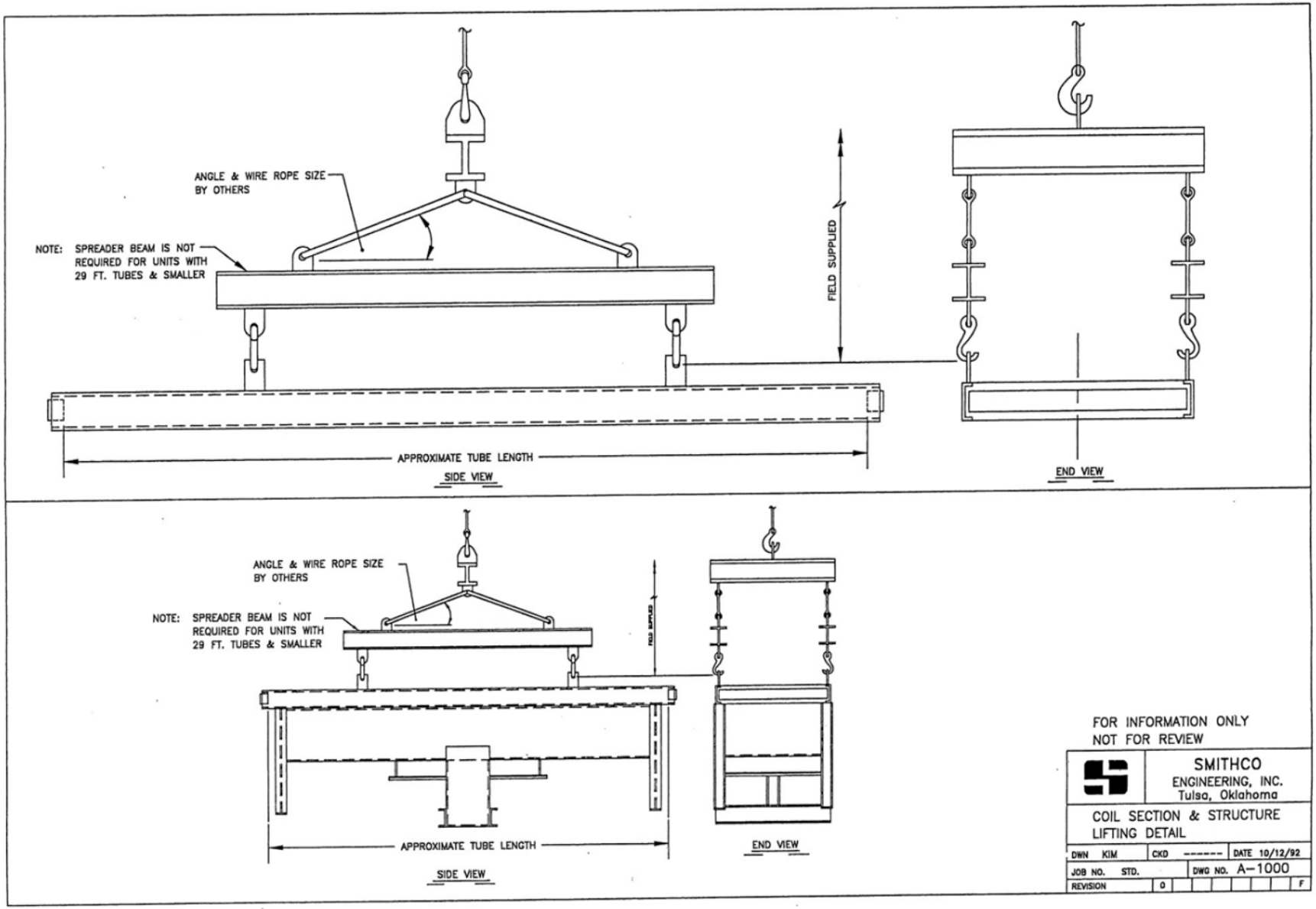
2311	4	BOTTOM LEFT COLUMN	{W 6.00 x 15 x 64}	404
2316	4	BOTTOM RIGHT COLUMN	{W 6.00 x 15 x 64}	404
2326	8	WALKWAY SUPPORT	{W 6.00 x 15 x 52}	568
2331	16	WALKWAY COLUMN BRACE	{L 3.00 x 0.25 x 70}	432
2336	4	WALKWAY FLOOR	{FLR 31 x 8.00 x 176}	2644
2341	8	WALKWAY OUTSIDE RAIL	{L 44 x 2.50 x 176}	1960
1361	4	LADDER	{ 2.50 x 0.25 x 168}	1064
A71-27	4	FABENCO SAFETY GATE		

CHECKED
By: Brett Ford Date:11/03/17 8:36

LOOSE BOLTS:

292	422	BOLT,NUT,LOCK&(2)FLATS 5/8" X 2" A-325 GALV.
293	844	BOLT,NUT,LOCK&(2)FLATS 5/8" X 2 1/2" A-325 GALV.

LIFTING DETAIL



COIL SECTION & STRUCTURE LIFTING DETAIL

SHORT TERM AND LONG TERM STORAGE RECOMMENDATIONS

Shut down periods of an air cooled heat exchanger for an extended period of time can cause serious damage to some components under almost any conditions. Shut down in a wet or humid atmosphere can cause condensate to damage the electric motors, bearings, and unprotected machined surfaces. Drive belts can be damaged by extended exposure to either wet or dry conditions. The terms of shut down as shown below are general and based on moderate conditions. If the shutdown is on a coastal or tropical area, the conditions will require a higher level of protection for even a short storage period.

Shut Down Period – 1 Month or Less

If the unit will be idle for a period longer than one week, it will be necessary to run the unit for ten (10) Minutes every week it is idle. This short operation will keep the gears and bearings coated with oil and prevent rusting due to condensation of moisture resulting from temperature changes.

Shut Down Period – 1 to 6 Months (Moderate Conditions)

1. Nozzles covered and sealed with tape
2. Drive belts relieved of tension
3. Motors covered (shrink wrap and add desiccant bags) to protect against weather
4. Plywood covers on fin tube bundle to avoid damage to the fins
5. Coat all exposed machined surfaces with rust inhibiting preservative
6. Rotate the fan and motor shafts by hand every sixty (60) days (maximum) to circulate lubricant and avoid “brinelling” the bearings
7. Parts such as vibration switches, louver actuators, and all other parts boxed separately should be properly marked and stored indoors in an area designated for the cooler

Shut Down Period – 6 Months or Longer (Moderate Conditions)

1. Nozzles – Install gaskets and seal with metal covers or blind flanges
2. Nitrogen purge of bundle to retard corrosion. Check the purge pressure every week and recharge as necessary to maintain five (5) to fifteen (15) psi pressure
3. Remove motors and drives from unit and store inside a humidity controlled building
4. If the electric motors have internal space heaters, they can be connected to power continuously to avoid condensate in the motors
5. Plywood covers on fin tube bundle to avoid damage to the fins
6. Coat all exposed machined surfaces with rust inhibiting preservative
7. Rotate the fan and motor shafts by hand every sixty (60) days (maximum) to circulate lubricant and avoid “brinelling” the bearings

8. Parts such as vibration switches, louver actuators, and all other parts boxed separately should be properly marked and stored indoors in an area designated for the cooler

The above are recommendations only. All or part of the recommendations may be selected depending on length of shut down and weather conditions at the site. You are advised to document all steps taken to protect the components during storage should a warranty issue arise at a later date. These recommendations are made with the understanding that Smithco assumes no responsibility for deterioration on any part of the equipment due to corrosion or erosion, when such deterioration occurs after leaving Smithco premises.

SECTION (2)

INSTALLATION

PREPARING FOR START UP

1. FIELD ASSEMBLED COMPONENTS

Structural components requiring field assembly are to be assembled per the drawing furnished. All parts are marked with a piece mark and the drawing shows the location of the part by piece mark number.

After Assembly:
Check all bolts (including shop assembled unit) to confirm they are tightened.
Remove any protective plywood panels from the top of the tube bundles.
Remove any restraint used to keep the fan from rotating during transport.

2. BEARINGS

Rotate the fan by hand to confirm that the shaft, bearings, speed reducer and driver turn freely.

3. ELECTRIC MOTORS

Remove the condensate drain plug from each motor to drain any condensate that may have accumulated during storage. If space heaters are provided in the electric motors, activate them approximately 24 hours before starting the equipment.

4. V-BELT DRIVES

Check V-Belt tension in accordance with V-Belt tensioning in the Maintenance section of this manual.

5. GEAR BOX

Check gearbox for oil. Some gearboxes are shipped with no oil and must be filled and serviced per the Maintenance section of this manual.

6. LOUVERS

Check all louvers for ease of movement prior to operation. If they do not operate freely, loosen the frame mounting bolts and adjust the frame until the louvers move freely. Retighten the bolts.

7. FLOATING HEADER BOLTS TO BE REMOVED PRIOR TO BEING PUT IN SERVICE

If the bundle has an even number of passes, bolts attaching return header(s) to side frames must be removed. If the bundle has an odd number of passes, the bolts attaching the outlet header to the side frames must be removed. In either case, the bolts must be removed before the unit is put into service to allow thermal expansion of the tubes.

Failure to remove these bolts may result in serious damage to the bundle. See attached drawing.

8. FANS

The fan must be checked for adequate fan blade tip clearance. Move the blades around the inside of the fan ring and observe where blades have the least amount of clearance. The fan tip clearance should be approximately 1/2" for fans up to 9ft. Dia., 5/8" for fans 9 ft to 11 ft. Dia., 3/4" for fans 11 ft. Dia. and larger.

Confirm the fan blade pitch setting. Looking into the end of the fan blade, the leading edge of the blade should be down and to the left. See the maintenance section for vendor instructions to set the blade pitch.

9. HYDROSTATIC TEST

SMITHCO tube bundles are hydrostatically tested at 1.3 times the design pressure before being released for shipment. To ensure that no damage has occurred during shipment and/or erection, it is good practice to hydrostatically test the entire system, including piping, heat exchangers, pumps, etc., prior to start-up. Do not use water to hydrostatically test Oil Coolers. Movement during shipment and temperature fluctuations may cause minor seepage at the plug to plug-sheet joint. If this occurs, it will require tightening the plugs. Please contact the factory at the phone number below for advice on how to proceed.

After hydrostatic test, remove the test connections. Completely drain the bundle and, if required, dry it. Connect all process piping and auxiliary connections. Inspect all process connections as well as vent, drain, temperature and pressure connections to confirm they are plugged or connected properly.

FLOATING HEADER BOLTS TO BE REMOVED PRIOR TO BEING PUT IN SERVICE

Bolts attaching return header to sideframe must be removed prior to this unit being put in service, to allow for thermal expansion of this bundle.

Failure to remove these bolts may result in serious damage to this bundle.

START UP

WARNING! Turn off and lock out or tag power source before proceeding

1. Complete wiring of all electrical components including the motor(s), vibration switch(s), controls, etc. **DO NOT START MOTORS.**

2. Remove all hand tools and debris from the cooler plenum, drive supports, and any area containing components that will be moving when the fan is turning. Any loose debris under or around the unit may be pulled into the fan and should be removed from the area of the unit.

3. **If the unit is equipped with a fan anti-wind milling device, it must be disengaged prior to supplying power to the electric motors or serious damage could occur.**

4. Install all equipment guards to protect personnel from possible injury.

5. Switch on the fan driver momentarily to check for proper direction of rotation and fan blade orientation. A forced draft horizontal cooler fan should rotate counter-clockwise (left hand rotation) when looking at the air intake of the fan. The fan in an induced draft cooler should rotate clockwise looking at the air discharge of the fan.

6. Re-engage the anti-wind milling device if the unit is so equipped.

7. If the starting torque trips the vibration switch, turn the adjusting screw located on the right hand side of the vibration switch to the right (clockwise) for a less sensitive setting.

8. When the above steps are completed, start the fans and let them run for several minutes to warm the motors, bearings, etc. The fan should run smoothly and evenly in the fan ring. If there is noticeable vibration in the unit, stop and lock out the motor(s) and check the drive bolting for tightness. If necessary, tighten the bolts. If the vibration persists, check the fan blades for proper pitch and possible damage.

   With the unit running smoothly, the next step is to start he process through the tube bundle(s). The following methods of introducing the process fluid into the bundle should be followed.

The process start-up should minimize thermal shock to the tube bundle(s) and avoid overcooling critical services during conditions of low ambient temperature and low heat load.

9. Low pour point and low viscosity services should have the process fluid introduced at a low rate and gradually increased to the design flow rate with the fans off. Start the fan(s) one at a time as the process fluid starts to exceed the design operating temperature. Start the fan(s) until all fan(s) are on or the process temperature is at the design operating temperature.

10. High viscosity fluids and fluids with a pour point above the ambient air temperature should have the process fluid introduced rapidly to prevent over cooling the first process liquid to contact the tubes. When the design process flow is reached and the process temperature begins to exceed the design temperature, start the fan(s) one at a time until the process temperature is at the design temperature or all the fan(s) are running.

SECTION (3)

OPERATION

OPERATION

This section of the manual contains drawings and documents specific to this air cooled heat exchanger. Please consult the Maintenance section of this manual for schedules of periodic maintenance.

LIST OF DOCUMENTS IN THIS SECTION (IF APPLICABLE)

1. Specification Sheet(s)
2. Drawing(s)
3. Calculations
4. Weld Map
5. Weld Procedures
6. Vendor Specific Data

OTHER REFERENCE SOURCES

VENDOR WEBSITES

Electric Motors:	www.reliance.com www.sea.siemens.com/motors
Fans:	www.cofimco.com www.moorefans.com
Fan Shaft Bearings:	www.dodge-pt.com
V-Belts:	www.gates.com www.dayco.com
Vibration Switches:	www.fwmurphy.com www.metrix1.com www.icca.invensys.com (Robert Shaw)
Spiral Bevel Gear Boxes:	www.amarillogear.com www.hubcityinc.com
Louver Actuators/Controllers:	www.airtechproducts.com www.emersonprocess.com
Louvers:	www.airtechproducts.com

SPECIFICATION SHEET(S)

SMITHCO Engineering Inc.
PO Box 571330 Tulsa, OK 74157
Ph. (918) 446-4406 FAX (918) 445-2857

AIR COOLED EXCHANGER SPECIFICATION SHEET

Date	06/06/16	Rev	1
Proposal/Job No.	2016B-286-01		
Reference	70301548		

Customer	ATLANTIC COAST PIPELINE				Item No.	D2.2C CASE 2	
Plant Location	NORTHAMPTON, NC						
Service	GAS COOLER						
Model	4 F60-142-3	Type	FORCED		No. of Bays	4	
Surface per Unit-Finned Tube	473,924	Ft²			Bare Tubes	22,385.30	Ft²
Heat Exchanger	26,430,000	BTU/Hr			Eff MTD	14.7	Counter Flow °F
Transfer Rate-Finned tube	3.81		Bare Tube, Service	80.59			BTU/Hr.Ft²°F

PERFORMANCE DATA - TUBE SIDE

Fluid Name	NATURAL GAS			Lethal Service	Yes [ ] No [X]	IN	OUT
Total Fluid Entering	Lb/Hr	1,485,910		Density	Lb/Ft³	4.96	5.4
	IN	OUT		Specific Heat [Liq/Vap]	BTU/Lb°F	/ 0.701	/ 0.728
Temperature °F	105.0	80.0		Cond. Avg [Liq/Vap]	BTU/HrFt°F	/ 0.0265	
Liquid Lb/Hr				Pour/Freeze Point	°F		
Vapor Lb/Hr (MW)	1,485,910 (17.8)	1,485,910 (17.8)		Bubble Point	°F		
Nocond Lb/Hr (MW)				Latent Heat	BTU/Lb		
Steam Lb/Hr				Pressure	Psia	1,400.00	
Water Lb/Hr				Pressure Drop Allow/Calc	Psi	2.00 / 1.30	
Visc. [Liq/Vap] Cp	/0.014	/0.014		Fouling resist, Inside	Ft²Hr°F/BTU	0.0010	

PERORMANCE DATA - AIR SIDE

Air Quantity SCFM	981,400	Lb/Hr	4,416,000	Altitude	Ft	145
Air Quantity/Fan ACFM	80,600			Temperature In	°F	60.0
				Temperature Out	°F	84.8

DESIGN - MATERIAL - CONSTRUCTION

Design Pressure	1,527	Psig	Test Pressure	2,443	Psig	Design Temperature	130 / MDMT -20	°F					
TUBE BUNDLE			**HEADER**, Type	PLUG BOX		**TUBE** Material	SA-249 T304						
Size	7.1 x 60.0		Material	SA-516 GR-70N									
No. 8	No. Tube Rows	5	No. Passes	1	Slope In/Ft	0.0625	OD	1.000	In	Avg. thick	0.0650	In	
Bays 4	In Parallel	In Series	Plug	A105 1832			No./Bundle	178		Length	60.0	Ft	
Bundle 8	In Parallel	In Series	Gasket	CS 1813			Pitch	2.3125				InΔ	
Pass Arrangement	(Top to Bottom)		Corrosion Allowance	0.0625	In		FIN Type	L-TENSION					
Row/Pass	5 / 1		Size In Nozzle	(2) 8.00 SCH 120 SA-234 WPB/WPC In			Material	ALUM					
Turbulators	NO		Size Out Nozzle	(2) 8.00 SCH 120 SA-234 WPB/WPC In			OD	2.250	In	Stock Thick	0.016	In	
Steam Coil	NO		Rating & Face	900-RF SA-105			No/In	10		Support	Chan. / Staple		
Hailscreens	YES	Bugscreens NO	Vent	(1) 1- 6000	Drain	(1) 1- 6000	Code-ASME VIII,Div 1	YES		Stamp	NATL BD		
Louvers	NONE (0)		TI		PI		Radiograph	YES API-661		Heat Treat	YES		
Frame Finish	HTC 1 Coat Galvanize		Header Finish	WMSB 1 Coat Metalize			Tube Hole Grooving	YES					

MECHANICAL EQUIPMENT

FAN Mfg & Model	MOORE 10K MAG HD		**DRIVER** Type	ELECTRIC MOTOR			**SPEED REDUCER** Type	V-BELT					
No./Bay 3	RPM	99	S.F.	1.15	Insul/TR	CLASS F / B		BELTS (2) 5VX-1320 SHEAVES 37.4/4.3					
Dia. 12.0 Ft	No. Blades	3	No./Bay	3	Frame	254T	HP 5.0	No/Bay		3 Test Run Fan			
Pitch ADJUSTABLE	Angle °	21.5	RPM	(3) 860	Duty	CHEM		HP Rating		8.20	Ratio	8.7	
Blade ALUMINUM	Hub	GALV STEEL	Enclosure	EXPLOSION (H.E.)	V&D	V&D		Support	SUSPENDED FROM STRUCTURE				
HP/Fan, Des. 3.7	DBA	68	V/P/C	460/3/60	Space Heater	NO		Vibration Switch	MURPHY VS-2EX				

STRUCTURE

Mounting	GRADE			Inlet header In	30 GRATING
Windload PSF	30	Seismic	2	Outlet/Return In	30 GRATING
Finish	HTC 1 Coat Galvanize			Drive Access In	NONE

WALKWAYS

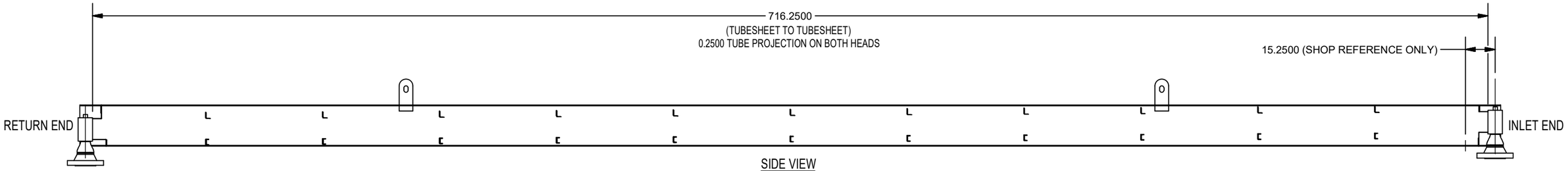
NOTES

Coil Volume (ft^3): 48.2

Assembled Drive, Structure & Bundles (Within Shipping Restrictions)

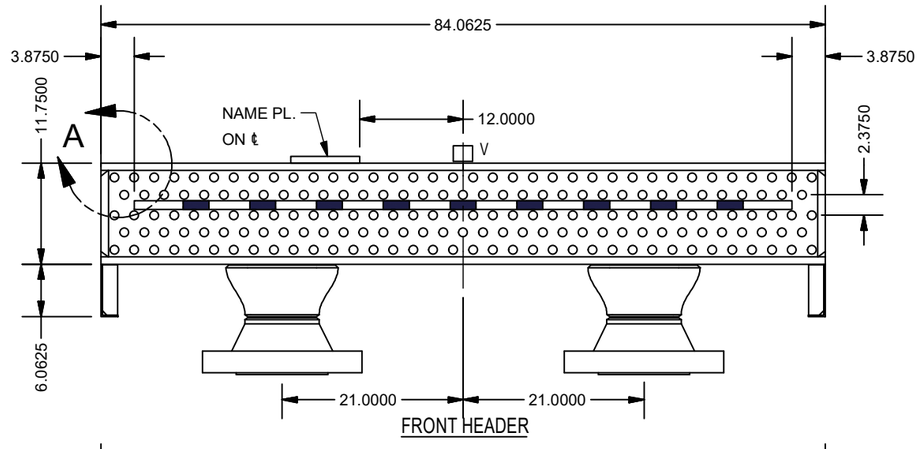
Plot Area	56.8 X 60.0 Ft	Weight Bundle	22,244 Lbs	Total Shipping	303,795 Lbs

DRAWING(S)

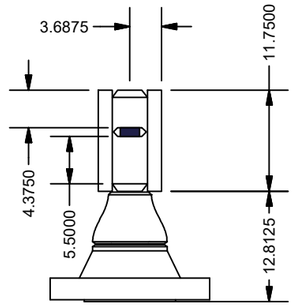


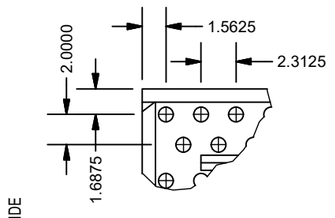
SIDE VIEW

OUT TO OUT OF SIDEFRAMES = 85.1875 in



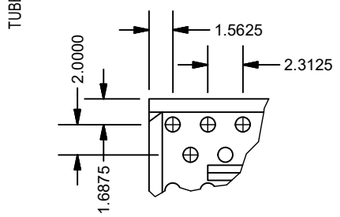
FRONT HEADER



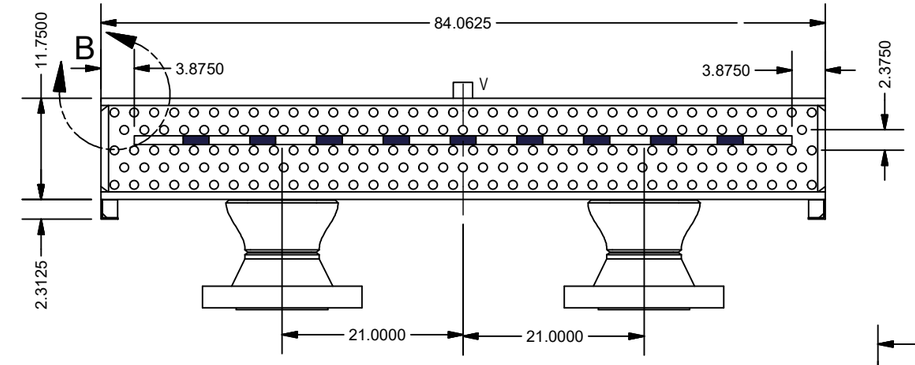


DETAIL A

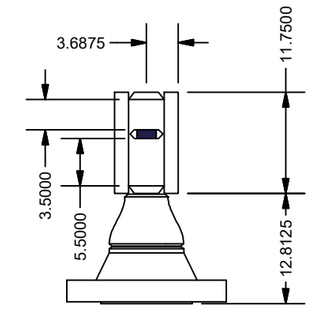
TUBE SHEET SIDE

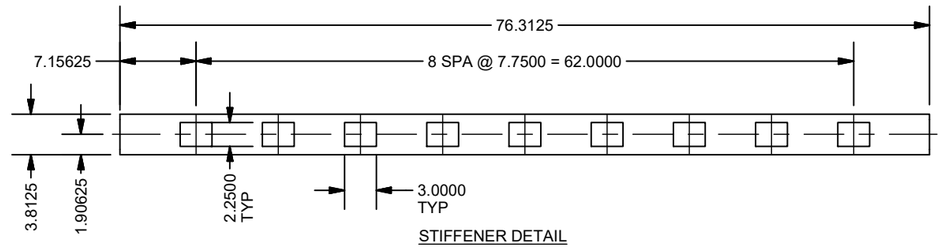


DETAIL B



BACK HEADER





STIFFENER DETAIL

CERTIFIED
APPROVED FOR FABRICATION
25-Jun-2018
SMITHCO ENGINEERING

NOTE:
1) 1 X NOZZLE LOADS IN ACCORDANCE WITH API STD. 661 FEBRUARY 2006.

REV 4: CHANGE ASME DATE JJ 6/19/18
REV 3: ADDED DIM FOR TUBE SPACING JJ 3/1/18
REV 2: UPDATED PWHT AND ADDED CUSTOMER INFO AM 11/2/17
REV 1: CERTIFIED FINAL JJ 6/24/2016
REV 0: SUBMITTED FOR APPROVAL JJ 5/2/2016

MACHINING	DRILL	REAM	SPECIAL
TUBE HOLE:	0.9375	1.010 ± 0.002	DG
PLUG HOLE:	1.0312 SF	1.3750 TAP	2.0000

NOZZLE: IN (2) 8 - 900 # RF SCH 160 W/ TRANSITION
OUT (2) 8 - 900 # RF SCH 160 W/ TRANSITION

VENT: (2) 1-6000

WEIGHT:
HEAT TREAT: (1125-1175) DEG. F (75) MIN.
RADIOGRAPH: API-661 ; 10 INCH SHOT
ALL PRESSURE WELDS 100% MT
ALL BUTT WELDS 100% RT
ALL FILLET WELDS 100% MT

Design No : S16286-IOM

	THICK	LENGTH	WIDTH	BEVELS
FRONT TUBE PLUG	1.6250	84.0625	11.7500	NONE
FRONT COVER	0.8750	84.0625	3.8125	LONG
FRONT END	0.8750	3.8125	9.6875	ALL SIDES
FRONT STAY	1.0000	4.1250	76.3125	DBLS
REAR TUBE PLUG	1.6250	84.0625	11.7500	NONE
REAR COVER	0.8750	84.0625	3.8125	LONG
REAR END	0.8750	3.8125	9.6875	ALL SIDES
REAR STAY	1.0000	4.1250	76.3125	DBLS

MATERIAL SPECIFICATIONS
PLATE: SA-516 GR70 NORM
FLG: SA-105

CPLG: SA-105
TRANSITION: SA-234 WPB

FABRICATE PER:
ASME VIII, DIV. 1, 2015, STAMP U
API-661, 7TH ED, 2013

PLATE TOLERANCES: +.0000"/ -.1250

TUBES 178 TF 36 ROWS 5 PASS 1 LGTH 720 IN.
TUBE OD 1.0000 X 0.065 MATL SA-249 T304
FIN TYPE L-TENSION 10 - 0.625 - ALUM
FRONT PLUG QTY: 178 TYPE A105-1832 GASKET: CS-1813
REAR PLUG QTY: 178 TYPE A105-1832
FRAME THICK: 0.3750
LENGTH: 729.2500 IN. DEPTH: 21.0000 IN. X 4.0000 IN.
SUPPORT: 11 BINDER: 11 CLOSER: 4 83.6875
SUPPORT TYPE: SCALLOPED CHANNEL
F.FOOT: 6" X 6.0625 B.FOOT: 6" X 2.3125

TEST PRESSURE: 2443 TIME: 480 MIN. W/ CHART
HEADS: WHITE METAL BLAST CLEAN WITH 1 COAT METALIZE
FRAME: HAND TOOL CLEAN WITH 1 COAT GALVANIZE
COIL VOLUME: 44 CUBIC FEET
DESIGN TEMP: 130 F
DESIGN PRESSURE: 1527 Psig
MDMT: -20 F
CORROSION ALLOWANCE: 0.0625

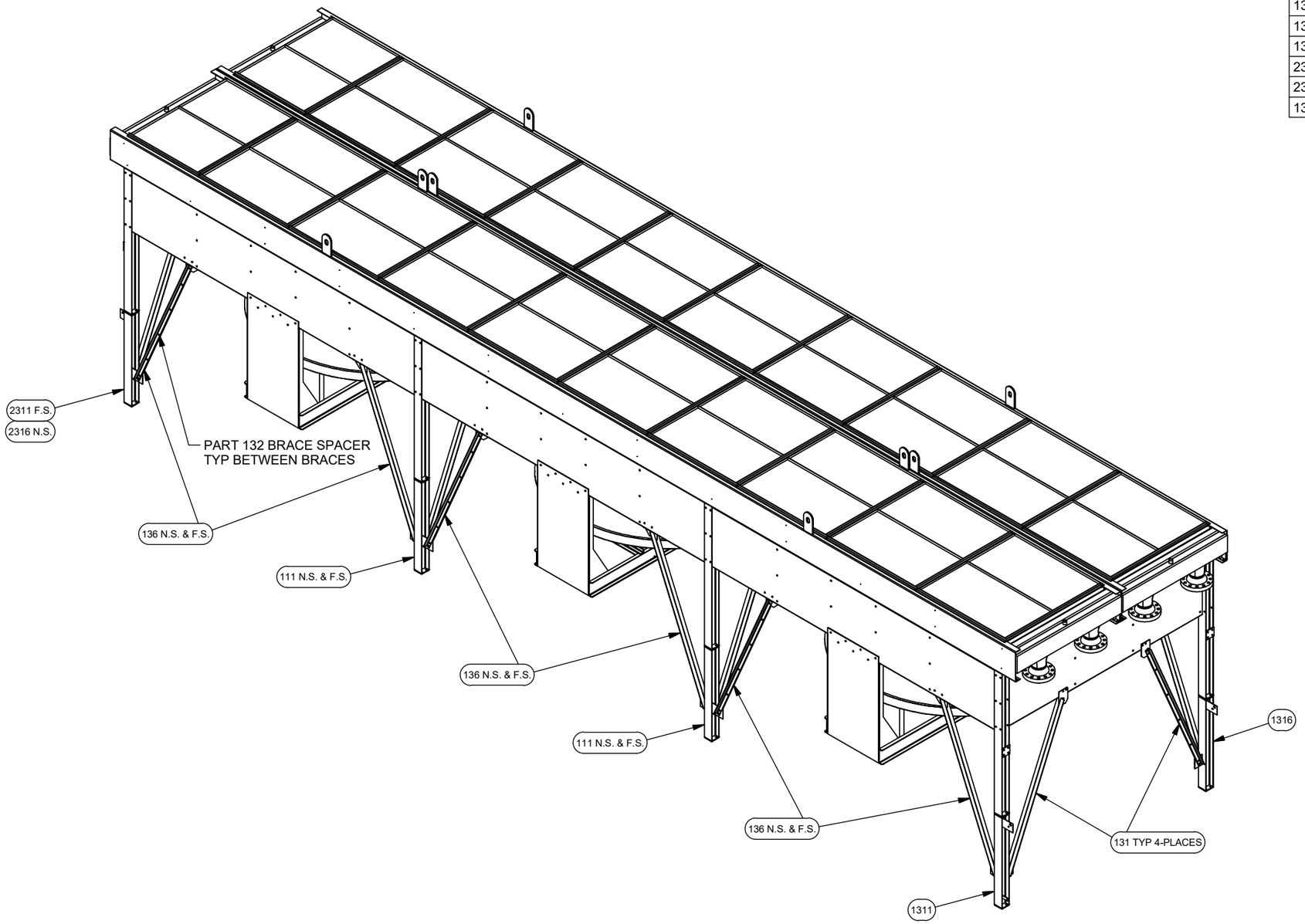
CERTIFIED FINAL: DATE:

AIR COOLED DIVISION
BUNDLE DETAILS
ENG: JJ | REV: 4 | 5/1/2016

SERVICE: GAS COOLER
ITEM: D2.2C CASE 2
PO#: 70301548
CUSTOMER: ATLANTIC COAST PIPELINE, LLC.
LOCATION: NORTHAMPTON, NC

QTY: 8 | WEIGHT: 22800 | S16286-1

Parts List		
P/N	ITEM QTY	DESCRIPTION
111	4	BOTTOM CENTER COLUMN
131	16	ANGLE, 2-1/2 X 2-1/2 X 1/4
1311	1	BOTTOM LEFT COLUMN (WW) INLET
1316	1	BOTTOM RIGHT COLUMN (WW) INLET
136	24	ANGLE, 2-1/2 X 2-1/2 X 1/4
2311	1	BOTTOM LEFT COLUMN (WW) RETURN
2316	1	BOTTOM RIGHT COLUMN (WW) RETURN
132	60	BRACE SPACER



CERTIFIED
APPROVED FOR FABRICATION
6-Nov-2017
SMITHCO ENGINEERING

CHECKED
By: Brett Ford Date:11/03/17 11:20

FOR INFORMATION ONLY
NOT FOR REVIEW

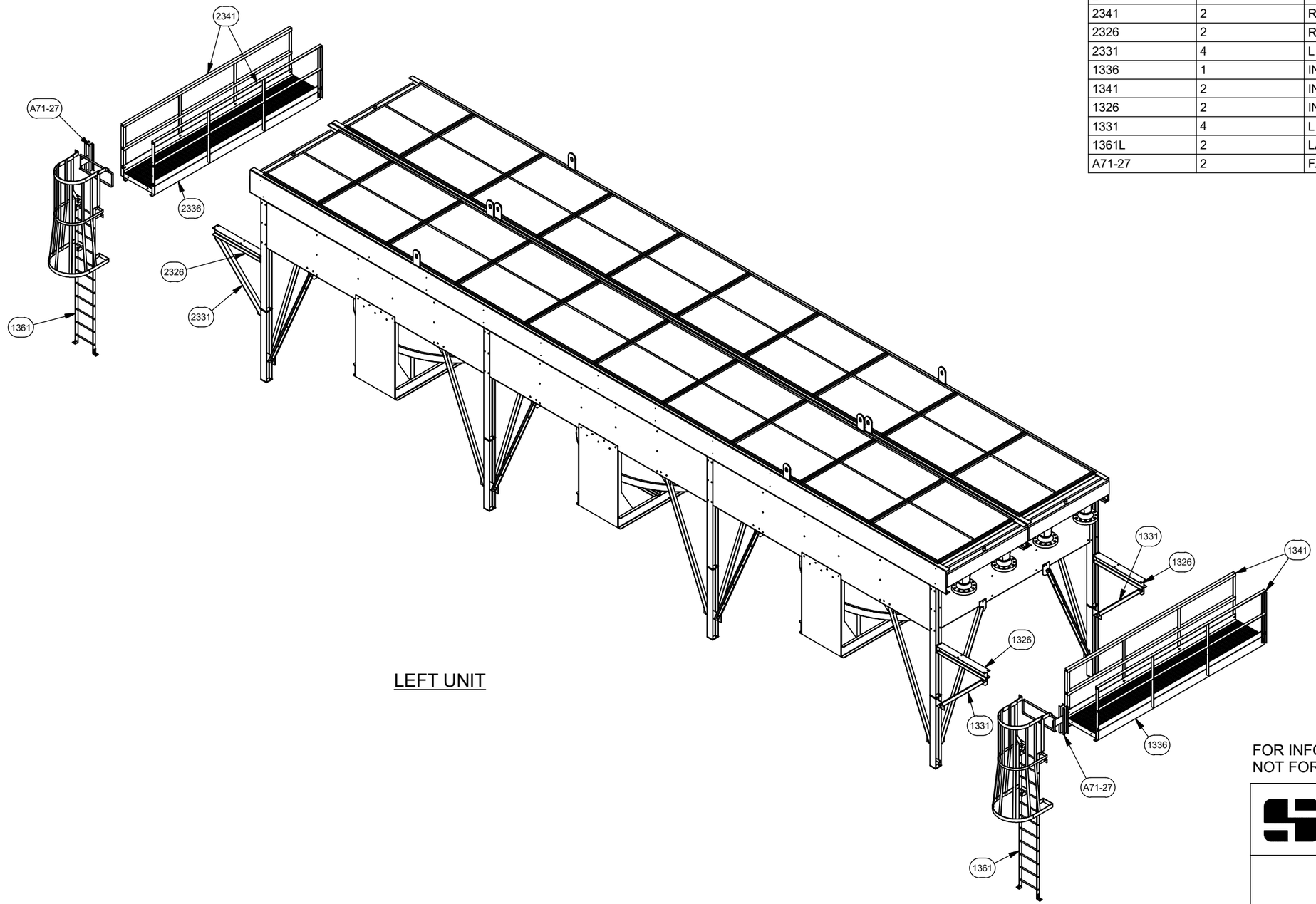
NOTE:
1. USE 5/8" X 2 1/2" (A-325) BOLT, NUT, LOCKWASHER & (2) FLATWASHERS AT ALL COLUMN SPLICE CONNECTIONS.
2. USE 5/8" X 2 1/2" (A325) BOLT, NUT, LOCKWASHER & (2) FLATWASHERS AT ALL COLUMN BRACE CONNECTIONS.
3. REMOVE REAR HEADER BOLTS BEFORE START UP.

SMITHCO
ENGINEERING, INC.
Tulsa, Oklahoma

FIELD
ERECTION

ENGR: AM	CK'D BY:	DATE: 11/1/2017
JOB NO: S16286	DWG NO: FE-1	
REV: 0	SCALE:	QTY: 4

Parts List		
P/N	ITEM QTY	DESCRIPTION
2336	1	RETURN WALKWAY PLATFORM
2341	2	RETURN WALKWAY HANDRAIL
2326	2	RETURN END WALKWAY SUPPORT
2331	4	L 3 X 3 X 1/4
1336	1	INLET WALKWAY
1341	2	INLET WALKWAY HANDRAIL
1326	2	INLET END WALKWAY SUPPORT
1331	4	L 3 X 3 X 1/4
1361L	2	LADDER
A71-27	2	FABENCO SAFETY GATE



LEFT UNIT

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6-Nov-2017
SMITHCO ENGINEERING

FOR INFORMATION ONLY
NOT FOR REVIEW

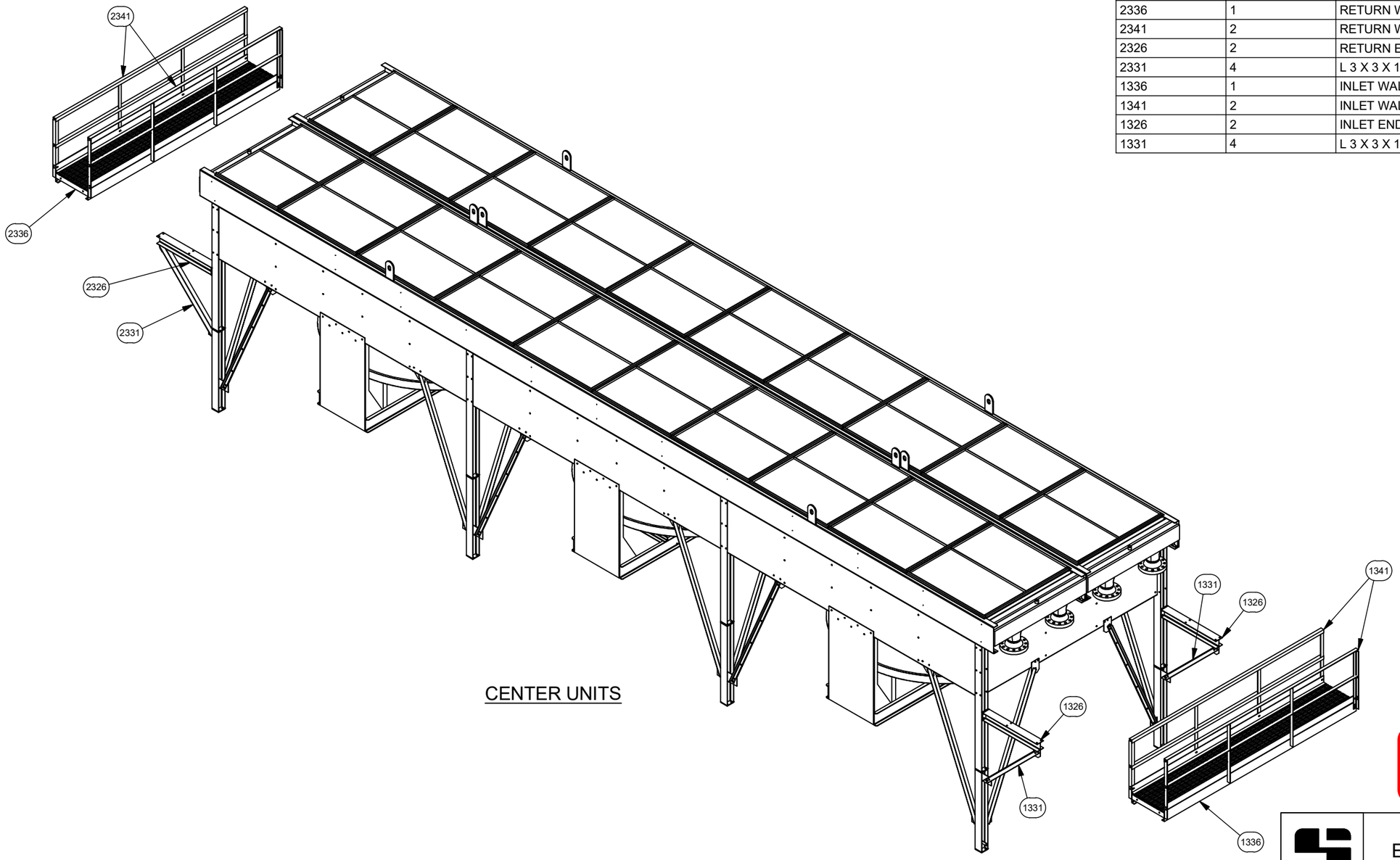
SMITHCO
ENGINEERING, INC.
Tulsa, Oklahoma

FIELD
ERECTION

ENGR: AM	CK'D BY:	DATE: 11/1/2017
JOB NO: S16286	DWG NO: FE-2	
REV: 0	SCALE:	QTY: 1

NOTE:
1. USE 5/8" X 2" (A325) BOLT, NUT, LOCKWASHER & (2) FLATWASHERS AT ALL WALKWAY CONNECTIONS.

Parts List		
P/N	ITEM QTY	DESCRIPTION
2336	1	RETURN WALKWAY PLATFORM
2341	2	RETURN WALKWAY HANDRAIL
2326	2	RETURN END WALKWAY SUPPORT
2331	4	L 3 X 3 X 1/4
1336	1	INLET WALKWAY
1341	2	INLET WALKWAY HANDRAIL
1326	2	INLET END WALKWAY SUPPORT
1331	4	L 3 X 3 X 1/4



CENTER UNITS

CERTIFIED
APPROVED FOR FABRICATION
6-Nov-2017
SMITHCO ENGINEERING

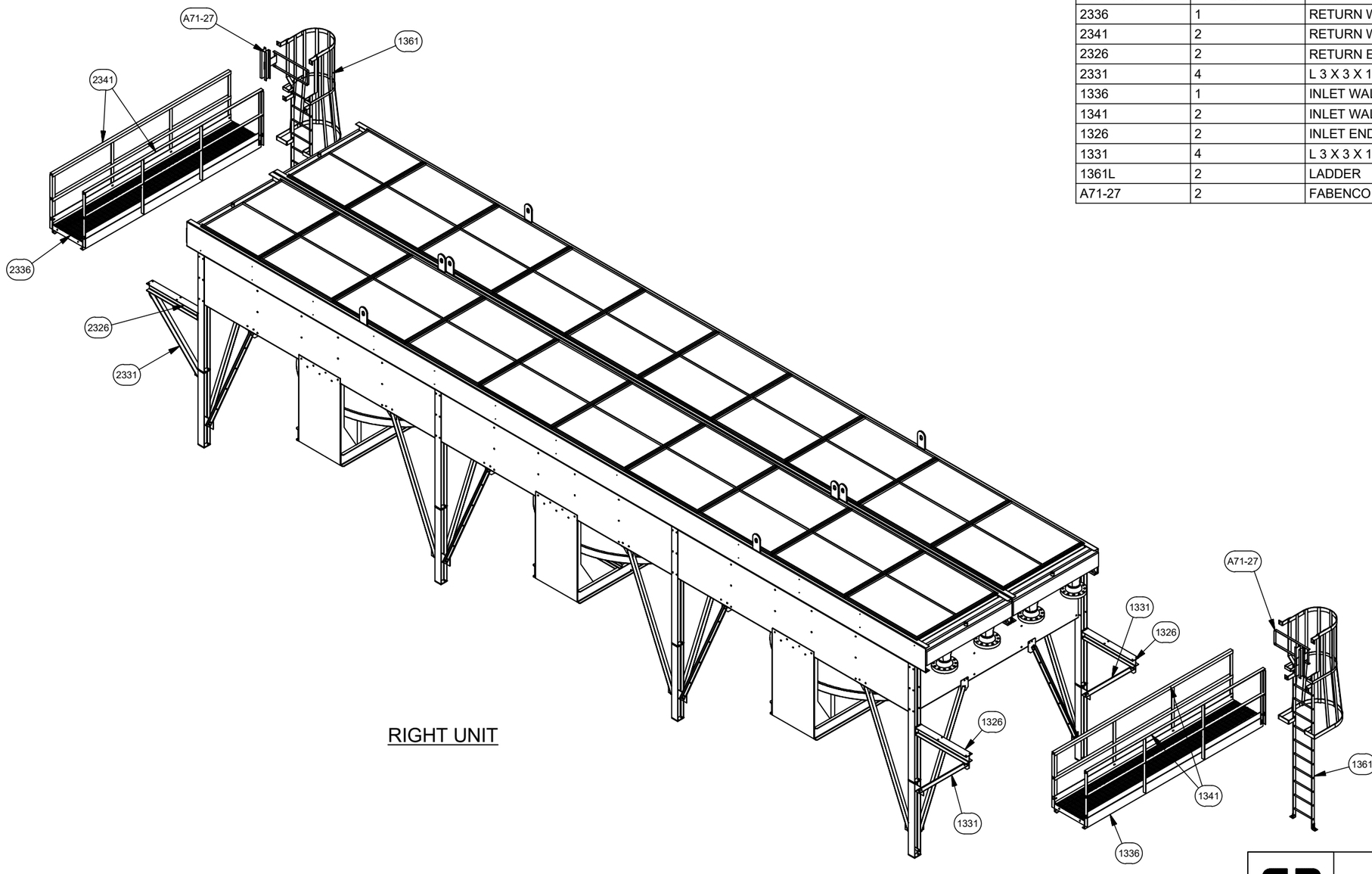
SMITHCO
ENGINEERING, INC.
Tulsa, Oklahoma

FIELD
ERECTION

ENGR: AM	CK'D BY:	DATE: 11/1/2017
JOB NO: S16286	DWG NO: FE-3	
REV: 0	SCALE:	QTY: 2

NOTE:
1. USE 5/8" X 2" (A325) BOLT, NUT, LOCKWASHER & (2) FLATWASHERS AT ALL WALKWAY CONNECTIONS.

Parts List		
P/N	ITEM QTY	DESCRIPTION
2336	1	RETURN WALKWAY PLATFORM
2341	2	RETURN WALKWAY HANDRAIL
2326	2	RETURN END WALKWAY SUPPORT
2331	4	L 3 X 3 X 1/4
1336	1	INLET WALKWAY
1341	2	INLET WALKWAY HANDRAIL
1326	2	INLET END WALKWAY SUPPORT
1331	4	L 3 X 3 X 1/4
1361L	2	LADDER
A71-27	2	FABENCO SAFETY GATE



RIGHT UNIT

NOTE:
1. USE 5/8" X 2" (A325) BOLT, NUT, LOCKWASHER & (2) FLATWASHERS AT ALL WALKWAY CONNECTIONS.

CERTIFIED
APPROVED FOR FABRICATION
6-Nov-2017
SMITHCO ENGINEERING

SMITHCO
ENGINEERING, INC.
Tulsa, Oklahoma

FIELD
ERECTION

ENGR: AM	CK'D BY:	DATE: 11/1/2017
JOB NO: S16286	DWG NO: FE-4	
REV: 0	SCALE:	QTY: 1

CALCULATIONS

Smithco Engineering

Customer:	Atlantic Coast Pipeline	Job:	S16286
Service:	Gas Cooler	Item:	D2.2C
Plant:	Northampton, NC	Page:	1 of 5
Revision:	0		
PO No:	70301548		V2.2

Doc. No.: H 1 **Plug Header Calculations**

CERTIFIED
APPROVED FOR FABRICATION
07-Feb-2018
SMITHCO ENGINEERING

TUBES	2015 ASME VIII, Div. 1, App. 1, Eq. (1)		
SA-249,TP304/304L,WLD			
P	Design Pressure	1527	psig
Ro	Outside Radius	0.5	in
Sd	Allowable Stress at 130 F	17000	psi
Sa	Allowable Stress at 70 F	17000	psi
E	Longitudinal Weld Eff	1	~
CA	Tube Corrosion Allowance	0	in
t	Tube Thickness	0.0585	in
EMB	Embedded Groove Depth	0	in
t(min)	=P*Ro / (Sd*E+0.4*P)+CA	**0.0434**	in
MAWP(hot & corr)	=(t-CA)*Sd*E / (Ro-0.4*(t-CA))	**2086.66**	psig
MAP(new & cold)	=t*Sa*E / (Ro-0.4*t)	**2086.66**	psig
NOZZLES	App. 1, Eq. (1)		
Ri	Inlet Outside Radius	4.3125	in
ti	Inlet Nozzle Wall (0.906 * 0.875)	0.7928	in
Ro	Outlet Outside Radius	4.3125	in
to	Outlet Nozzle Wall (0.906 * 0.875)	0.7928	in
Sd	Allowable Stress at 130 F	20000	psi
Sa	Allowable Stress at 70 F	20000	psi
E	Longitudinal Weld Eff	1	~
CA	Nozzle Corrosion Allowance	0.0625	in
Inlet Pipe	SA-234,WPB/WPC,S58,SMLS		
t(min)	=P*Ri / (Sd*E+0.4*P)+CA	**0.3820**	in
MAWP(hot & corr)	=(ti-CA)*Sd*E / (Ri-0.4*(ti-CA))	**3632.72**	psig
MAP(new & cold)	=ti*Sa*E / (Ri-0.4*ti)	**3968.31**	psig
Outlet Pipe	SA-234,WPB/WPC,S58,SMLS		
t(min)	=P*Ro / (Sd*E+0.4*P)+CA	**0.3820**	in
MAWP(hot & corr)	=(to-CA)*Sd*E / (Ro-0.4*(to-CA))	**3632.72**	psig
MAP(new & cold)	=to*Sa*E / (Ro-0.4*to)	**3968.31**	psig
Flanges	SA-105,N		
MAWP(hot & corr)	ASME B16.5 at 130 F	**2164.50**	psig
MAP(new & cold)	ASME B16.5 at 70 F	**2220.00**	psig

Designer:	GJH	**Date:**	1/15/2018	**Chkd By:**		**Date:**	

Smithco Engineering

Customer:	Atlantic Coast Pipeline	Job:	S16286
Service:	Gas Cooler	Item:	D2.2C
Plant:	Northampton, NC	Page:	2 of 5
Revision:	0		
PO No:	70301548		

Doc. No.: H 1 **INLET Plug Header Calculations** **Box 1**

TUBE, PLUG, AND COVER PLATE App. 13, Figure 13-2(a), Sketch (7) & 13-9(b)

SA-516,70,N

		new & cold	hot & corr	
P	Design Pressure		1527	psig
CA	Header Corrosion Allowance		0.0625	in
h	Maximum Vertical Span	5.5	5.625	in
H	Horizontal Span	4.125	4.25	in
a	=H/h	0.7500	0.7556	~
t1	Cover Plate	0.875	0.8125	in
t2	Tubesheet	1.625	1.5625	in
t22	Plugsheet	1.625	1.5625	in
I1	=t1^3/12	0.0558	0.0447	in^3
I2	=t2^3/12	0.3576	0.3179	in^3
I22	=t22^3/12	0.3576	0.3179	in^3
K	=(I2/I1)a	4.8039	5.3735	~
k1	=I22/I2	1.0000	1.0000	~
k2	=(I22/I1)a	4.8039	5.3735	~
K1	=2k2+3	12.6079	13.7470	~
K2	=3k1+2k2	12.6079	13.7470	~
N	=K1K2-k2^2	135.8806	160.1050	~
S	Allowable Stress at 70 F & 130 F	20000	20000	psi
d	Plug Thread Pitch Dia at 1.125 Thread	1.0787	1.0787	in
p	Horizontal Tube Pitch	2.3125	2.3125	in
e	Ligament Efficiency of Tube/Plugsheet =1-d/p	0.5335	0.5335	~

COVER PLATE

		new & cold	hot & corr	
Sm	=Ph/4t1(act)*{4-[2+K(5-a^2)]/(1+2K)}	4324	4767	psi
(Sb)N	=P(t1/2)/24I1*[-3H^2+2h^2*(1+2a^2K)/(1+2K)]	-7240	-9108	psi
(Sb)Q	=Ph^2(t1/2)/12I1*(1+2a^2K)/(1+2K)	18213	22227	psi
(Sm+Sb)N	Membrane + Bending at Midpoint	11564	13875	psi
(Sm+Sb)Q	Membrane + Bending at Corner	22536	26994	psi

Smithco Engineering

Customer:	Atlantic Coast Pipeline	Job:	S16286
Service:	Gas Cooler	Item:	D2.2C
Plant:	Northampton, NC	Page:	3 of 5
Revision:	0		
PO No:	70301548		

Doc. No.: H 1 **INLET Plug Header Calculations** **Box 1**

TUBE/PLUG

		new & cold	hot & corr	
Sm	=PH/2t2(act)/e	3633	3892	psi
(Sb)M	=Ph^2(t2/2)/12I2*{[1+K(3-a^2)]/(1+2K)}/e	19641	22187	psi
(Sb)Q	=Ph^2(t2/2)/12I2*(1+2a^2K)/(1+2K)	5281	6010	psi
(Sm+Sb)M	Membrane + Bending at Midpoint	23274	26079	psi
(Sm+Sb)Q	Membrane + Bending at Corner	7219	8087	psi

STAY PLATE

		new & cold	hot & corr	
t4	Stay Thickness	1	0.875	in
ep	Stay Ligament & Weld Eff	0.59	0.59	~
t(min)	=Ph/2S*[2+K(5-a^2)]/(1+2K)/ep+2CA		**0.9244**	in

END PLATE Figure UG-34(g) & Eq. (3)

		new & cold	hot & corr	
d	Minimum Span	4.125	4.25	in
D	Maximum Span	10	10.125	in
Z	=3.4-2.4d/D (Max 2.5)	2.410	2.393	~
C	[Per 13-4(f)]	0.2	0.2	~
P	Design Pressure		1527	psig
S	Allowable Stress at 70 F & 130 F	20000	20000	psi
E	[Per 13-5, Endnote 99]	1	1	~
t	End Plate Thickness	0.875	0.8125	in
CA	Header Corrosion Allowance		0.0625	in
t(min)	=d*sqrt(ZCP/SE)+CA		**0.8748**	in

Smithco Engineering

Customer:	Atlantic Coast Pipeline	Job:	S16286
Service:	Gas Cooler	Item:	D2.2C
Plant:	Northampton, NC	Page:	4 of 5
Revision:	0		
PO No:	70301548		

Doc. No.: H 1 **OUTLET Plug Header Calculations** **Box 2**

TUBE, PLUG, AND COVER PLATE App. 13, Figure 13-2(a), Sketch (7) & 13-9(b)

SA-516,70,N

		new & cold	hot & corr	
P	Design Pressure		1527	psig
CA	Header Corrosion Allowance		0.0625	in
h	Maximum Vertical Span	5.5	5.625	in
H	Horizontal Span	4.125	4.25	in
a	=H/h	0.7500	0.7556	~
t1	Cover Plate	0.875	0.8125	in
t2	Tubesheet	1.625	1.5625	in
t22	Plugsheet	1.625	1.5625	in
I1	=t1^3/12	0.0558	0.0447	in^3
I2	=t2^3/12	0.3576	0.3179	in^3
I22	=t22^3/12	0.3576	0.3179	in^3
K	=(I2/I1)a	4.8039	5.3735	~
k1	=I22/I2	1.0000	1.0000	~
k2	=(I22/I1)a	4.8039	5.3735	~
K1	=2k2+3	12.6079	13.7470	~
K2	=3k1+2k2	12.6079	13.7470	~
N	=K1K2-k2^2	135.8806	160.1050	~
S	Allowable Stress at 70 F & 130 F	20000	20000	psi
d	Plug Thread Pitch Dia at 1.125 Thread	1.0787	1.0787	in
p	Horizontal Tube Pitch	2.3125	2.3125	in
e	Ligament Efficiency of Tube/Plugsheet =1-d/p	0.5335	0.5335	~

COVER PLATE

		new & cold	hot & corr	
Sm	=Ph/4t1(act)*{4-[2+K(5-a^2)]/(1+2K)}	4324	4767	psi
(Sb)N	=P(t1/2)/24I1*[-3H^2+2h^2*(1+2a^2K)/(1+2K)]	-7240	-9108	psi
(Sb)Q	=Ph^2(t1/2)/12I1*(1+2a^2K)/(1+2K)	18213	22227	psi
(Sm+Sb)N	Membrane + Bending at Midpoint	11564	13875	psi
(Sm+Sb)Q	Membrane + Bending at Corner	22536	26994	psi

Smithco Engineering

Customer:	Atlantic Coast Pipeline	Job:	S16286
Service:	Gas Cooler	Item:	D2.2C
Plant:	Northampton, NC	Page:	5 of 5
Revision:	0		
PO No:	70301548		

Doc. No.: H 1 **OUTLET Plug Header Calculations** **Box 2**

TUBE/PLUG

		new & cold	hot & corr	
Sm	=PH/2t2(act)/e	3633	3892	psi
(Sb)M	=Ph^2(t2/2)/12I2*{[1+K(3-a^2)]/(1+2K)}/e	19641	22187	psi
(Sb)Q	=Ph^2(t2/2)/12I2*(1+2a^2K)/(1+2K)	5281	6010	psi
(Sm+Sb)M	Membrane + Bending at Midpoint	23274	26079	psi
(Sm+Sb)Q	Membrane + Bending at Corner	7219	8087	psi

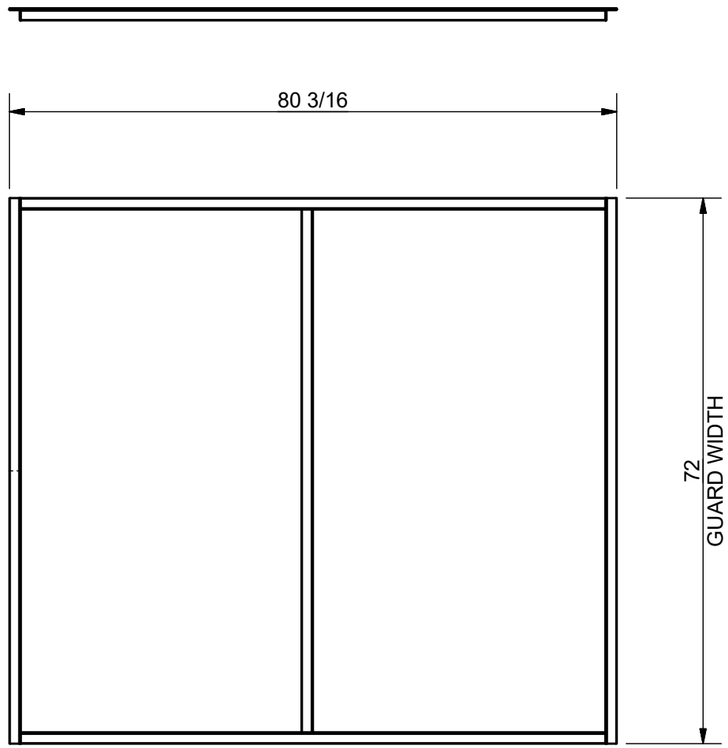
STAY PLATE

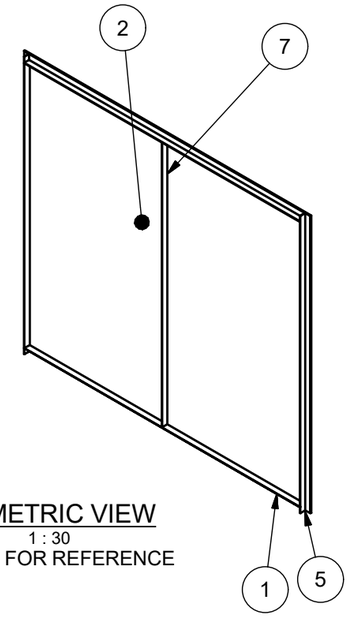
		new & cold	hot & corr	
t4	Stay Thickness	1	0.875	in
ep	Stay Ligament & Weld Eff	0.59	0.59	~
t(min)	=Ph/2S*[2+K(5-a^2)]/(1+2K)/ep+2CA		**0.9244**	in

END PLATE Figure UG-34(g) & Eq. (3)

		new & cold	hot & corr	
d	Minimum Span	4.125	4.25	in
D	Maximum Span	10	10.125	in
Z	=3.4-2.4d/D (Max 2.5)	2.410	2.393	~
C	[Per 13-4(f)]	0.2	0.2	~
P	Design Pressure		1527	psig
S	Allowable Stress at 70 F & 130 F	20000	20000	psi
E	[Per 13-5, Endnote 99]	1	1	~
t	End Plate Thickness	0.875	0.8125	in
CA	Header Corrosion Allowance		0.0625	in
t(min)	=d*sqrt(ZCP/SE)+CA		**0.8748**	in

ITEM	QTY	P/N	DESCRIPTION	LENGTH (in)
5	2	H1-11	ANGLE, 1-1/2" X 1-1/2" X 1/8", A36	72
1	2	H1-12	ANGLE, 1-1/2" X 1-1/2" X 1/8", A36	77 3/16
7	1	H1-13	ANGLE, 1-1/2" X 1-1/2" X 1/8", A36	69
2	1	H1-EXP11	(3/4"-#13 FLATTENED EXP. MTL, 72 X 80.1875)	





ISOMETRIC VIEW
1 : 30
SHOWN FOR REFERENCE

GENERAL NOTES:

1. STANDARD FLATTENED EXPANDED METAL SHEET SIZE USED BY SMITHCO IS 72" X 120".
2. PRIOR TO WELDING; REMOVE ALL BURRS AND SHARP EDGES.
3. ALL SUPPORT FRAME ANGLE MEMBERS TO BE JOINED TOGETHER WITH FULL FILLET WELDS.
4. ALL FINISHED WELDS TO BE CLEAN AND FREE FROM SPLATTER.
5. ATTACH TO BUNDLE SIDEFRAMES USING HEX WASHER HEAD SELF-DRILLING SCREWS 1/4" DIA. X 1" LONG (**ITEM 6**).
6. USE CUSTOM GUARD WIDTHS AS REQUIRED TO COMPLETE GUARD SECTION FOR BUNDLE.

QTY	UNIT	STOCK NUMBER	MATERIAL DESCRIPTION	FOR ITEMS
1	Each		ANGLE, 1-1/2" X 1-1/2" X 1/8", A36	7
1	Each		ANGLE, 1-1/2" X 1-1/2" X 1/8", A36	5
1	Each		(3/4"-#13 FLATTENED EXP. MTL, 72 X 80.1875)	2
1	Each		ANGLE, 1-1/2" X 1-1/2" X 1/8", A36	1

CUT MATERIAL QTY LIST

Project Job No : S16286-IOM

CERTIFIED
APPROVED FOR FABRICATION
6-Nov-2017
SMITHCO ENGINEERING

CHECKED
By: Brett Ford Date:11/03/17 11:21

REV	DATE	DESCRIPTION	DRAWN	APPR'D
0	11/1/2017	FINAL CERTIFICATION	AM	

ISSUE AND REVISION HISTORY

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES.
TOLERANCES ARE:

DECIMALS		ANGLES	
X.	: ± .06	X.°	: ± 2°
.X	: ± .03	.X°	: ± 1°
.XX	: ± .015	.XX°	: ± .5°
.XXX	: ± .005		

FRACTIONS
ALL : ± 1/16

MATERIAL:

COATING:

SMITHCO ENGINEERING
Tulsa, Oklahoma

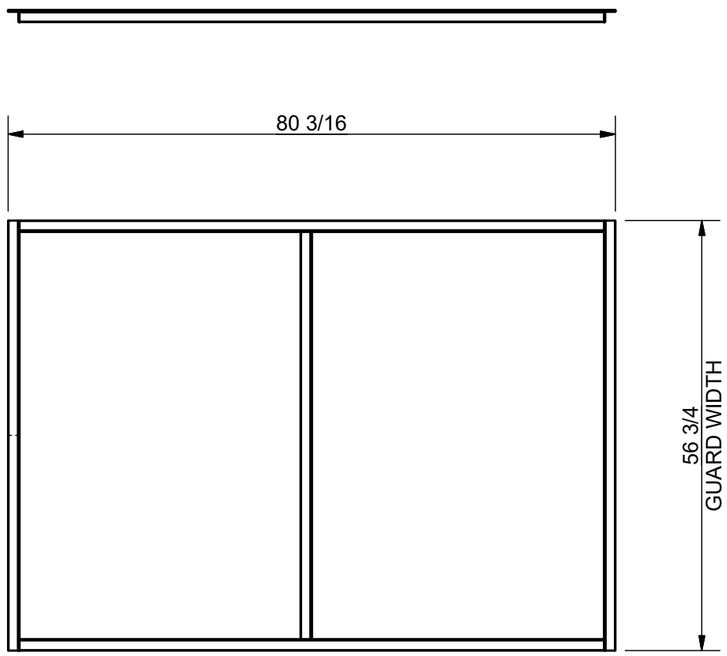
TITLE

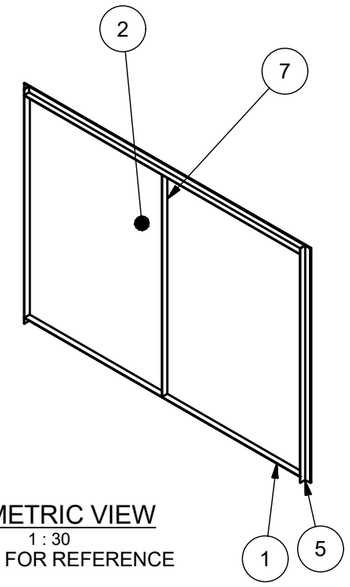
HAILSCREEN PANEL TYPE A

SIZE	PROJECT	DRAWING NUMBER	SHEET 1 OF 1	REV
B	S16286	H1-A1		0

DO NOT MANUALLY ALTER OR SCALE | EST. WT: (N/A) lbs | THIRD ANGLE PROJECTION: | SCALE 1 : 20

ITEM	QTY	P/N	DESCRIPTION	LENGTH (in)
5	2	H1-14	ANGLE, 1-1/2" X 1-1/2" X 1/8", A36	56 3/4
1	2	H1-12	ANGLE, 1-1/2" X 1-1/2" X 1/8", A36	77 3/16
7	1	H1-15	ANGLE, 1-1/2" X 1-1/2" X 1/8", A36	53 3/4
2	1	H1-EXP13	(3/4"-#13 FLATTENED EXP. MTL, 56.75 X 80.1875)	





ISOMETRIC VIEW
1 : 30
SHOWN FOR REFERENCE

GENERAL NOTES:

1. STANDARD FLATTENED EXPANDED METAL SHEET SIZE USED BY SMITHCO IS 72" X 120".
2. PRIOR TO WELDING; REMOVE ALL BURRS AND SHARP EDGES.
3. ALL SUPPORT FRAME ANGLE MEMBERS TO BE JOINED TOGETHER WITH FULL FILLET WELDS.
4. ALL FINISHED WELDS TO BE CLEAN AND FREE FROM SPLATTER.
5. ATTACH TO BUNDLE SIDEFRAMES USING HEX WASHER HEAD SELF-DRILLING SCREWS 1/4" DIA. X 1" LONG (**ITEM 6**).
6. USE CUSTOM GUARD WIDTHS AS REQUIRED TO COMPLETE GUARD SECTION FOR BUNDLE.

QTY	UNIT	STOCK NUMBER	MATERIAL DESCRIPTION	FOR ITEMS
1	Each		ANGLE, 1-1/2" X 1-1/2" X 1/8", A36	7
1	Each		ANGLE, 1-1/2" X 1-1/2" X 1/8", A36	5
1	Each		(3/4"-#13 FLATTENED EXP. MTL, 56.75 X 80.1875)	2
1	Each		ANGLE, 1-1/2" X 1-1/2" X 1/8", A36	1

CUT MATERIAL QTY LIST

Project Job No : S16286-IOM

CERTIFIED
APPROVED FOR FABRICATION
6-Nov-2017
SMITHCO ENGINEERING

CHECKED
By: Brett Ford Date:11/03/17 11:21

REV	DATE	DESCRIPTION	DRAWN	APPR'D
0	11/1/2017	FINAL CERTIFICATION	AM	

ISSUE AND REVISION HISTORY

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES.
TOLERANCES ARE:

DECIMALS		ANGLES	
X.	: ± .06	X.°	: ± 2°
.X	: ± .03	.X°	: ± 1°
.XX	: ± .015	.XX°	: ± .5°
.XXX	: ± .005		

FRACTIONS
ALL : ± 1/16

MATERIAL:

COATING:

SMITHCO ENGINEERING
Tulsa, Oklahoma

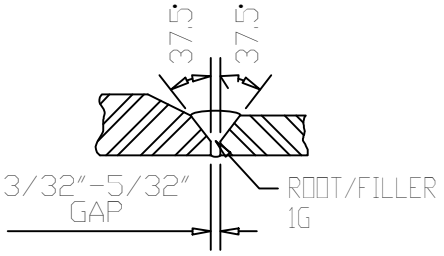
TITLE

HAILSCREEN PANEL TYPE B

SIZE	PROJECT	DRAWING NUMBER	SHEET 1 OF 1	REV
B	S16286	H1-B1		0

DO NOT MANUALLY ALTER OR SCALE | EST. WT: (N/A) lbs | THIRD ANGLE PROJECTION: | SCALE 1 : 20

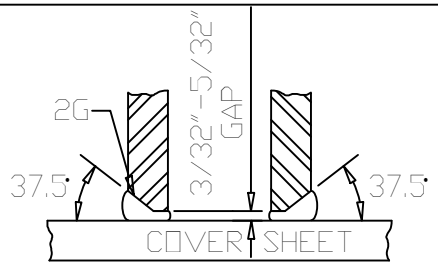
WELD MAP
WELD PROCEDURES



PIPE-FLANGE

4" DIA.

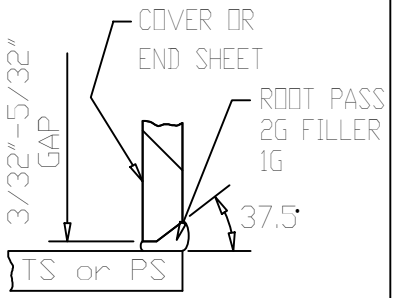
1 HPM-006 (GMAW) + HPM-007 (FCAW)
ALT: HPM-008 (GTAW) + HPM-007 (FCAW)
HPM-010 (G + F + A)



PIPE, FLANGE, COUPLING-HEAD

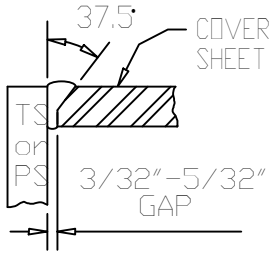
4" DIA.

2 HPM-006 (GMAW) + HPM-007 (FCAW)
ALT: HPM-008 (GTAW) + HPM-007 (FCAW)
HPM-010 (G + F + A)



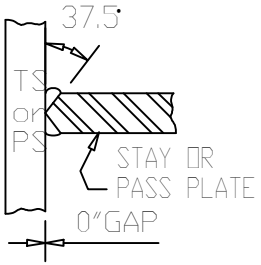
HAND WELD

3 HPM-006 (GMAW) + HPM-007 (FCAW)
ALT: HPM-010 (G + F + A)



AUTO-WELD

5 HPM-006 (GMAW) + HPM-007 (FCAW)
ALT: HPM-010 (G + F + A)



AUTO-WELD

8 HPM-010 (G + F + A)

CHECKED
By: IG Date:02/21/18 2:32

PWHT: 1150° F

CERTIFIED
APPROVED FOR FABRICATION
21-Feb-2018
SMITHCO ENGINEERING

SMITHCO
ENGINEERING, INC.
Tulsa, Oklahoma

WELD MAP AND DETAILS

DWN: JJ	CK'D BY:	DATE: 2/21/18
JOB NO: S16286		DWG NO: WM
REV: 0		41 of 131

Project Job No : S16286-IOM

CERTIFIED
APPROVED FOR FABRICATION
05-Mar-2018
SMITHCO ENGINEERING

WELD PROCEDURES

CUSTOMER:	Atlantic Coast Pipeline
SMITHCO JOB NO:	2016B286
WELD PROC. NOS.:	HPM-006 REV.1 GMAW-PWHT-No CVN HPM-007 REV.1 FCAW-PWHT-No CVN HPM-008 REV.1 GTAW-PWHT-No CVN HPM-010 REV.0 (G+F+A) PWHT
REVISION:	0
DATE:	02-Mar-2018

HPM

Welding Procedure Specification (WPS)

WPS No. HPM-006 | Rev: 1 | Date: 12/04/2015 | Page: 1 | of: 2

Supporting by PQR No. (s): 006 By: LUIS SARIÑANA

Welding process(es): GAS METAL ARC WELD (GMAW w/PWHT), GLOBULAR

Types (Manual, Automatic, Semi-automatic, Machine): SEMI-AUTOMATIC

JOINT DETAILS (QW-402):

Joint Desing: Groove and Fillet

(X) Single (X) Double Weld

Backing: (X) Yes (X) No

Backing Material: *Weld Metal, P1 Material, Copper, Ceramic.

(X)Metal (-) Nonfusing-Metal

(-) Nonmetallic (-) Other

Retainers: (-) Yes (X) No

Joint Details:

Root Opening:

0 - 3/16" Weld Joint Welded From One Side.

0 - 3/16" Weld Joint Welded From Both Side.

Other: Base Metal (One side)

Weld Metal (Other side)

Permanent Backing Bars, Rings, Straps, etc. Shall not be Used.

☑ Reviewed ☐ Witnessed

4, 2015

14865

HSB GS

BASE METALS: (QW-403)

P No.	1	Group No.	1 & 2	To	P No.	1	Group No. 1 & 2
Material Specification:			Any P1	To	Any P1		
Type or Grade:			Any	To	Any		
Thickness range:	Groove:		3/16"	To	1"		
	Fillet:		All	To	All		
Pipe Diameter Range:	Groove:		2 7/8" O.D. or Greater				
	Fillet:		All	To	All		

Chemical Analysis: -----

Mechanical Property: -----

Other: All Weld Pass to be Less than 0.5" Thick (QW-403.9)

If Base Metal Exceeds 3/8", then GMAW is Restricted to Root Pass Only.

POSITIONS: (QW-405)

Position of Groove: All

Position of Fillet: All

Welding Progression

Uphill (X) Downhill (-)

Other: N/A

PREHEAT: (QW-406)

Preheat Temp. Min. 50°F

Interpass Temp. Max. 420°F

Preheat Maintenance. NONE

Other: N/A

FILLER METALS: (QW-404)

		GMAW
SFA Specification:		SFA 5.18
AWS Classification:		ER70S-6
F-Number:		6
A-Number:		1
Size of Filler metal:		0.35", 0.045"
Electrode Trade Name:		Washington Alloy and others
Filler Metal Form:		SOLID WIRE ONLY
Flux Trade Name:		N/A
Flux Type:		N/A
Electrode Flux (Class):		N/A
Weld Metal Thickness:	Groove:	3/16" to 1"
	Fillet:	All

Other: Each Base Metal-Filler Metal Combination Should be Recorded Individually.

No additional Supplemental Filler Metal. (QW-404.24/27)

Weld metal Chemical Composition, C-0.08% (0.20% Max), Mn-1.44% (1.60% Max), Si-0.83% (1.00% Max) (QW-404.5)

POSTWELD HEAT TREATMENT: (QW-407)

Type: Stress Relief

Temperature: 1100 °F Minimum

Time Range. 1 Hr / Inch Thickness, 1 Hour minimum

Other: N/A

GAS (QW-408)

	Gas(es)	Mixture	Flow Rate
Shielding:	CO 2	99.99%	20 - 50 CFH
Trailing:	NONE	NONE	NONE
Backing:	NONE	NONE	NONE

Other: N/A

Welding Procedure Specification (WPS)

ELECTRICAL CHARACTERISTICS: (QW-409)

Current: AC (-) DCEP (X) DCEN (-) PULSED (-)

Amps: *180 - 240 AMP.*

Volts: *24 - 28 VOLT.*

Transfer Mode:

Short Circuiting: (-) Globular (X) Spray: (-)

Electrode Wire Feed Speed Range: *As Req`d.*

Tungsten Electrode Size and Type:

Size: *N/A* Type: *N/A*

Other: *N/A*

TECHNIQUE: (QW-410)

String or Weave Bead: *Stringer/Weave, Up to 1/2" Bead Width.*

Orifice or Gas Cup Size: *3/8" Dia. to 3/4" Dia.*

Initial and Interpass Cleaning (Brushing, Grinding, etc.): *Wire Brushing, Grinding and Chipping.*

Method of Back Gouging: **Grinding and Carbon Air Arc.*

Oscillation: *N/A*

Contact Tube to Work Distance: *3/8" to 1"*

Multiple or Single Pass (per side): *Multiple.*

Multiple or Single Electrodes: *Single.*

Peening: *Not Allowed.*

Use of thermal processes: *Not Allowed. (QW-410.64)*

Other: *The Surfaces to be Welded Must be Clean and Free From Dirt, Oil and Rust.*

Clean a Minimum 2" of on Each Side of the Joing, Internal and External Adjacent Surfaces.

** If Carbon Arc Gouging is Used, Grind a minimum of 1/16" Thickness to Remove all Traces of Carburization Prior to Welding.*

** Postweld Heat Treatment in Gas Oven.*

Weld Layer(s)	Process	Filler Metal		Current		Volts	Travel Speed (IPM)	Others
		Class	Dia.	Type Polarity	Amp.			
ALL	*GMAW*	*ER70S-6*	*0.035"*	*DCEP*	*180 - 200*	*24 - 26*	*VARIABLE*	---
ALL	*GMAW*	*ER70S-6*	*0.035"*	*DCEP*	*180 - 240*	*24 - 28*	*VARIABLE*	---

Additional Instructions:

HPM

Procedure Qualification Record (PQR)

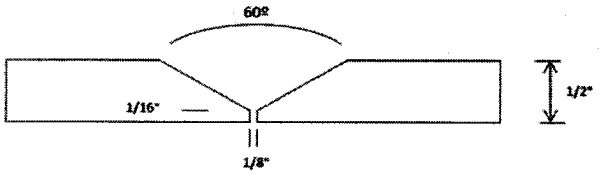
PQR No. 006
Rev.: 1 Date: 12/04/2015
Page: 1 of: 2

Reference WPS No: HPM-006 Rev.: 1

Welding process(es): GAS METAL ARC WELD (GMAW)

Types (Manual, Automatic, Semi-automatic, Machine): SEMI-AUTOMATIC

JOINTS: (QW-402)



JOINT DESIGN

Joint Details:

Joint Type:	Single V Groove
Bevel Angle:	60° in Angle
Land:	1/16"
Root Opening:	1/8"

BASE METALS (QW-403)

Material Specification:	SA-516		
Type or Grade:	Gr 70		
P No.	1	To P No:	1
Thickness of Test coupon:	1/2"		
Diameter of Test coupon:	N/A		
Other:	N/A		

FILLER METALS: (QW-404)

	GMAW
SFA Specification:	SFA 5.18
AWS Classification:	ER70S-6
F-Number:	6
A-Number:	1
Size of Filler metal:	0.035"
Electrode Trade Name:	Washington Alloy and others
Filler Metal Form:	SOLID WIRE ONLY
Flux Trade Name:	N/A
Flux Type:	N/A
Electrode Flux (Class):	N/A
Weld Metal Thickness:	1" MAX.

Other: No additional Supplemental Filler Metal. (QW-404.24/27)

POSITION (QW-405)

Position of groove:	3G
Position of Fillet:	N/A
Vertical progression:	

Uphill (X) Downhill (---)

Other: N/A

PREHEAT (QW-406)

Preheat Temperature (min.)	50 °F
Interpass Temperature (Máx.)	420 °F

Other: N/A

POSTWELD HEAT TREATMENT (QW-407)

Type:	Stress Relief
Temperature:	1123 °F
Time Range:	1 Hr. 15 Minutes
Other	N/A

GAS(ES): (QW-408)

	Gas(es)	% (Mixture)	Flow Rate
Shielding:	CO_2	99.99%	30 CFH
Trailing:	NONE	NONE	NONE
Backing:	NONE	NONE	NONE

ELECTRICAL CHARACTERISTICS (QW-409)

Current:	DCEP
Polarity:	REVERSE
Amps:	200 AMP
Volts:	25 VOLT.
Mode of Metal Transfer:	Globular
Tungsten elect. Size:	N/A
Type:	N/A
Other	N/A

TECHNIQUE (QW-410)

Travel Speed:	13 IPM
String or Weave Bead:	Weave Bead Width 3/8".
Multipass or single pass:	Multipass.
Number of Electrodes:	Single.
Use of thermal processes:	Not Used (QW-410.64)

Other: N/A

HPM

PQR No. 006

Rev.: 1 **Date:** 12/04/2015

Procedure Qualification Record (PQR)

TENSION TEST (QW-150)

Specimen no.	Width		Thickness		Area		Ultimate Total Load		Ultimate Unit Stress		Type of Failure & Location
	mm	in	mm	in	mm^2	(sq in)	Kg	(Pounds Lbs.)	Psi	Mpa	
T1	----	0.750	----	0.501	----	0.3758	----	29,807	79,316	----	BASE METAL
T2	----	0.752	----	0.498	----	0.3745	----	31,064	82,948	----	BASE METAL

GUIDED BEND TEST (QW-160)

Specimen No.	Type of Bend	Figure No.	Result	Remark
D1	Face Bend Test	QW 462.3 (a)	SATISFACTORY	WITHOUT SURFACE DISCONTINUITY
D2	Face Bend Test	QW 462.3 (a)	SATISFACTORY	WITHOUT SURFACE DISCONTINUITY
D3	Root Bend Test	QW 462.3 (a)	SATISFACTORY	WITHOUT SURFACE DISCONTINUITY
D4	Root Bend Test	QW 462.3 (a)	SATISFACTORY	WITHOUT SURFACE DISCONTINUITY

THOUGHNESS TEST (QW-170)

No. Especimen	Notch Location		Specimen Size		Test Temp.	Impact Values		% Shear	Mils Lat. Expansion	Drop Weight Break (Y/N)	
						Ft / lbs	Joules			Break	No Break
----	----	----	----	----	----	----	----	----	----	----	----
----	----	----	----	----	----	----	----	----	----	----	----

FILLET WELD TEST (QW-180)

Result Satisfactory: yes (-) No (-) **Penetration into Parent Metal:** yes (-) No (-)

Macro: ----- Results -----

OTHER TESTS

Other:

Side	Weld Layer / pass	Weld Process	Filler Metal		Current Type & Polarity	Amps. (A)	Volts. (V)	Travel Speed (IPM)	Others
			AWS Class.	Dia.					
	1	GMAW	ER70S-6	0.035"	DCEP	180 - 200	24 - 26	VARIABLE	
	2	GMAW	ER-70S-6	0.035"	DCEP	180 - 240	24 - 28	VARIABLE	

Welder's Name: Raymundo Robledo **Clock No:** 1365 **Stamp No:** 06

Test conduced by: Tec. Yahir Gonzalez Rodriguez

Laboratory Test no.: CISA-PD-05/12 AND CISA-PT-05/12

Test Date: March 15, 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 ASME Section IX.

Manufacturer: HUDSON PRODUCTS DE MEXICO S.A. DE C.V.

Prep'd By: LUIS SARIÑANA **Prep'd Date:** December 04, 2015

HPM

Welding Procedure Specification (WPS)

WPS No. HPM-007 | Rev: 1 | Date: 12/04/2015 | Page: 1 of: 2

Supporting by PQR No. (s): 007 By: LUIS SARIÑANA

Welding process(es): FLUX CORED ARC WELD (FCAW, w/PWHT)

Types (Manual, Automatic, Semi-automatic, Machine): SEMI-AUTOMATIC

JOINT DETAILS (QW-402):

Joint Desing: Groove and Fillet

(X) Single (X) Double Weld

Backing: (X) Yes (X) No

Backing Material: *Weld Metal, P1 Material, Copper, Ceramic.

(X)Metal (-) Nonfusing-Metal

(-) Nonmetallic (-) Other

Retainers: (-) Yes (X) No

Joint Details:

Root Opening:

0 - 3/16" Weld Joint Welded From One Side.

0 - 3/16" Weld Joint Welded From Both Side.

☑ Reviewed
☐ Witnessed
June 4, 2015
14865
HSB GS

Other: Base Metal (One side)
Weld Metal (Other side)
Permanent Backing Bars, Rings, Straps, etc. Shall not be Used.

BASE METALS: (QW-403)

P No.	1	Group No. 1 & 2	To	P No. 1	Group No. 1 & 2
Material Specification:	Any P1		To	Any P1	
Type or Grade:	Any		To	Any	
Thickness range:	Groove:	3/16"	To	1"	
	Fillet:	All	To	All	
Pipe Diameter Range:	Groove:	2 7/8" O.D. or Greater			
	Fillet:	All	To	All	
Chemical Analysis:	-----				
Mechanical Property:	-----				

Other: All Weld Pass to be Less than 0.5" Thick (QW-403.9)

POSITIONS: (QW-405)

Position of Groove: All

Position of Fillet: All

Welding Progression

Uphill (X) Downhill (-)

Other: N/A

PREHEAT: (QW-406)

Preheat Temp. Min. 50°F

Interpass Temp. Max. 500°F

Preheat Maintenance. NONE

Other: N/A

FILLER METALS: (QW-404)

	GMAW
SFA Specification:	SFA 5.20
AWS Classification:	E71T-1C
F-Number:	6
A-Number:	E71T-1C
Size of Filler metal:	0.35", 0.045"
Electrode Trade Name:	Washington Alloy and others
Filler Metal Form:	FLUX CORED
Flux Trade Name:	N/A
Flux Type:	N/A
Electrode Flux (Class):	N/A
Weld Metal Thickness: Groove:	3/16" to 1"
Fillet:	All

Other: Each Base Metal-Filler Metal Combination Should be Recorded Individually.
No additional Supplemental Filler Metal. (QW-404.24/27)
Weld metal Chemical Composition, C-0.08% (0.20% Max), Mn-1.44% (1.60% Max), Si-0.83% (1.00% Max) (QW-404.5)

POSTWELD HEAT TREATMENT: (QW-407)

Type: Stress Relief

Temperature: 1100 °F Minimum

Time Range. 1 Hr / Inch Thickness, 1 Hour minimum

Other: N/A

GAS (QW-408)

	Gas(es)	Mixture	Flow Rate
Shielding:	CO 2	99.99%	20 - 50 CFH
Trailing:	NONE	NONE	NONE
Backing:	NONE	NONE	NONE

Other: N/A

ELECTRICAL CHARACTERISTICS: (QW-409)

Current: AC (-) DCEP (X) DCEN (-) PULSED (-)

Amps: *180 - 350 AMP.*

Volts: *24 - 32 VOLT.*

Transfer Mode:

Short Circuiting: (-) Globular (X) Spray: (-)

Electrode Wire Feed Speed Range: *As Req`d.*

Tungsten Electrode Size and Type:

Size: *N/A* Type: *N/A*

Other: *N/A*

TECHNIQUE: (QW-410)

String or Weave Bead: *Stringer/Weave, Up to 1/2" Bead Width.*

Orifice or Gas Cup Size: *3/8" Dia. to 3/4" Dia.*

Initial and Interpass Cleaning (Brushing, Grinding, etc.): *Wire Brushing, Grinding and Chipping.*

Method of Back Gouging: **Grinding and Carbon Air Arc.*

Oscillation: *N/A*

Contact Tube to Work Distance: *3/8" to 1"*

Multiple or Single Pass (per side): *Multiple.*

Multiple or Single Electrodes: *Single.*

Peening: *Not Allowed.*

Use of thermal processes: *Not Allowed. (QW-410.64)*

Other: *The Surfaces to be Welded Must be Clean and Free From Dirt, Oil and Rust.*

Clean a Minimum 2" of on Each Side of the Joing, Internal and External Adjacent Surfaces.

** If Carbon Arc Gouging is Used, Grind a minimum of 1/16" Thickness to Remove all Traces of Carburization Prior to Welding.*

** Postweld Heat Treatment in Gas Oven.*

Weld Layer(s)	Process	Filler Metal		Current		Volts	Travel Speed (IPM)	Others
		Class	Dia.	Type Polarity	Amp.			
ALL	*FCAW*	*E71T-1C*	*0.045"*	*DCEP*	*180 - 350*	*24 - 32*	*VARIABLE*	*---*

Additional Instructions:

HPM

Procedure Qualification Record (PQR)

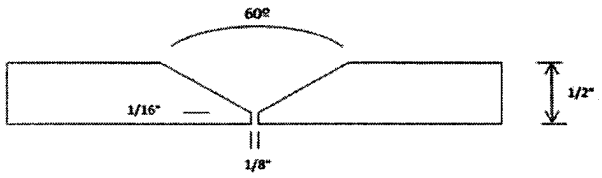
PQR No. 007
Rev.: 1 Date: 12/04/2015
Page: 1 of: 2

Reference WPS No: HPM-007 Rev.: 1

Welding process(es): FLUX CORED ARC WELD (FCAW, w/PWHT)

Types (Manual, Automatic, Semi-automatic, Machine): SEMI-AUTOMATIC

JOINTS: (QW-402)



JOINT DESIGN

Joint Details:

Joint Type:	Single V Groove
Bevel Angle:	60° in Angle
Land:	1/16"
Root Opening:	1/8"

BASE METALS (QW-403)

Material Specification:	SA-516		
Type or Grade:	Gr 70		
P No.	1	To P No:	1
Thickness of Test coupon:	1/2"		
Diameter of Test coupon:	N/A		
Other:	N/A		

POSTWELD HEAT TREATMENT (QW-407)

Type:	Stress Relief
Temperature:	1123 °F
Time Range:	1 Hr. 15 Minutes
Other	N/A

FILLER METALS: (QW-404)

	GMAW
SFA Specification:	SFA 5.20
AWS Classification:	E71T-1C
F-Number:	6
A-Number:	E71T-1C
Size of Filler metal:	0.045"
Electrode Trade Name:	Washington Alloy and others
Filler Metal Form:	FLUX CORED
Flux Trade Name:	N/A
Flux Type:	N/A
Electrode Flux (Class):	N/A
Weld Metal Thickness:	1" MAX.

Other: No additional Supplemental Filler Metal. (QW-404.24/27)

GAS(ES): (QW-408)

	Gas(es)	% (Mixture)	Flow Rate
Shielding:	CO 2	99.99%	30 CFH
Trailing:	NONE	NONE	NONE
Backing:	NONE	NONE	NONE

ELECTRICAL CHARACTERISTICS (QW-409)

Current:	DCEP
Polarity:	REVERSE
Amps:	210 AMP
Volts:	30 VOLT.
Mode of Metal Transfer:	Globular
Tungsten elect. Size:	N/A
Type:	N/A
Other	N/A

POSITION (QW-405)

Position of groove:	1G
Position of Fillet:	N/A
Vertical progression:	

Uphill (---) Downhill (---)

Other: N/A

TECHNIQUE (QW-410)

Travel Speed:	16 IPM
String or Weave Bead:	Weave Bead Width 3/8".
Multipass or single pass:	Multipass.
Number of Electrodes:	Single.
Use of thermal processes:	Not Used (QW-410.64)

Other: N/A

PREHEAT (QW-406)

Preheat Temperature (mín.)	50 °F
Interpass Temperature (Máx.)	500 °F

Other: N/A

HPM

PQR No. 007

Rev.: 1 **Date:** 12/04/2015

Procedure Qualification Record (PQR)

TENSION TEST (QW-150)

Specimen no.	Width		Thickness		Area		Ultimate Total Load		Ultimate Unit Stress		Type of Failure & Location
	mm	in	mm	in	mm^2	(sq in)	Kg	(Pounds Lbs.)	Psi	Mpa	
T1	----	0.750	----	0.499	----	0.3743	----	32,674	87,294	----	BASE METAL
T2	----	0.752	----	0.500	----	0.3760	----	32,679	86,912	----	BASE METAL

GUIDED BEND TEST (QW-160)

Specimen No.	Type of Bend	Figure No.	Result	Remark
D1	Face Bend Test	QW 462.3 (a)	SATISFACTORY	WITHOUT SURFACE DISCONTINUITY
D2	Face Bend Test	QW 462.3 (a)	SATISFACTORY	WITHOUT SURFACE DISCONTINUITY
D3	Root Bend Test	QW 462.3 (a)	SATISFACTORY	WITHOUT SURFACE DISCONTINUITY
D4	Root Bend Test	QW 462.3 (a)	SATISFACTORY	WITHOUT SURFACE DISCONTINUITY

THOUGHNESS TEST (QW-170)

No. Especimen	Notch Location		Specimen Size		Test Temp.	Impact Values		% Shear	Mils Lat. Expansion	Drop Weight Break (Y/N)	
						Ft / lbs	Joules			Break	No Break
----	----	----	----	----	----	----	----	----	----	----	----
----	----	----	----	----	----	----	----	----	----	----	----

FILLET WELD TEST (QW-180)

Result Satisfactory: yes (-) No (-) **Penetration into Parent Metal:** yes (-) No (-)

Macro: ----- Results -----

OTHER TESTS

Other:

Side	Weld Layer / pass	Weld Process	Filler Metal		Current Type & Polarity	Amps. (A)	Volts. (V)	Travel Speed (IPM)	Others
			AWS Class.	Dia.					
	1	FCAW	E71T-1C	0.045"	DCEP	180 - 350	24 - 32	VARIABLE	

Welder's Name: Raymundo Robledo **Clock No:** 1365 **Stamp No:** 06

Test conduced by: Tec. Yahir Gonzalez Rodriguez

Laboratory Test no.: CISA-PD-06/12 AND CISA-PT-06/12

Test Date: March 15, 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 ASME Section IX.

Manufacturer: HUDSON PRODUCTS DE MEXICO S.A. DE C.V.

Prep'd By: LUIS SARIÑANA **Prep'd Date:** December 04, 2015

HPM

Welding Procedure Specification (WPS)

WPS No. HPM-008 | Rev: 1 | Date: 12/07/2015 | Page: 1 of: 2

Supporting by PQR No. (s): 008 By: LUIS SARIÑANA

Welding process(es): GAS TUNGSTEN ARC WELD (GTAW) w/PWHT

Types (Manual, Automatic, Semi-automatic, Machine): MANUAL

JOINT DETAILS (QW-402):

Joint Desing: Groove and Fillet

(X) Single (X) Double Weld

Backing: (X) Yes (X) No

Backing Material: *Weld Metal, P1 Material, Copper, Ceramic.

(X) Metal (X) Nonfusing-Metal

(X) Nonmetallic (X) Other

Retainers: (-) Yes (X) No

Joint Details:

Root Opening:

0 - 3/16" Weld Joint Welded From One Side.

0 - 3/16" Weld Joint Welded From Both Side.

☑ Reviewed
☐ Witnessed

15534
HSB GS

Other: Base Metal (One Side)
Weld Metal (Other Side)

BASE METALS: (QW-403)

P No.	1	Group No.	1 & 2	To	P No. 1	Group No.	1 & 2
Material Specification:			Any P1	To	Any P1		
Type or Grade:			Any	To	Any		
Thickness range:	Groove:		3/16"	To	1"		
	Fillet:		All	To	All		
Pipe Diameter Range:	Groove:		2 7/8" O.D. or Greater				
	Fillet:		All	To	All		

Chemical Analysis: ----

Mechanical Property: ----

Other: All Weld Passes to be Less than 0.5" Thick (QW-403.9)

POSITIONS: (QW-405)

Position of Groove: All

Position of Fillet: All

Welding Progression

Uphill (X) Downhill (X)

Other: N/A

PREHEAT: (QW-406)

Preheat Temp. Min. 50°F

Interpass Temp. Max. 420°F

Preheat Maintenance. NONE

Other: N/A

FILLER METALS: (QW-404)

		GTAW
SFA Specification:		SFA 5.18
AWS Classification:		ER70S-6
F-Number:		6
A-Number:		1
Size of Filler metal:		1/16", 3/32", 1/8"
Electrode Trade Name:		Washington Alloy or Others
Filler Metal Form:		WIRE
Flux Trade Name:		N/A
Flux Type:		N/A
Electrode Flux (Class):		N/A
Weld Metal Thickness:	Groove:	1" MAX.
	Fillet:	All

Other: Each Base Metal-Filler Metal Combination Should be Recorded Individually.
No additional Supplemental Filler Metal. (QW-404.24/27)
Weld metal Chemical Composition, C-0.08% (0.20% Max), Mn-1.44% (1.60% Max), Si-0.83% (1.00% Max) (QW-404.5)

POSTWELD HEAT TREATMENT: (QW-407)

Type: Stress Relief

Temperature: 1100 °F Minimum

Time Range. 1 Hr / Inch , 1 Hour / 15 min Minimum

Other: N/A

GAS (QW-408)

	Gas(es)	Mixture	Flow Rate
Shielding:	Ar	99.99%	10 - 20 CFH
Trailing:	NONE	NONE	NONE
Backing:	NONE	NONE	NONE

Other: Backing Gas is Optional (QW-408.5)

HPM

Welding Procedure Specification (WPS)

WPS No. HPM-008 Rev.: 1 Date: 12/07/2015

ELECTRICAL CHARACTERISTICS: (QW-409)

Current: AC (-) DCEP (-) DCEN (X) PULSED (-)

Amps: 80 - 250

Volts: 10 - 19

Transfer Mode:

Short Circuiting: (-) Globular (-) Spray: (-)

Electrode Wire Feed Speed Range: As Req'd

Tungsten Electrode Size and Type:

Size: 3/32", 1/8" Type: EWTh-2, 2% THORIATED

Other: N/A

TECHNIQUE: (QW-410)

String or Weave Bead: Stringer/Weave, Up to 1/2" Bead Width.

Orifice or Gas Cup Size: As Req'd

Initial and Interpass Cleaning (Brushing, Grinding, etc.): Wire Brushing, Grinding and Chipping.

Method of Back Gouging: *Grinding and Carbon Air Arc.

Oscillation: N/A

Contact Tube to Work Distance: 1/8" to 3/8"

Multiple or Single Pass (per side): Multiple

Multiple or Single Electrodes: Single

Peening: Not Allowed.

Use of thermal processes: Not Allowed. (QW-410.64)

Other: The Surfaces to be Welded Must be Clean and Free from dirt, Oil and rust for a Distance at least 1/2" from the joint weld.

Clean a Minimum 2" of on Each Side of the Joing, Internal and External Adjacent Surfaces.

* If Carbon Arc Gouging is Used, Grind a minimum of 1/16" Thickness to Remove all Traces of Carburization Prior to Welding.

* Postweld Heat Treatment in Gas Oven.

Weld Layer(s)	Process	Filler Metal		Current		Volts	Travel Speed (IPM)	Others
		Class	Dia.	Type Polarity	Amp.			
ALL	GTAW	ER70S-6	1/16"	DCEN	80 - 175	13 - 23	VARIABLE	---
ALL	GTAW	ER70S-6	3/32"	DCEN	90 - 220	13 - 24	VARIABLE	---
ALL	GTAW	ER70S-6	1/8"	DCEN	90 - 250	13 - 26	VARIABLE	---

Additional Instructions:

HPM

Procedure Qualification Record (PQR)

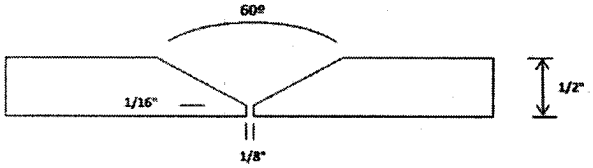
PQR No. 008
Rev.: 1 Date: 12/07/2015
Page: 1 of: 2

Reference WPS No: HPM-008 Rev.: 1

Welding process(es): GAS TUNGSTEN ARC WELD (GTAW) w/PWHT

Types (Manual, Automatic, Semi-automatic, Machine): MANUAL

JOINTS: (QW-402)



JOINT DESIGN

Joint Details:

Joint Type:	Single V Groove
Bevel Angle:	60° in Angle
Land:	1/16"
Root Opening:	1/8"

BASE METALS (QW-403)

Material Specification:	SA-516		
Type or Grade:	Gr 70		
P No.	1	To P No:	1
Thickness of Test coupon:	1/2"		
Diameter of Test coupon:	N/A		
Other:	N/A		

POSTWELD HEAT TREATMENT (QW-407)

Type:	Stress Relief
Temperature:	1100 °F Minimum
Time Range:	1 Hr / Inch Thickness, 1 Hour minimum
Other	N/A

FILLER METALS: (QW-404)

	GTAW
SFA Specification:	SFA 5.18
AWS Classification:	ER70S-6
F-Number:	6
A-Number:	1
Size of Filler metal:	3/32"
Electrode Trade Name:	Washington Alloy and others
Filler Metal Form:	WIRE
Flux Trade Name:	N/A
Flux Type:	N/A
Electrode Flux (Class):	N/A
Weld Metal Thickness:	1" MAX.

Other: No additional Supplemental Filler Metal. (QW-404.24/27)

GAS(ES): (QW-408)

	Gas(es)	% (Mixture)	Flow Rate
Shielding:	Ar	99.99%	18 CFH
Trailing:	NONE	NONE	NONE
Backing:	NONE	NONE	NONE

ELECTRICAL CHARACTERISTICS (QW-409)

Current:	DCEN
Polarity:	STRAIGTH
Amps:	220 AMP
Volts:	14 VOLT.
Mode of Metal Transfer:	N/A
Tungsten elect. Size:	1/8"
Type:	EWTh-2, 2% THORIATED
Other	N/A

POSITION (QW-405)

Position of groove:	1G
Position of Fillet:	N/A
Vertical progression:	

Uphill (---) Downhill (---)

Other: N/A

TECHNIQUE (QW-410)

Travel Speed:	8 IPM
String or Weave Bead:	String and Weave bead 3/8"
Multipass or single pass:	Multipass.
Number of Electrodes:	Single.

Other: N/A

PREHEAT (QW-406)

Preheat Temperature (min.)	50 °F
Interpass Temperature (Máx.)	420 °F

Other: N/A

HPM

PQR No. 008

Rev.: 1 **Date:** 12/07/2015

Procedure Qualification Record (PQR)

TENSION TEST (QW-150)

Specimen no.	Width		Thickness		Area		Ultimate Total Load		Ultimate Unit Stress		Type of Failure & Location
	mm	in	mm	in	mm^2	(sq in)	Kg	(Pounds Lbs.)	Psi	Mpa	
T1	----	0.750	----	0.500	----	0.3750	----	30,364	80,971	----	BASE METAL
T2	----	0.751	----	0.500	----	0.3755	----	30,682	81,710	----	BASE METAL

GUIDED BEND TEST (QW-160)

Specimen No.	Type of Bend	Figure No.	Result	Remark
D-1	Face Bend Test	QW 462.3 (a)	SATISFACTORY	WITHOUT SURFACE DISCONTINUITY
D-2	Face Bend Test	QW 462.3 (a)	SATISFACTORY	WITHOUT SURFACE DISCONTINUITY
D-3	Root Bend Test	QW 462.3 (a)	SATISFACTORY	WITHOUT SURFACE DISCONTINUITY
D-4	Root Bend Test	QW 462.3 (a)	SATISFACTORY	WITHOUT SURFACE DISCONTINUITY

THOUGHNESS TEST (QW-170)

No. Especimen	Notch Location		Specimen Size		Test Temp.	Impact Values		% Shear	Mils Lat. Expansion	Drop Weight Break (Y/N)	
						Ft / lbs	Joules			Break	No Break
----	----	----	----	----	----	----	----	----	----	----	----
----	----	----	----	----	----	----	----	----	----	----	----

FILLET WELD TEST (QW-180)

Result Satisfactory: yes (-) No (-) **Penetration into Parent Metal:** yes (-) No (-)

Macro: ----- Results

OTHER TESTS

Other:

Side	Weld Layer / pass	Weld Process	Filler Metal		Current Type & Polarity	Amps. (A)	Volts. (V)	Travel Speed (IPM)	Others
			AWS Class.	Dia.					
	ALL	GTAW	ER70S-6	.0937"	DCEN	220	14	VARIABLE	

Welder's Name: Jose Guadalupe Palacios **Clock No:** S/N **Stamp No:** O

Test conduced by: Tec. Yahir Gonzalez Rodriguez

Laboratory Test no.: CISA-PD-07/12, CISA-PT-07/12

Test Date: March 15, 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 ASME Section IX.

Manufacturer: HUDSON PRODUCTS DE MEXICO S.A. DE C.V.

Prep'd By: LUIS SARIÑANA **Prep'd Date:** December 07, 2015

HPM

Welding Procedure Specification (WPS)

WPS No. HPM-010 Rev: 0 Date: 04/14/2014 Page: 1 of: 2

Supporting by PQR No. (s): 010 By: LUIS SARIÑANA

Welding process(es): GAS METAL ARC WELDING (GMAW) + FLUX CORED ARC WELD (FCAW) + SUBMERGED ARC WELD (SAW) w/PWHT

Types (Manual, Automatic, Semi-automatic, Machine): (GMAW, FCAW) SEMI-AUTOMATIC, (SAW) MACHINE.

JOINT DETAILS:

FOR JOINT DESIGN AND WELDING SEQUENCE [SEE FABRICATION DRAWING]

Sketches, Production Drawings, Weld Symbols or Written Description should show the general arrangement of the parts to be welded. Where applicable, the root spacing and the details of weld groove may be specified.

JOINT:

Type: Groove and Fillet
SINGLE (X) Double Weld (X)

Backing: Yes (X) No (-)

Backing Material: Weld Metal, P1 Matl, Copper, Ceramic.
Metal (X) Nonfusing-Metal (-)
Nometalic (-) Other (-)

Other: Base Metal (One Side)
Weld Metal (Other Side)

☑ Reviewed
☐ Witnessed

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Base Metals: (QW-403)

P No.	1	Group No.	1 & 2	To	P No.	1	Group No. 1 & 2
Material Specification:		Any P1		To	Any P1		
Type or Grade:		Any		To	Any		
Thickness range:	Groove:	3/16"		To	8"		
	Fillet:	All		To	All		
Pipe Diameter Range:	Groove:	2 7/8" O.D. or Greater					
	Fillet:	All		To	All		

Chemical Analysis: N.A

Mechanical Property: N.A

Other: All Weld Bead/Pass to be Less than 0.5" Thick (QW-403.9)

POSITIONS: (QW-405)

Position of Groove: All GMAW/FCAW

Position of Fillet: All GMAW/FCAW

Welding Progression
Uphill (X) Downhill (-)

Other: For SAW Pos. the groove 1G , For Fillet 1F & 2F

PREHEAT:

Preheat Temp. Min. 50°F

Interpass Temp. Max. 420°F

Preheat Maintenance. NONE

Other:

FILLER METALS:

	GMAW	FCAW	SAW
SFA Specification:	SFA 5.18	SFA 5.20	SFA 5.17
AWS Classification:	ER70S-6	E71T-1	EM13K
F-Number:	6	6	6
A-Number:	1	1	1
Size of Filler metal:	0.035" 0.045"	0.045" 1/16"	3/32" 1/8"
Flux Type:	N.A.	N.A.	ACTIVE
Flux Trade Name:	N.A.	N.A.	N.A.
Electrode Flux (Class):	N.A.	N.A.	F7A0-EM13K
Filler Metal Form:	SOLID WIRE ONLY	FLUX CORED	SOLID WIRE ONLY
Weld Metal Thickness Range: Filete/ Fillet:	0.140"	1/2"	2 1/4"
	All	All	All

Other: Each Base Metal-Filler Metal Combination Should be Recorded Individually.

No additional Supplemental Filler Metal (QW-404.24/27) (QW-404.24/27)

POSTWELD HEAT TREATMENT:

Temperature Range. 1100 °F MINIMUM

Time Range. 1 HR. 15 MINUTES, MIN.

Other: N.A.

GAS: (QW-408)

	Gas(es)	Mixture	Flow Rate
Shielding:	Ar + CO2	75% + 25%	20 - 50 CFH
Trailing:	N.A.	N.A.	N.A.
Backing:	N.A.	N.A.	N.A.

Other: N.A.

HPM

Welding Procedure Specification (WPS)

WPS No. *HPM-010*
Rev.: *0* Date: *04/14/2014*
Page: *1* of: *2*

ELECTRICAL CHARACTERISTICS: (QW-409)

Current: AC (-) DCEP (X) DCEN (-) PULSED (-)

Amps: *90 - 170 (GMAW); 170 - 350 (FCAW); 170 - 425 (SAW)*

Volts: *17 - 23 (GMAW); 24 - 30 (FCAW); 24 - 29 (SAW)*

Transfer Mode: Short Circuiting: Globular: Spray:

Electrode Wire Feed Speed Range: *As Req'd*

Tungsten Electrode Size and Type: Size: *N.A.* Type: *N.A.*

Other: **GMAW (Short Circuiting); FCAW (Globular).*

TECHNIQUE:

String or Weave Bead: *Stringer/Weave, Up to 1/2" Bead Width.*
Orifice or Gas Cup Size: *3/8" Dia. To 3/4"Dia.*
Initial and Interpass Cleaning (Brushing, Grinding, etc): *Wire Brushing, Grinding and Chipping.*
Method of Back Gouging: *Grinding and Carbon Air Arc.*
Oscillation: *N.A.*
Contact Tube to Work Distance: *3/8" to 1"*
Multiple or Single Pass (per side): *Multiple.*
Multiple or Single Electrodes: *Single*
Peening: *Not Allowed*

Other: *The Surfaces to be Welded Must be Clean and Free From Dirt, Oil and Rust.*

Weld Layer(s)	Process	Filler Metal		Current		Volts	Travel Speed Range	Others (eg. Remarks, Comments, Hot Wire, Addition, Technique, Torch Angle, Etc.)
		Class	Dia.	Type Polarity	Amp.(range)			
1	GMAW	ER70S-6	0.035"	DCEP	90 - 170	16 - 23	VARIABLE	---
2	FCAW	E71T-1	0.045"	DCEP	170 - 350	24 - 30	VARIABLE	---
3	SAW	EM13K	1/8"	DCEP	250-550	26 - 37	VARIABLE	---
4	SAW	EM13K	1/8"	DCEP	250-550	26 - 37	VARIABLE	---
5	SAW	EM13K	1/8"	DCEP	250-550	26 - 37	VARIABLE	---
6	SAW	EM13K	1/8"	DCEP	250-550	26 - 37	VARIABLE	---
7	SAW	EM13K	1/8"	DCEP	250-550	26 - 37	VARIABLE	---
8	SAW	EM13K	1/8"	DCEP	250-550	26 - 37	VARIABLE	---
9	SAW	EM13K	1/8"	DCEP	250-550	26 - 37	VARIABLE	---
10	SAW	EM13K	1/8"	DCEP	250-550	26 - 37	VARIABLE	---
11	SAW	EM13K	1/8"	DCEP	250-550	26 - 37	VARIABLE	---
12	SAW	EM13K	1/8"	DCEP	250-550	26 - 37	VARIABLE	---

Additional Instructions:

HPM

Procedure Qualification Record (PQR)

PQR No. 010 Rev.: 0 Date: 04/14/2014

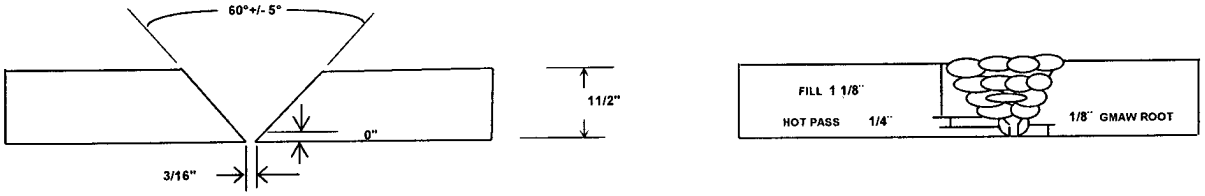
Page: 1 of: 2

Reference WPS No: HPM-010 Rev.: 0

Welding process(es): GAS METAL ARC WELDING (GMAW) + FLUX CORED ARC WELD (FCAW) + SUBMERGED ARC WELDING (SAW) w/PWHT

Types (Manual, Automatic, Semi-automatic, Machine): (GMAW, FCAW) SEMI-AUTOMATIC, (SAW) MACHINE.

JOINTS:



JOINT DESIGN

Groove Design of Test Coupon

(For combination qualifications, the deposited weld metal thickness shall be recorded for each filler metal or process used.)

BASE METALS

Material Specification: SA - 516
Type or Grade: GR.70
P No. 1 A / to P No: 1
Thickness of Test coupon: 1 1/2"
Diameter of Test coupon: N.A.
Other: N.A.

FILLER METALS:

	GMAW	FCAW	SAW
SFA Specification:	SFA 5.18	SFA 5.20	SFA 5.17
AWS Classification:	ER70S-6	E71T-1	EM13K
F-Number:	6	6	6
A-Number:	1	1	1
Size of Filler metal:	0.035"	0.045"	1/8"
Flux Type:	N.A.	N.A.	ACTIVE
Flux Trade Name:	N.A.	N.A.	N.A.
Electrode Flux (Class):	N.A.	N.A.	F7A0-EM13K
Filler Metal Form:	SOLID WIRE ONLY	FLUX CORED	SOLID WIRE ONLY
Weld Metal Thickness:	1/8"	1/4"	1 1/8"

Other: No additional Supplemental Filler Metal (QW-404.24/27) (QW-404.24/27)

POSITION

Position of groove: 3G (GMAW/FCAW) And 1G (SAW)
Position of Fillet: N.A.
Vertical progression:

Uphill (X) Downhill (---)

Other: N.A

PREHEAT (QW-406)

Preheat Temperature (min.): 50 °F
Interpass Temperature (Máx.): 420 °F

Other: N.A.

POSTWELD HEAT TREATMENT(QW-407)

Temperature: 1123 °F
Time: 1 HR. 15 MINUTES
Other: N.A.

GAS(ES) (QW-408)

	Gas(es)	% Mixture	Flow Rate
Shielding:	Ar + CO_2	75% + 25%	25 CFH
Trailing:	N.A.	N.A.	N.A.
Backing:	N.A.	N.A.	N.A.

ELECTRICAL CHARACTERISTICS (QW-409)

Current: DCEP
Polarity: REVERSE
Amps: GMAW (115); FCAW (210); SAW (350)
Volts: GMAW (18.5); FCAW (25); SAW (32)
Mode of Metal Transfer: GMAW (Short Circuiting); FCAW (Globular)

Tungsten elect. Size: N.A.
N.A.

TECHNIQUE (QW-410)

Travel Speed: GMAW(21.6 IPM); FCAW(16 IPM); SAW(26 IPM)
String or weave bead: GMAW And FCAW (WEAVE); SAW(STRING)
Weave Bead Width 3/8"
Multipass or single pass: GMAW And FCAW (SINGLE); SAW (MULTIPASS)
Number of Electrodes: Single

Other: N.A.

HPM

PQR No. 010

Rev.: 0 Date: 04/14/2014

Procedure Qualification Record (PQR)

Page: 2 of: 2

TENSION TEST (QW-150)

Specimen no.	Diameter		Thickness		Area		Ultimate Total Load		Ultimate Unit Stress		Type of Failure & Location
	mm	in	mm	in	mm^2	(sq in)	Kg	(Pounds Lbs.)	Psi	Mpa	
T1	----	0.503	----	----	----	0.1987	----	15,150	76,246	----	BASE METAL
T2	----	0.504	----	----	----	0.1950	----	15,330	78,615	----	BASE METAL
T3	----	0.503	----	----	----	0.1987	----	15,060	75,793	----	BASE METAL
T4	----	0.504	----	----	----	0.1950	----	15,160	77,744	----	BASE METAL
T5	----	0.502	----	----	----	0.1979	----	14,480	73,168	----	BASE METAL
T6	----	0.503	----	----	----	0.199	----	14,440	72,672	----	BASE METAL

GUIDED BEND TEST (QW-160)

Specimen No.	Type of Bend	Figure No.	Result	Remark
D1	Side Bend Test	QW 462.3 (a)	SATISFACTORY	
D2	Side Bend Test	QW 462.3 (a)	SATISFACTORY	
D3	Side Bend Test	QW 462.3 (a)	SATISFACTORY	
D4	Side Bend Test	QW 462.3 (a)	SATISFACTORY	

THOUGHNESS TEST (QW-170)

Specimen no.	Notch Location	Specimen Size	Test Temp.	Impact Values			Drop Weight Break (Y/N)
				Ft.lbs	% Shear	Mils	
---	----	-----	---	---	---	---	---

Comments: N.A.

FILLET WELD TEST (QW-180)

Result: Satisfactory: yes (-) No (-)

Penetration into Parent Metal: yes (-) No (-)

Macro: ----- Results N.A.

OTHER TESTS

Type of Test: N.A.

Deposit analysis: N.A.

Other:

Welder's Name: JESUS BERNAL (GMAW, FCAW, SAW) Clock No: 1342 Stamp N 8

Test conduced by: TEC. YAHIR GONZALEZ RODRIGUEZ

Laboratory Test no.: CITECSA-PD-011/12 And CITECSA-PT-11/12

Test Date: June 06, 2012

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.

Manufacturer: HUDSON PRODUCTS By: LUIS SARIÑANA Code Year: 2010

Date: July 01, 2011

Remark: 2011a Addenda, Date July 1, 2011

Consorcio INDUSTRIAL TECNOLOGÍAS

DEPARTAMENTO DE CONTROL DE CALIDAD
QUALITY CONTROL DEPARTMENT

LABORATORIO DE PRUEBAS DESTRUCTIVAS
DESTRUCTIVE TEST LABORATORY

PRUEBA DE TENSION
TENSION TEST

FECHA: DATE: *JUNE 6th, 2012* — **No. DE REPORTE:** REPORT No.: *CISA-PT-11/12*

CLIENTE: CUSTOMER: ***HUDSON PRODUCTS DE MEXICO, S.A. DE C.V.***

IDENTIFICACION: IDENTIFICATION: *CALIFICACION DE PROCEDIMIENTO DE SOLDADURA: PROCESOS DE SOLDADURA "GMAW+FCAW+SAW" [HPM-010]*

ESPECIFICACION DEL MATERIAL: MATERIAL SPECIFICATION: *METAL BASE: SA-516-70 & METALES DE APORTE:GMAW [ER70S-6]; FCAW [E71T-1] AND SAW [E7A0+EM13K]*

MAQUINA UTILIZADA PARA LA PRUEBA: MACHINE USED FOR TESTING: *UNIVERSAL MACHINE: TINIUS OLSEN*

No. DE SERIE: SERIAL NUMBER: *157195* — **FECHA DE CALIBRACION:** CALIBRATION DATE: *DECEMBER 3th, 2011*

INFORMACION GENERAL:
GENERAL INFORMATION:

No. de ESPECIMEN: SPECIMEN No.:	T1	T2	T3	T4	T5	T6
LOCALIZACION: LOCATION:	SEE QW-151.3 ASME, SECTION IX, 2010 EDITION, 2011a ADDENDA [Turned Specimens]					
DIAMETRO DEL SPECIMEN (pulgadas): SPECIMEN DIAMETER (inches):	0.503"	0.504"	0.503"	0.504"	0.502"	0.503"
AREA DEL ESPECIMEN (pulgadas²): SPECIMEN AREA (inches2)	0.1987	0.1950	0.1987	0.1950	0.1979	0.1987
ULTIMA CARGA TOTAL (Lb).: ULTIMATE TOTAL LOAD (Lb).:	15,150	15,330	15,060	15,160	14,480	14,440
ESFUERZO A LA TENSION (psi): TENSILE STRENGTH (Psi)	76,246	78,615	75,793	77,744	73,168	72,672
TIPO DE FALLA Y LOCALIZACION: TYPE OF FAILURE & LOCATION:	DUCTIL WELD METAL	DUCTIL WELD METAL	DUCTIL WELD METAL	DUCTIL WELD METAL	DUCTIL WELD METAL	DUCTIL WELD METAL
CARGA LIMITE ELASTICO (Lb) YIELD LIMIT LOAD (Lb).:	-----	-----	-----	-----	-----	-----
ESFUERZO DE CEDENCIA (psi): YIELD STRENGTH (psi):	-----	-----	-----	-----	-----	-----
ELONGACION EN 2 in (%): ELONGATION IN 2 in (%):	-----	-----	-----	-----	-----	-----
RESULTADO: RESULT:	ACCEPTABLE	ACCEPTABLE	ACCEPTABLE	ACCEPTABLE	ACCEPTABLE	ACCEPTABLE

CONSORCIO INDUSTRIAL, S.A. DE C.V.
CONTROL DE CALIDAD / QUALITY CONTROL
REVISADO Y APROBADO / REVIEWED AND APPROVED
J. CORTES
NOMBRE Y FIRMA / NAME AND SIGNATURE

OBSERVACIONES :/REMARKS *REFERENCE: ASME SECTIONS II, PART A AND C, 2010 EDITION, 2011a. ADDENDA.*

ASME II PART A: SA-516-70: TENSILE STRENGHT: 70,000 TO 90,000 Psi.

ASME II PART C: GMAW.- SFA 5.18 (ER70S-6) TENSILE STRENGHT: 70,000 PSI MINIMUM; FCAW.- SFA 5.20 (E71T-1) TENSILE STRANGHT: 70,000 TO 95,000 PSI AND SAW.- SFA 5.17 (F7AO+EM13K) TENSILE STRENGHT: 70,000 TO 95,000 PSI.

SPECIMEN WIT POSTWELD HEAT TREATMENT. *TEST COUPON THICKNESS = 1 1/2".*

THE TEST WAS PERFORMED ACCORDING TO SA-370 OF ASME CODE, SECTION II, PART A, 2010 EDITION, 2011a ADDENDA: "STANDARD TEST METHODS & DEFINITIONS FOR MECHANICAL TESTING".

ELABORADO POR	APROBADO POR:	RECIBIDO DE CONFORMIDAD CLIENTE
ELABORATED BY	APPROVED BY:	RECEIVED CUSTOMER CONFORMITY
YAHIR GONZALEZ RODRIGUEZ	JAIME CORTES PEREZ	
June 6th, 2012	June 6th, 2012	
NOMBRE, FECHA Y FIRMA	NOMBRE, FECHA Y FIRMA	NOMBRE, FECHA Y FIRMA
NAME, DATE AND SIGNATURE	NAME, DATE AND SIGNATURE	NAME, DATE AND SIGNATURE
JEFE DE PRUEBAS DESTRUCTIVAS	GERENTE DE CONTROL DE CALIDAD	
DESTRUCTIVE TEST CHIEF	QUALITY CONTROL MANAGER	

Consorcio INDUSTRIAL TECNOLOGÍAS

DEPARTAMENTO DE CONTROL DE CALIDAD
QUALITY CONTROL DEPARTMENT

LABORATORIO DE PRUEBAS DESTRUCTIVAS
DESTRUCTIVE TEST LABORATORY

PRUEBA DE DOBLEZ
BEND TEST

FECHA: DATE — *JUNE 6th, 2012* — **No. DE REPORTE:** REPORT No. — *CISA-PD-011/12*

CLIENTE: CUSTOMER: — ***HUDSON PRODUCTS DE MEXICO, S.A. DE C.V.***

IDENTIFICACION: IDENTIFICATION: — *CALIFICACION DE PROCEDIMIENTO DE SOLDADURA: PROCESOS DE SOLDADURA "GMAW+FCAW+SAW" [HPM-010]*

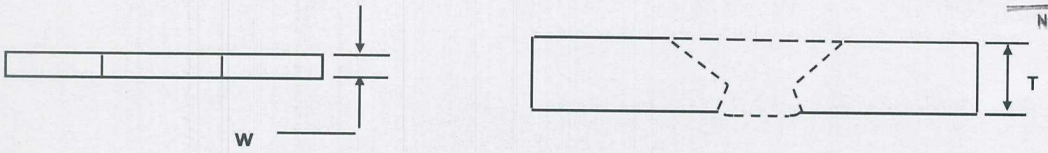
ESPECIFICACION DEL MATERI MATERIAL SPECIFICATION — *METAL BASE: SA-516-70 & METALES DE APORTE:GMAW [ER70S-6]; FCAW [E71T-1] AND SAW [E7A0+EM13K]*

MAQUINA UTILIZADA PARA LA PRUEBA: MACHINE USED FOR TESTING: — *MAQUINA DE ENSAYOS FISICOS, METODO UNIVERSAL, MK TINIUS OLSEN*

No. DE SERIE: SERIAL NUMBER: — *157195* — **FECHA DE CALIBRACION:** CALIBRATION DATE: — *DECEMBER 3th, 2011*

INFORMACION GENERAL Y CROQUIS DE LA FIGURA:
GENERAL INFORMATION AND SKETCH:

CONSORCIO INDUSTRIAL, S.A. DE C.V.
CONTROL DE CALIDAD / QUALITY CONTROL
REVISADO Y APROBADO / REVIEWED AND APPROVED
J. CORTÉS
NOMBRE Y FIRMA / NAME AND SIGNATURE



T, in. (mm)	w, in. (mm)
1 1/2" (38.1)	3/8 (9.52)

No. de ESPECIMEN: SPECIMEN No.:	D1	D2	D3	D4
TIPO Y FIGURA No.: TYPE AND FIGURE No.:	SIDE BEND FIGURE: 462.2	SIDE BEND FIGURE: 462.2	SIDE BEND FIGURE: 462.2	SIDE BEND FIGURE: 462.2
RESULTADO: RESULT:	*ACCEPTABLE*	*ACCEPTABLE*	*ACCEPTABLE*	*ACCEPTABLE*

OBSERVACIONES :/REMARKS — ***WPS: HPM-010***

REFERENCE: ASME CODE, SECTION IX, 2010 EDITION, 2011a. ADDENDA.

WELDING PROCESS: GMAW+FCAW+SAW. — *POSITIONES: GMAW & FCAW: 3G AND SAW: 1G.*

THE TESTS WAS PERFORMED ACCORDING TO SA-370 OF ASME CODE, SECTION II, PART A, 2007 EDITION, 2009 ADDENDA: "STANDARD TEST METHODS & DEFINITIONS FOR MECHANICAL TESTING"

TEST COUPON THICKNESS: 1 1/2". — *SPECIMENS WAS TESTING WITH POSTWELD HEAT TREATMENT.*

ELABORADO POR / ELABORATED BY	APROBADO POR / APPROVED BY	RECIBIDO DE CONFORMIDAD CLIENTE / RECEIVED CUSTOMER CONFORMITY
Y. Gonzalez	J. CORTÉS	
YAHIR GONZALEZ RODRIGUEZ	JAIME CORTES PEREZ	
JUNE 6th, 2012	*JUNE 6th, 2012*	
NOMBRE, FECHA Y FIRMA / NAME, DATE AND SIGNATURE	NOMBRE, FECHA Y FIRMA / NAME, DATE AND SIGNATURE	NOMBRE, FECHA Y FIRMA / NAME, DATE AND SIGNATURE


7AM
6AM
5AM
4AM
8AM
9AM
10AM
11AM
NOON
1PM
2PM
3PM
4PM
5PM
6PM
7PM
8PM
9PM
0 TO 2000°F K T/C
2.0 Hrs. 15 Mins.
CONSORCIO INDUSTRIAL, S.A. DE C.V.
CONTROL DE CALIDAD / QUALITY CONTROL
REVISADO Y APROBADO / REVIEWED AND APPROVED
NOMBRE Y FIRMA / NAME AND SIGNATURE
HONEYWELL
24001660-005
MINNEAPOLIS, MN.
Consorcio
INDUSTRIAL
TECNOLOGÍAS
WELDING PROCEDURE QUALIFICATION: HPM-010
CUSTOMER: HUDSON PRODUCTS DE MEXICO, S.A. DE C.V.
WELDING PROCESS: GMAW+FCAW+SAW
BASE METAL: SA - 516 - 70
THICKNESS METAL: 1 1/2"
FILLER METALS: GMAW (ER70S-6); FCAW (E7AT-1) AND SAW (F7A0+EM13K).
REFERENCE CODE: ASME SECTIONS II PART A & C AND IX 2010 EDITION, 2011a. ADDENDA.
PWHT CHART: CISA-PWHT-6/2012
DATE: JUNE 6th, 2012

JOB SPECIFIC
VENDOR DATA

SIEMENS

NEMA Motor Data

Motors Manufactured Before JAN 18 Only Suitable for

MLFB-Ordering data : **1MB2121-2BD11-4AG3**

Client order no. :
Order no. :
Offer no. :
Remarks :

Item no. :
Consignment no. :
Project :

Nameplate Data

Type	XP100	Div.1, CI , Groups C&D, CII, Groups F&G			
HP	5.0		Rating	Cont.	
Voltage	*(14) 230/460V,60Hz (Suitable for 208V)*		Ins. Class	Insulation class F	
Amps	17.6 / 8.8 A		S.F.	1.15	
FL RPM	875		Amb. Temp.	55 deg C	
FL Efficiency	86.5 %		Temp Code	T3C	
FRAME	254T		Temp. Rise	Class B	
DE AFBMA	45BC03JP30		NEMA Design	B	kVA Code G
ODE AFBMA	45BC03JP30		Mtr WT (lbs)	270	
60 Hertz	3 Ph	TEFC	IP	65	

Mounting and motor protection

Type of construction	
Motor protection	(G) Thermostats, Klixon type, normally
Terminal box design	(3) Mounting - F-1

Bearing Data

	DE	ODE
Bearing Size	6309 Z C3 S0	6309 Z C3 S0
Bearing Type	Ball Bearing	Ball Bearing
AFBMA	45BC03JP30	45BC03JP30

Typical Performance Data

Load	No Load	1/2	3/4	Full Load	LRC
Efficiency		85.5 %	87.0 %	86.5 %	
Power Factor		43.0	54.0	61.0	
Current (A)	5.5 A	6.4 A	7.5 A	17.6 / 8.8 A	33.0 A

Inverter Duty	VT	20:1	CT	4:1

Mechanical Data

SAFE STALL TIME		HOT (s)	65	COLD (s)	115	
Rtr wt (lbs)	55.4	Rtr WK2	1.3800			
FLT (ft-lbs)	41.0	LRT (%)	156	BDT (%)	210	
Ext Load Inertia (WK2) Capability			142			

Typical Noise Data

A-weighted Sound	Octave Band Center Frequencies Hertz (Hz)									
Pressure Level	63	125	250	500	1000	2000	4000	8000	SPL	67
at 3 feet		46	50	64	61	57	46	39	SPwrL	75

Wiring Connection Information

Description 3 PHASE - 9 LEAD - WYE

Voltage	L1	L2	L3	Connected together	
LOW	T1 T7	T2 T8	T3 T9	T4 T5 T6	Y Y
HIGH	T1	T2	T3	T4 T7-T5 T8-T6 T9	Y

Special design :

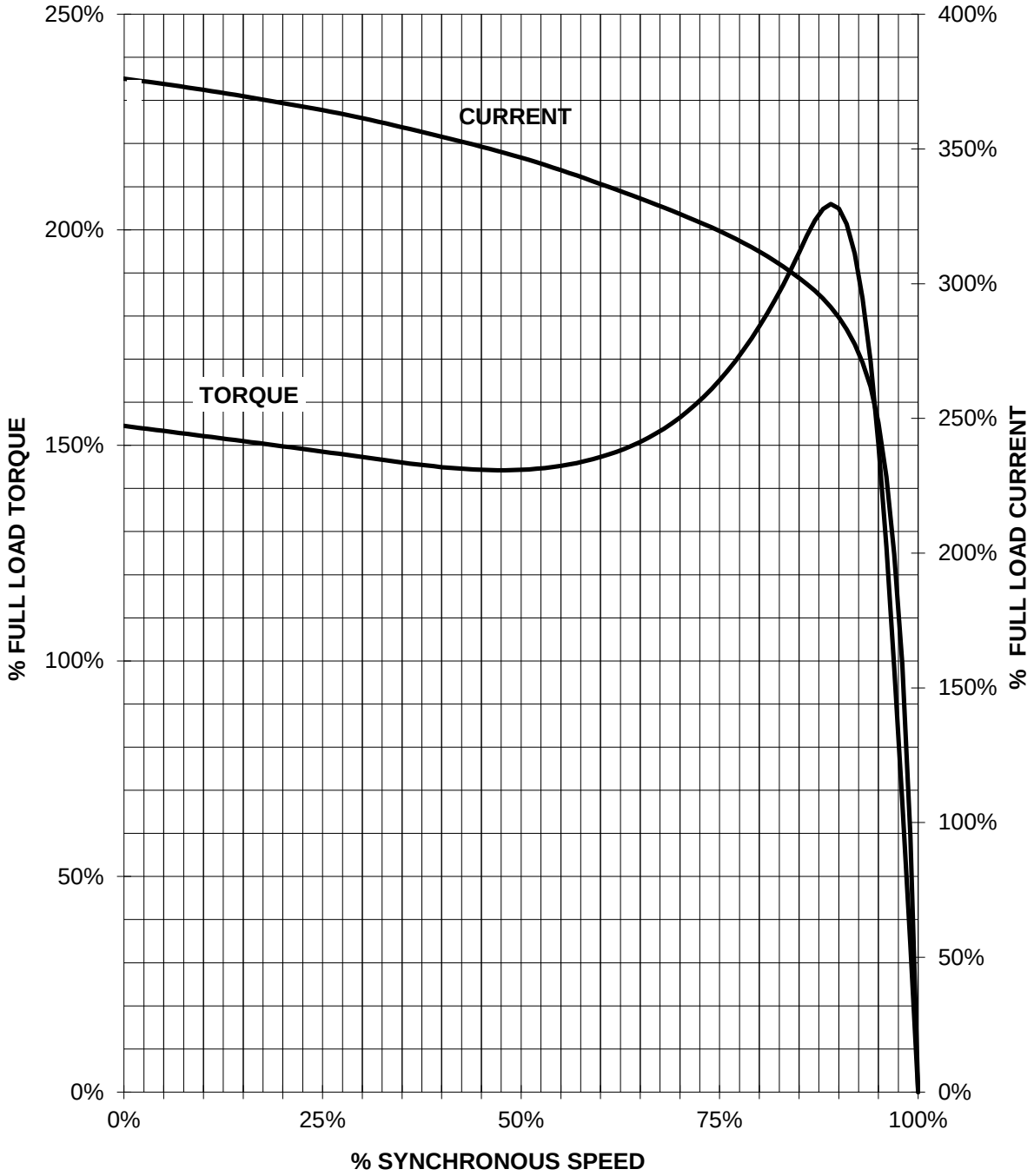
Lubrication Information

Manufacturer	Mobil Polyrex EM or equal
Type	Polyurea (standard)
DE Capacity (oz.)	0.50
ODEnd Capacity (oz.)	0.50

Relubricate bearings every six months (more frequent if conditions require). See Instruction Manual.

HP	5	VOLTS	<600	RPM	900	TYPE	XP100
HZ	60	PHASE	3	FRAME	254T	NEMA	B

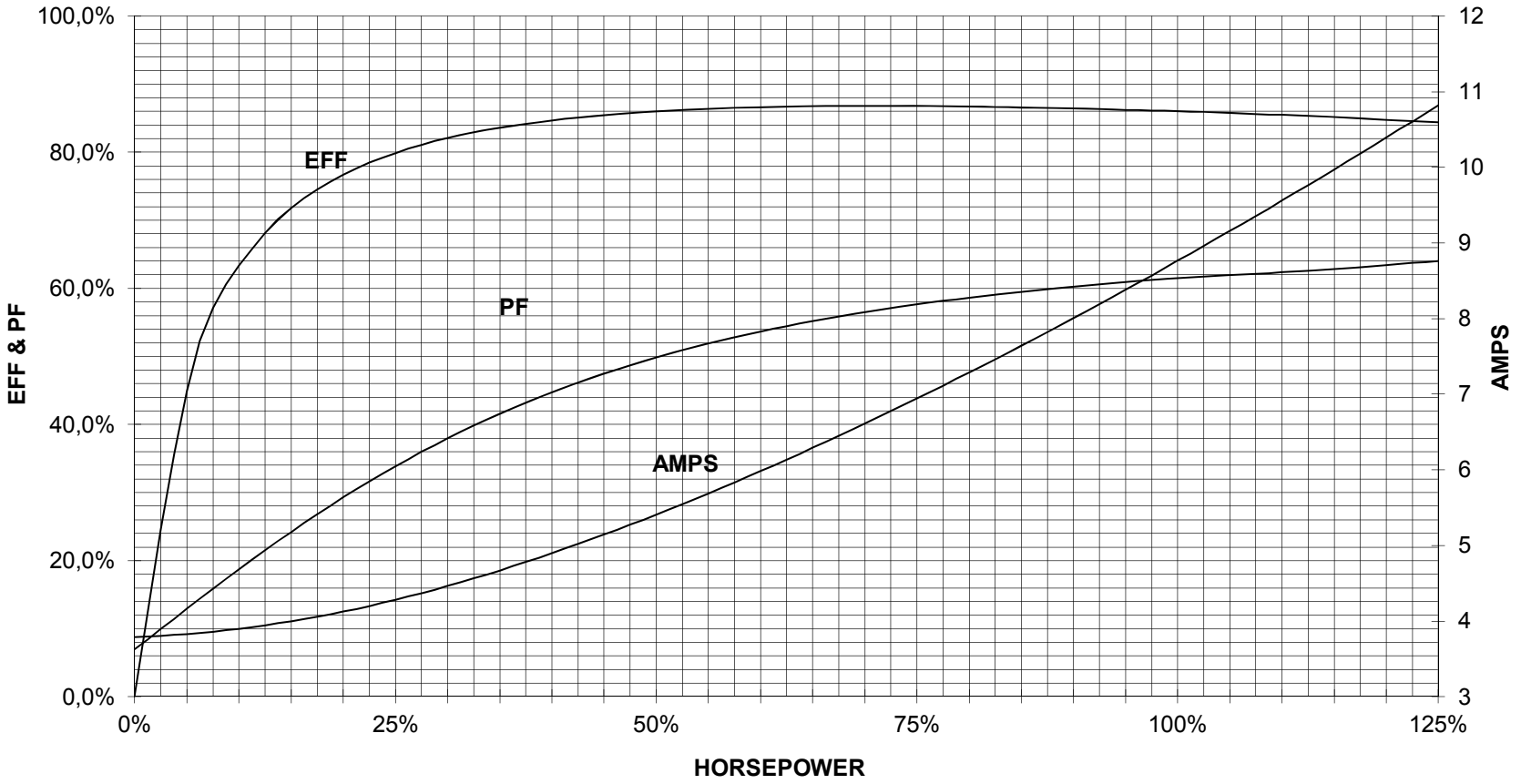
TORQUE & CURRENT VS. SPEED



5 HP 900 RPM 254T FRAME 460 VOLTS 3 PHASE NEMA DESIGN B

SIEMENS INDUSTRY, INC.

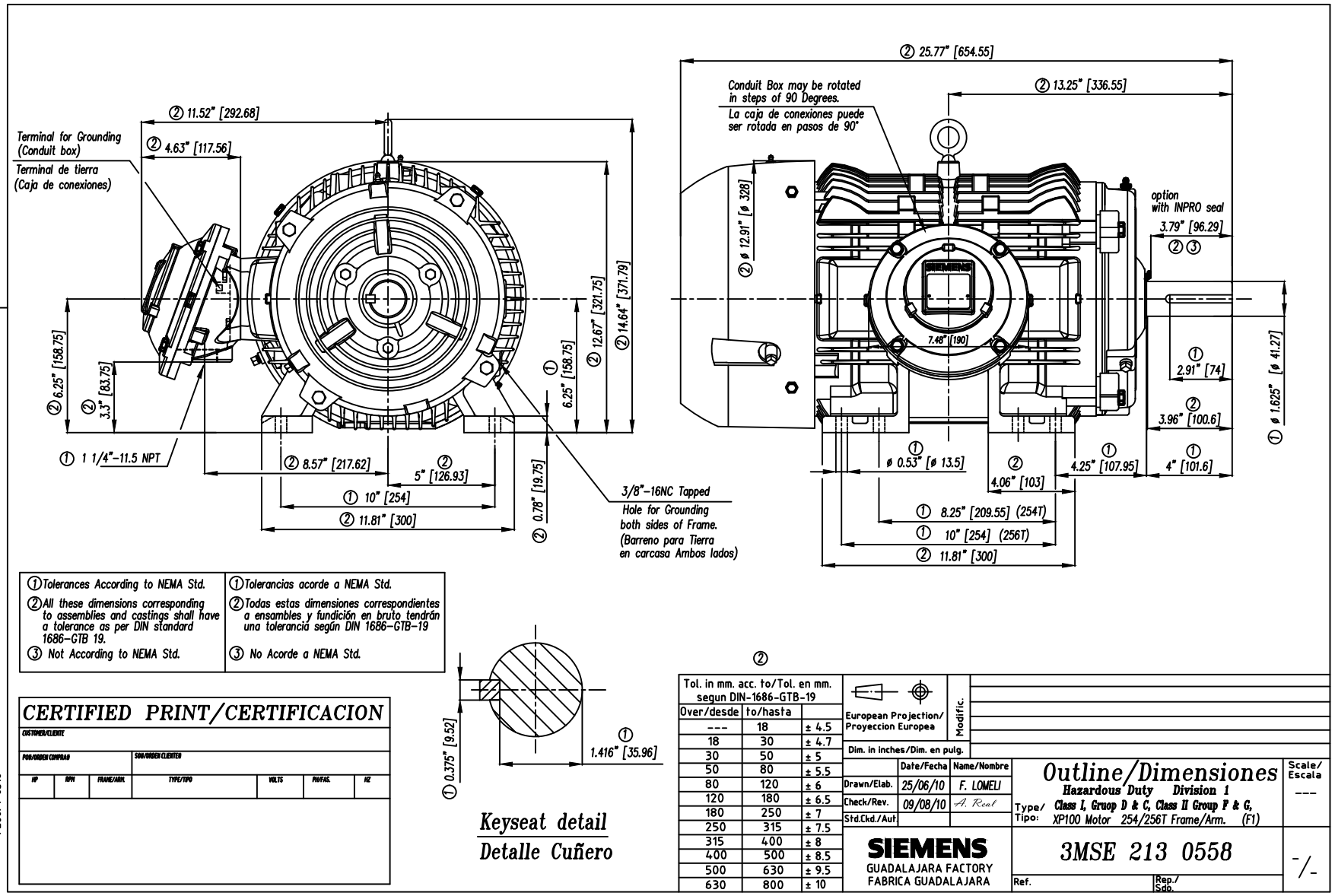
PERFORMANCE CURVE
XP100



CUSTOMER_____ ORDER #_____ PO #_____

PERFORMANCE BASED ON DESIGN CALCULATIONS. SUBJECT TO CHANGE WITHOUT NOTICE.

REV. 1



①Tolerances According to NEMA Std.	①Tolerancias acorde a NEMA Std.
②All these dimensions corresponding to assemblies and castings shall have a tolerance as per DIN standard 1686-GTB 19.	②Todas estas dimensiones correspondientes a ensambles y fundición en bruto tendrán una tolerancia según DIN 1686-GTB-19
③ Not According to NEMA Std.	③ No Acorde a NEMA Std.

CERTIFIED PRINT/CERTIFICACION

CUSTOMER/CLIENTE

POR/ORDEN COMPRAR | SOR/ORDEN CLIENTES

HP	RPM	FRAME/ARM.	TYPE/TIPO	VOLTS	PH/FAS.	HZ

Keyseat detail
Detalle Cuñero

②

Tol. in mm. acc. to/Tol. en mm. segun DIN-1686-GTB-19		
Over/desde	to/hasta	
---	18	± 4.5
18	30	± 4.7
30	50	± 5
50	80	± 5.5
80	120	± 6
120	180	± 6.5
180	250	± 7
250	315	± 7.5
315	400	± 8
400	500	± 8.5
500	630	± 9.5
630	800	± 10

European Projection/ Proyeccion Europea

Dim. in inches/Dim. en pulg.

Modific.

	Date/Fecha	Name/Nombre
Drawn/Elab.	25/06/10	F. LOMELI
Check/Rev.	09/08/10	A. Real
Std.Ckd./Aut		

SIEMENS
GUADALAJARA FACTORY
FABRICA GUADALAJARA

Outline/Dimensiones

Hazardous Duty Division 1

Type/ Tipo: **Class I, Group D & C, Class II Group F & G,** XP100 Motor 254/256T Frame/Arm. (F1)

Scale/ Escala: ---

3MSE 213 0558

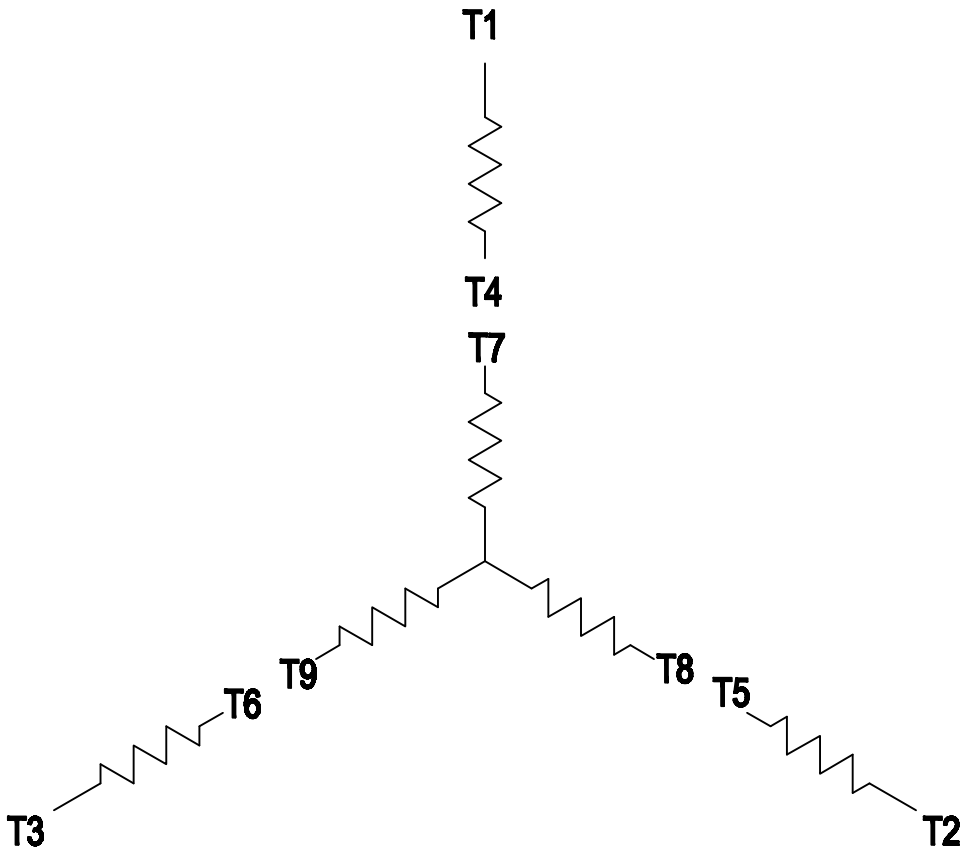
Ref. | Rep./ Sdo.

-/-

F260/1-0310

3 PHASE - 9 LEADS - WYE

VOLTS	LINES			CONNECTED TOGETHER	CONN.
	L1	L2	L3		
LOW	T1 T7	T2 T8	T3 T9	T4 T5 T6	Y Y
HIGH	T1	T2	T3	T4 T7–T5 T8–T6 T9	Y



THIS IS A CAD DRAWING
DO NOT MAKE MANUAL CHANGES

01	09–27–07	TYPE		–CONFIDENTIAL– PROPERTY OF Siemens Energy & Automation, Inc. Industrial Motor Division – Little Rock, AR	
		FRAME	HP	NAME WIRING DIAGRAM	
		VOLTS / RPM / HZ / PH	3	Customer	
		DRAWN 9.24.07 DATE JRH		PO # / SO #	
		CHECKED DATE		SHEET 1 OF 1 / Sim. To / PART NO. 51–382–114–501	A
		APP DATE			

SIEMENS

NEMA Motor Data

Motors Manufactured Before JAN 18 Only Suitable for

MLFB-Ordering data : **1MB2121-2CD11-6AG3**

Client order no. :
Order no. :
Offer no. :
Remarks :

Item no. :
Consignment no. :
Project :

Nameplate Data

Type	XP100	Div.1, CI , Groups C&D, CII, Groups F&G		
HP	10.0		Rating	Cont.
Voltage	(16) 230/460V STD		Ins. Class	Insulation class F
Amps	34.0 / 17.0 A		S.F.	1.15
FL RPM	885		Amb. Temp.	55 deg C
FL Efficiency	90.2 %		Temp Code	T3C
FRAME	284T		Temp. Rise	Class B
DE AFBMA	50BC03JP30		NEMA Design B	kVA Code H
ODE AFBMA	50BC03JP30		Mtr WT (lbs)	486
60 Hertz	3 Ph	TEFC	IP	65

Mounting and motor protection

Type of construction	
Motor protection	(G) Thermostats, Klixon type, normally
Terminal box design	(3) Mounting - F-1

Bearing Data

	DE	ODE
Bearing Size	6310 Z C3 S0	6310 Z C3 S0
Bearing Type	Ball Bearing	Ball Bearing
AFBMA	50BC03JP30	50BC03JP30

Typical Performance Data

Load	No Load	1/2	3/4	Full Load	LRC
Efficiency		88.2 %	89.8 %	90.2 %	
Power Factor		42.0	53.0	61.0	
Current (A)	11.0 A	12.6 A	14.8 A	34.0 / 17.0	81.0 A

Inverter Duty	VT	20:1	CT	4:1

Mechanical Data

SAFE STALL TIME	HOT (s)	15	COLD (s)	30	
Rtr wt (lbs)	85.4	Rtr WK2	4.1000		
FLT (ft-lbs)	59.0	LRT (%)	161	BDT (%)	224
Ext Load Inertia (WK2) Capability		273			

Typical Noise Data

A-weighted Sound	Octave Band Center Frequencies Hertz (Hz)									
Pressure Level	63	125	250	500	1000	2000	4000	8000	SPL	59
at 3 feet		49	51	54	52	54	44	37	SPwrL	70

Wiring Connection Information

Description 3 PHASE - 9 LEAD - DELTA

Voltage	L1	L2	L3	Connected together	
LOW	T1 T7 T6	T2 T8 T4	T3 T9 T5	-- -- --	ΔΔ
HIGH	T1	T2	T3	T4 T7-T5 T8-T6 T9	Δ

Special design :

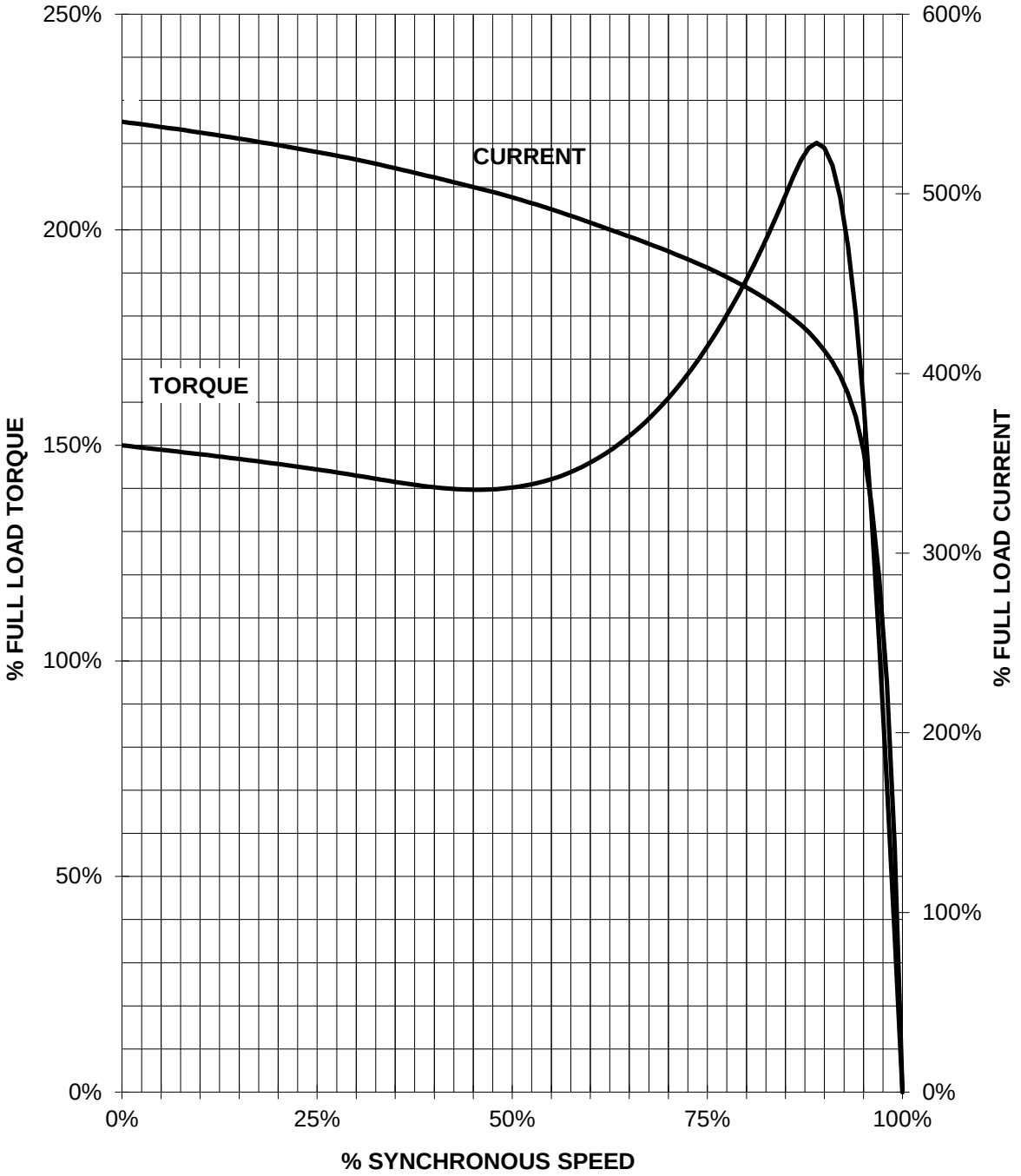
Lubrication Information

Manufacturer	Mobil Polyrex EM or equal
Type	Polyurea (standard)
DE Capacity (oz.)	2.60
ODEnd Capacity (oz.)	2.60

Relubricate bearings every six months (more frequent if conditions require). See Instruction Manual.

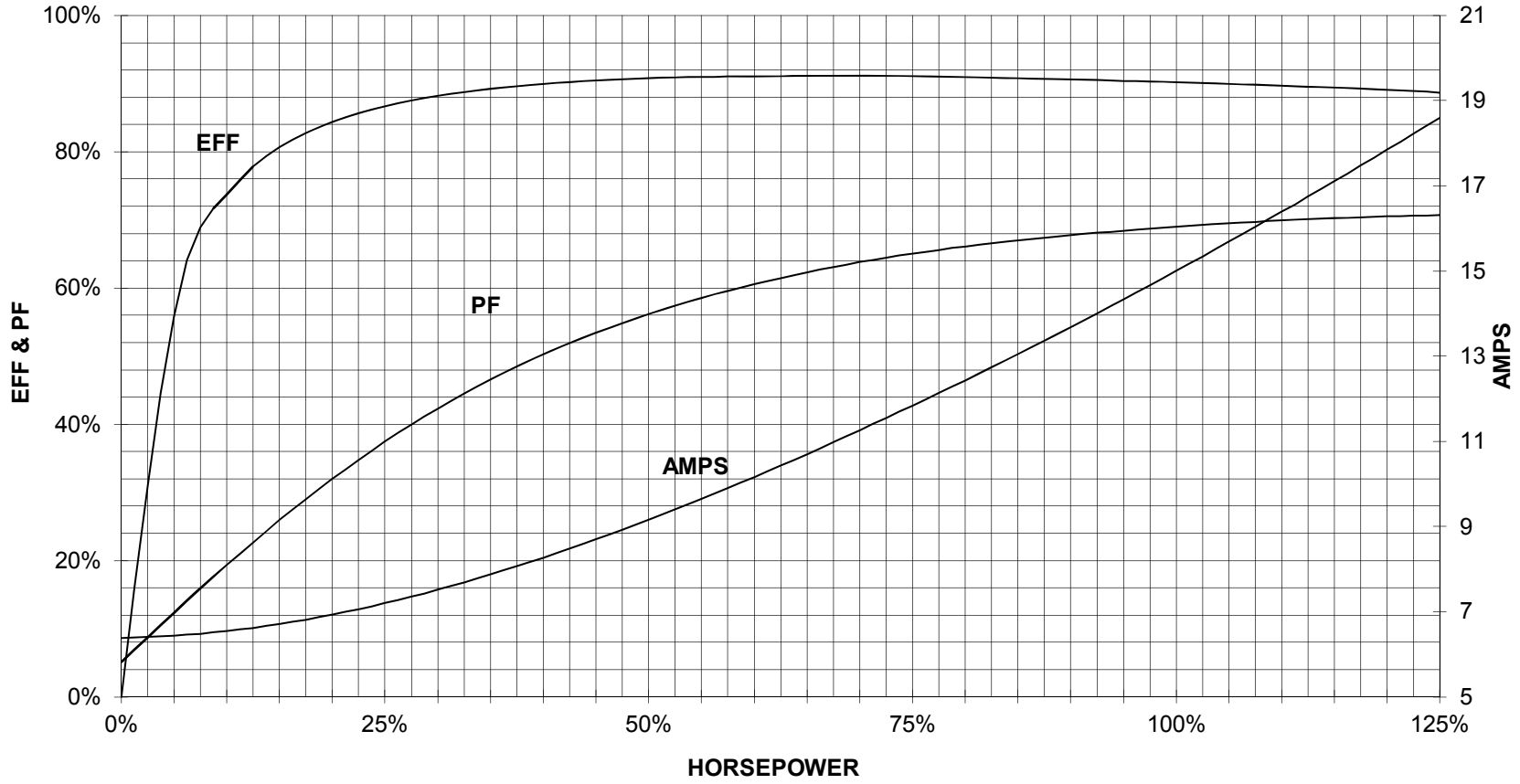
HP	10	VOLTS	<600	RPM	900	TYPE	XP100
HZ	60	PHASE	3	FRAME	284T	NEMA	B

TORQUE & CURRENT VS. SPEED



10 HP 900 RPM 284T FRAME 460 VOLTS 3 PHASE NEMA DESIGN B

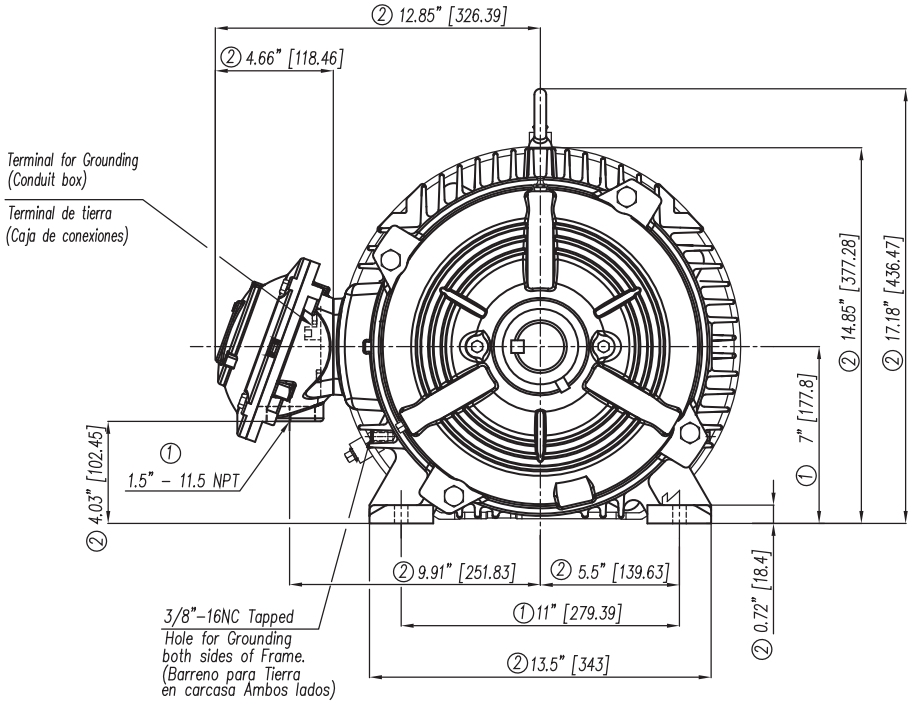
SIEMENS INDUSTRY, INC.
PERFORMANCE CURVE
XP100

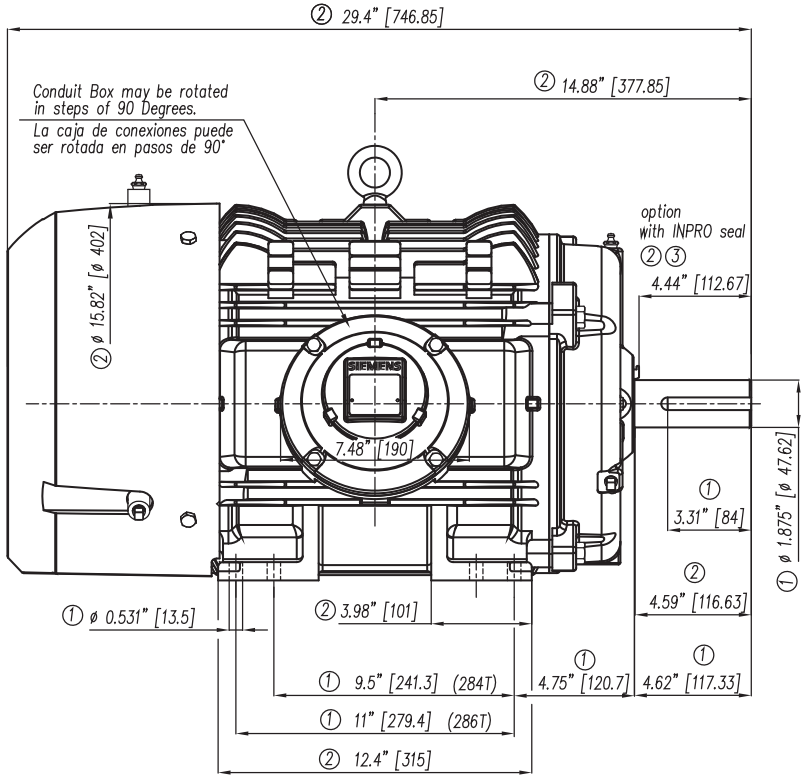


CUSTOMER_____ ORDER #_____ PO #_____

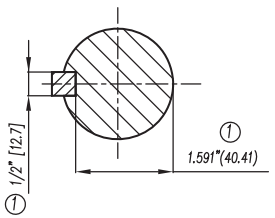
PERFORMANCE BASED ON DESIGN CALCULATIONS. SUBJECT TO CHANGE WITHOUT NOTICE.

REV. 1





① Tolerances According to NEMA Std.	① Tolerancias acorde a NEMA Std.
② All these dimensions corresponding to assemblies and castings shall have a tolerance as per DIN standard 1686–GTB 19.	② Todas estas dimensiones correspondientes a ensambles y fundición en bruto tendrán una tolerancia según DIN 1686–GTB–19
③ Not According to NEMA Std.	③ No Acorde a NEMA Std.



Keyseat detail
Detalle Cuñero

CERTIFIED PRINT/CERTIFICACION

CUSTOMER/CLIENTE						
PO#/ORDEN COMPRA#		SO#/ORDEN CLIENTE#				
HP	RPM	FRAME/ARM.	TYPE/TIPO	VOLTS	PH/FAS.	HZ

F260/1-0310

② Tol. in mm. acc. to/Tol. en mm. segun DIN-1686-GTB-19

Over/desde	to/hasta	
---	18	± 4.5
18	30	± 4.7
30	50	± 5
50	80	± 5.5
80	120	± 6
120	180	± 6.5
180	250	± 7
250	315	± 7.5
315	400	± 8
400	500	± 8.5
500	630	± 9.5
630	800	± 10

European Projection/
Proyeccion Europea

Modific.

Dim. in inches/Dim. en pulg.

	Date/Fecha	Name/Nombre
Drawn/Elab.	21/07/10	F. LOMELI
Check/Rev.	09/08/10	A. Real
Std.Ckd./Aut		

SIEMENS
GUADALAJARA FACTORY
FABRICA GUADALAJARA

Outline/Dimensiones

Hazardous Duty Division 1
Class I, Gruop D & C, Class II Group F & G,
Type/ Tipo: XP100 Motor 284/286T Frame/Arm. (F1)

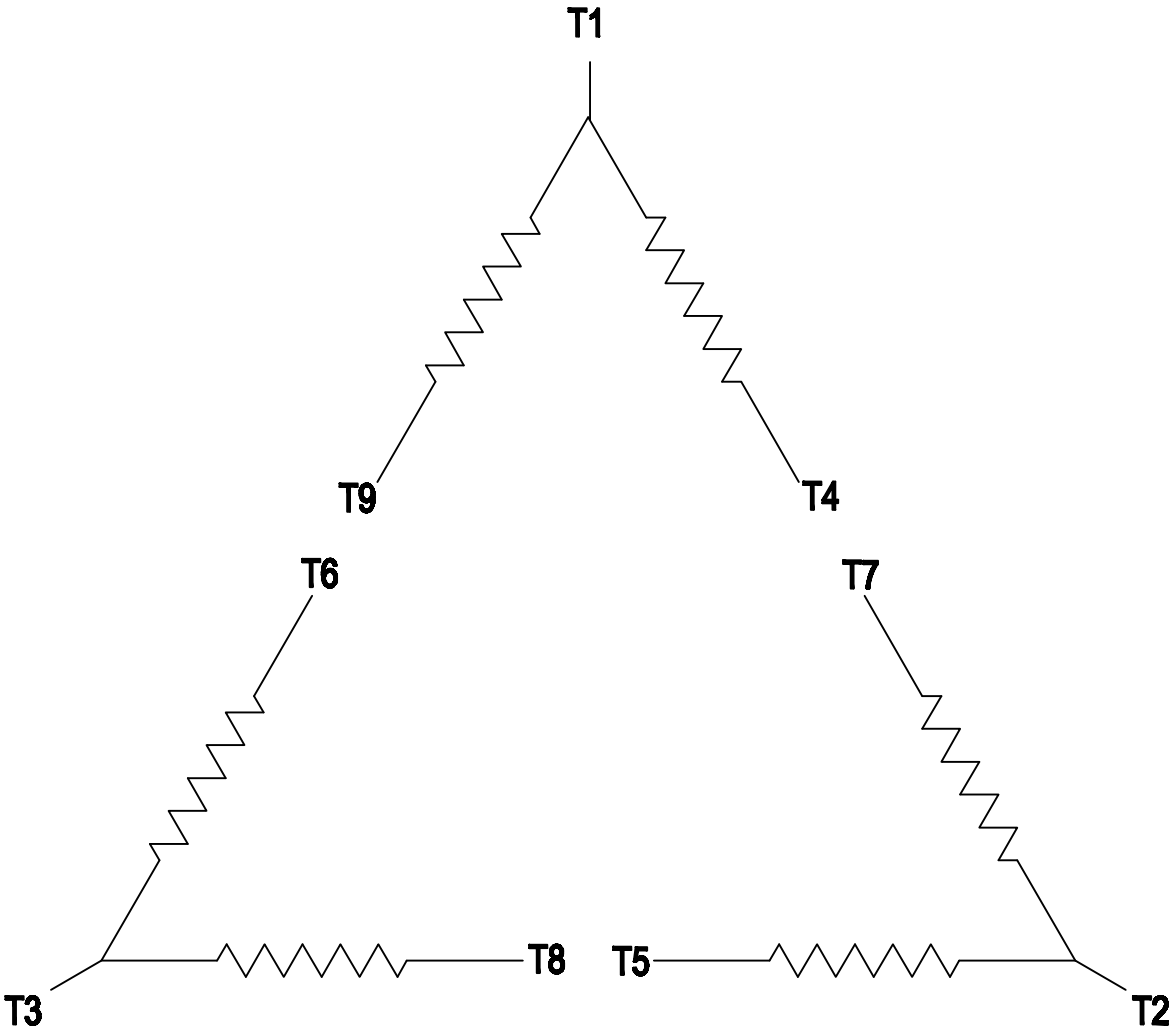
3MSE 710 2074

Ref. | Rep./ Sdo.

Project Job No.: TM286-IOM

Scale/ Escala: ---

Sheet/ Hoja: /_



3 PHASE - 9 LEADS - DELTA

VOLTS	LINES			CONNECTED TOGETHER	CONN.
	L1	L2	L3		
LOW	T1 T7 T6	T2 T8 T4	T3 T9 T5		△ △
HIGH	T1	T2	T3	T4 T7–T5 T8–T6 T9	△

THIS IS A CAD DRAWING
DO NOT MAKE MANUAL CHANGES

01 | 09–27–07	TYPE	–CONFIDENTIAL–	PROPERTY OF Siemens Little Rock, AR
	FRAME / HP	NAME	WIRING DIAGRAM
	VOLTS / RPM / HZ / PH 3	Customer	
	DRAWN 9.24.07 DATE JRH CHECKED DATE APP DATE	PO # / SO #	
		SHEET 1 OF 1 / Sim. To	PART NO. 51–382–114–504 / A

SIEMENS

Installation • Operation • Maintenance

Instructions

Induction Motors
143-449 Frame

NMIM-L1000

SIEMENS

TABLE OF CONTENTS

These instructions do not purport to cover all details or variations in equipment, nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the local Siemens Sales Office.

The contents of this instruction manual shall not become part or modify any prior or existing agreement, commitment or relationship. The sales contract contains the entire obligation of Siemens. The warranty contained in the contract between the parties is the sole warranty of Siemens. Any statements contained herein do not create new warranties or modify the existing warranty.

INTRODUCTION

THIS EQUIPMENT CONTAINS HAZARDOUS VOLTAGES, ROTATING PARTS AND HOT SURFACES. SEVERE PERSONAL INJURY OR PROPERTY DAMAGE CAN RESULT IF SAFETY INSTRUCTIONS ARE NOT FOLLOWED. ONLY QUALIFIED PERSONNEL SHOULD WORK ON OR AROUND THIS EQUIPMENT AFTER BECOMING THOROUGHLY FAMILIAR WITH ALL WARNINGS, SAFETY NOTICES, AND MAINTENANCE PROCEDURES CONTAINED HEREIN. THE SUCCESSFUL AND SAFE OPERATION OF THIS EQUIPMENT IS DEPENDENT UPON PROPER HANDLING, INSTALLATION, OPERATION AND MAINTENANCE.

QUALIFIED PERSON

For the purpose or this manual and product labels, a qualified person is one who is familiar with the installation, construction and operation of the equipment, and the hazards involved. In addition, he has the following qualifications:

a) Is trained and authorized to energize, de-energize, clear, ground and tag circuits and equipment in accordance with established safety practices.

b) Is trained in the proper care and use of protective equipment such as rubber gloves, hard hat, safety glasses or face shields, flash clothing, etc., in accordance with established safety practices.

DANGER

For the purpose of this manual and product labels, DANGER indicates death, severe personal injury or substantial property damage will result if proper precautions are not taken.

WARNING

For the purpose of this manual and product labels, WARNING indicates death, severe personal injury or substantial property damage can result if proper precautions are not taken.

CAUTION

For the purpose of this manual and product labels, CAUTION indicates minor personal injury or property damage can result if proper precautions are not taken.

INSPECTION

Care is taken at the factory to assure that the motor arrives at its destination in first class condition. If there is evidence of rough handling or damage in shipping, file a claim at once with the carrier and notify your Siemens Sales Office.

Examine the outside of the motor carefully for damage, with particular attention to conduit box, fans, and covers. Inspect and tighten all hardware and accessories which may have become loosened during shipping and handling. Turn the shaft by hand to be sure that it rotates freely. If the motor has been mishandled sufficiently to break external parts, the end shield should also be removed to check for internal damage unless the motor is explosion-proof. See warning below on explosion proof motors.

WARNING

Explosion-proof motors—these motors are constructed to comply with the U.L. Label Service Procedure Manual. When repairing and reassembling a motor that has an underwriter's label, it is imperative that the unit be reinspected and:

1. All original fits and tolerance be maintained.
2. All plugs and hardware be securely fastened.
3. Any parts replacements, including hardware, be accurate duplicates of the originals.

Repair work on explosion-proof motors can only be done by the original manufacturing or U.L. certified shops. Violations of any of the above items will invalidate the significance of the U.L. Label.

STORAGE

Motors must be stored in a clean, dry, well ventilated location free from vibration and rapid or wide temperature variations. If the unit is to be stored longer than three months, consult factory. Ball bearing motors are shipped from the factory properly lubricated and ready to operate. When in storage, the motor shaft must be turned several rotations every month and the bearing relubricated every year. On non-explosion-proof TEFC motors, a removable plug in the bottom of the frame or housing permits removal of accumulated moisture. Drain regularly if storage atmosphere result in formation of condensation.

INSTALLATION

Installation must be handled by qualified service or maintenance personnel. The motor foundation must rigidly support all four feet in the same plane. Place shims under the motor feet, as required, so they will not be pulled out of plane when mounting bolts are tightened. All wiring to the motor and control must be in accordance with the National Electrical Code and all local regulations. Before drive is connected, momentarily energize motor to check that direction of rotations proper. For direct drive, accurate alignment is 0.004 inch/ft. (radius to dial indicator = one foot.)

Any change in shims requires rechecking alignment. When alignment is within limits, dowel two feet of each unit. When installing flat belt pulley, V-belt sheave, spur or helical pinion or chain drives, be certain that they are within NEMA limitations. Refer to NEMA motor and general standards, MG-1 14.07 and 14.42.

OPERATION

Repeated trial starts can overhead the motor and may result in motor burnout (particularly for across the line starting). If repeated trial starts are made, allow sufficient time between trials to permit heat to dissipate from windings and rotor to prevent overheating. Starting currents are several times running currents, and heating varies as the square of the current.

After installation is completed, but before motor is put in regular service, make an initial start as follows:

1. Check motor starting and control device connections against wiring diagrams.
2. Check voltage, phase, and frequency of line circuit (power supply) against motor nameplate.
3. If possible, remove external load (disconnect drive) and turn shaft by hand to ensure free rotation. This may have been done during installation procedure; if so, and conditions have not changed since, this check may not be necessary.
    a. If drive is disconnected, run motor at no load long enough to be certain that no unusual conditions develop. Listen and feel for excessive noise, vibration, clicking, or pounding. If present, stop motor immediately. Investigate the cause and correct before putting motor in service.
    b. If drive is not disconnected, interrupt the starting cycle after motor has accelerated to low speed. Carefully observe for unusual conditions as motor coasts to a stop.
4. When checks are satisfactory, operate at minimum load and look for unusual condition. Increase load slowly to maximum. Check unit for satisfactory operation.

CAUTION

Guard against overloading. Overloading causes overheating and overheating means shortened insulation life. A motor subjected to a 10°C temperature rise above the maximum limit for the insulation may cause the insulation life to be reduced by 50%. To avoid overloading, be sure motor current does not exceed nameplate current when nameplate voltage is applied.

Electric motors operating under normal conditions become quite warm. Although some places may feel hot to the touch, the unit may be operational within limits. Use a thermocouple to measure winding temperature when there is any concern.

The total temperature, not the temperature rise, is the measure of safe operation. Investigate the operating conditions if the total temperature measured by a thermocouple placed on the winding exceeds:

230°F (110°C) for class “B” insulation

275°F (135°C) for class “F” insulation

302°F (150°C) for class “H” insulation

VOLTAGE REGULATION

Motors will operate successfully under the following conditions of voltage and frequency variation, but not necessarily in accordance with the standards established for operation under rated conditions:

a. When the variation in voltage does not exceed 10% above or below normal, with all phases balanced.

b. When the variation in frequency does not exceed 5% above or blow normal.

c. When the sum of the voltage and frequency does not exceed 10% above or below normal (provided the frequency variation does not exceed 5%).

MAINTENANCE

Failure to properly maintain the equipment can result in severe personal injury and product failure. The instructions contained herein should be carefully reviewed, understood and followed. The following maintenance procedures should be performed regularly:

1. Bearing lubrication
2. Insulation resistance check
3. Cleaning

This checklist does not represent an exhaustive survey of maintenance steps necessary to ensure safe operation of the equipment. Particular applications may require further procedures. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the local Siemens Sales Office.

Dangerous voltages are present in the equipment which can cause severe personal injury and product failure. Always de-energize and ground the equipment before maintenance. Maintenance should be performed only by qualified personnel.

The use of unauthorized parts in the repair of the equipment, tampering by unqualified personnel, or removal or alteration of guards or conduit covers will result in dangerous conditions which can cause severe personal injury or equipment damage. Follow all safety instructions contained herein.

BEARING LUBRICATION

CAUTION

Do not lubricate motor while in operation, since excess grease will be forced through the bearings and into the motor before it will force its way out of the drain plug. Excess grease accumulation on windings reduces insulation life.

Bearing life is assured by maintaining proper alignment, proper belt or chain tension, and good lubrication at all times.

Prior to shipment, motor bearings are lubricated with the proper amount and grade to provide six months of satisfactory service under normal operation and conditions.

For best results, grease should be compounded from a polyurea base and a good grade of petroleum oil. It should be of No. 2 consistency and stabilized against oxidation. Operating temperature range should be from -15°F to +250°F for class B insulation, and to +300°F fir class F and H. Most leading oil companies have special bearing greases that are satisfactory.

Relubricate bearings every six months (more often if conditions require), as follows:

1. Stop the motor. Lock out the switch.
2. Thoroughly clean off pipe plugs and remove from housings.
3. Remove hardened grease from drains with stiff wire or rod.
4. Add grease to inlet with hand gun until small amount of new grease is forced out of drain.
5. Remove excess grease from ports, replace inlet plugs, and run motor 1/2 hour before replacing drain plug.
6. Put motor back in operation.

INSULATION RESISTANCE

Check insulation resistance periodically. Any approved method of measuring insulation resistance may be used, provided the voltage across the insulation is at a safe value for the type and condition of the insulation. A hand cranked megger of not over 500 volts is the most convenient and safest method. Standards of the Institute of Electrical and Electronics Engineers, Inc. (IEEE) recommended that the insulation resistance of stator windings at 75°C, measure at 500 volts DC, after one minute should not be less than:

$$\frac{\text{Rated voltage of machine} + 1000}{1000} = \text{Insulation resistance in Megohms}$$

This formula is satisfactory for most checks. for more information, see IEEE Standard No. 43, “Recommended Practice for Insulation Resistance Testing of AC Rotating Machinery.”

SIEMENS

Siemens Energy & Automation, Inc.
Motors and Drives Division
14000 Dineen Drive
Little Rock, Arkansas 72206

CLEANING

WARNING

Do not attempt to clean motor while it is operating.. Contact with rotating parts can cause severe personal injury or property damage. Stop the motor and lock out switch before cleaning.

The motor exterior must be kept free of oil, dust, dirt, water, and chemicals. For fan cooled motors, it is particularly important to keep the air intake openings free of foreign material. Do not block air outlet or inlet.

On non-explosion-proof TEFC motors, a removable plug in the bottom center of the motor frame or housing permits removal of accumulated moisture. Drain regularly.

VERTICAL MOTOR THRUST BEARINGS

Top bearings — high external thrust from the driven unit is usually carried by he top bearing or bearings. If replacement is necessary, the new bearing must be the same size and type as the original. Duplex bearings must also be the same type and mounted in an identical manner. When angular contact type bearings are replaced, the new bearing must have the same thrust capacity.

Bottom bearings — grease lubricated lower bearings adequately lubricated at the factory for at least three months operation. The relubrication procedure is the same as outlined above under "Bearing Lubrication." It is important to maintain the lower cavity full of grease at all times.

The correct replacement bearings are given on the nameplate by AFBMA (Anti-Friction Bearing Manufacturers Association) number.

SERVICE

For immediate action on your motor problems call your certified service center or contact your nearest Siemens District Office.

Siemens Energy & Automation, Inc.
Industrial Products Division
14000 Dineen Drive
Little Rock, Arkansas 72206

Moore Fans LLC Rating

Phone: (660) 376-3575 http://www.moorefans.com **Fax:(660) 376-2909**

Version 2.21

12/3/2016 10:52

Dominion Trans 16B286			Ref No.:	**Northamption**		Item No:	**D2.2C**	
Class:	**10000**		Hub Type:	**HD**		Blade Type:	**MAG**	
Blade Tip:	**AM**		Adjustment:	**MAN**		Rotation:	**RH**	
Series:	**48**		Diameter:	**12**	feet	Blades:	**3**	
Temperature:	**60**	Deg. F	Elevation:	**145**	feet	Density Ratio:	**1.014**	
Volume:	**80600**	ACFM	Air Vel.:	**779.27**	fpm	Speed:	**99**	RPM
Static Pressure:	**0.153**	in H2O	Pv:	**0.038**	in H2O	Pt:	**0.191**	in H2O
Power Reqd.:	**3.65**	bhp	Motor:	**5**	bhp	Total Eff:	**66.7%**	
						Static Eff:	**53.3%**	
Blades Required:	**2.76**		API Blades Req.:	**3**		Blade Load:	**0.922**	
Tip Speed:	**3732.2**	fpm				Pitch Number:	**1.97**	
Entry Correction:	**1**		Tip Clearance:	**0.36**	inches	Design Angle:	**21.5**	deg
Exit Correction:	**1.00**		Draft:	**Forced**		Orientation:	**Horizontal**	
Torque Factor:	**2**		Motor Torque:	**531**	ft. lbs	Torq/Bld:	**177**	ft. lbs
Appr fan weight:	**282**	lbs		**128**	kg	Bore Size:		inches
WR2	**4051**	lb-ft2		**171.1**	kg m2	Bushing Type:	**U**	
Thrust Load:	**112**	lbs		**51**	kg	Qty required:	**12**	

Noise Levels Per Fan (Forced Draft) (Horizontal Orientation) See Note 2

Sound Power Level

dBA	HZ	63	125	250	500	1000	2000	4000	8000
74.7		**72.2**	**75.7**	**73.5**	**70.8**	**69.1**	**67.1**	**64.2**	**62.2**

Sound Pressure Level 1 meter below fan

60.6	**58.1**	**61.6**	**59.4**	**56.7**	**55.0**	**53.0**	**50.1**	**48.1**

Sound Pressure Level 1 meter radially from blade tip

55.6	**53.1**	**56.6**	**54.4**	**51.7**	**50.0**	**48.0**	**45.1**	**43.1**

Estimated Sound Pressure Level Multiple Fans (3 fans at 50 ft from periphery)

44.6	**42.1**	**45.6**	**43.4**	**40.7**	**39.0**	**37.0**	**34.1**	**32.1**

Class 10000, Series 48, 12 feet Diameter, 3 Blades

Manual Adjustment, Heavy Duty, MAG, Right Hand Rotation

With AM Blade Tips,

Fan Model No. 1048/094-U0-A/48R-AM-9-12.00-3

Fan Drawing: http://moorefans.com/pdfs/TMC_857_B.pdf

Note 1: Maximum blade angle to prevent fan stall is 25.5 degrees.
Available motor power may limit maximum angle to a lower value.

Note 2: Noise levels are the best estimate of the fan noise with 0 dBA additional noise included due to drive components, flow obstructions or structure reflection and reverberation.

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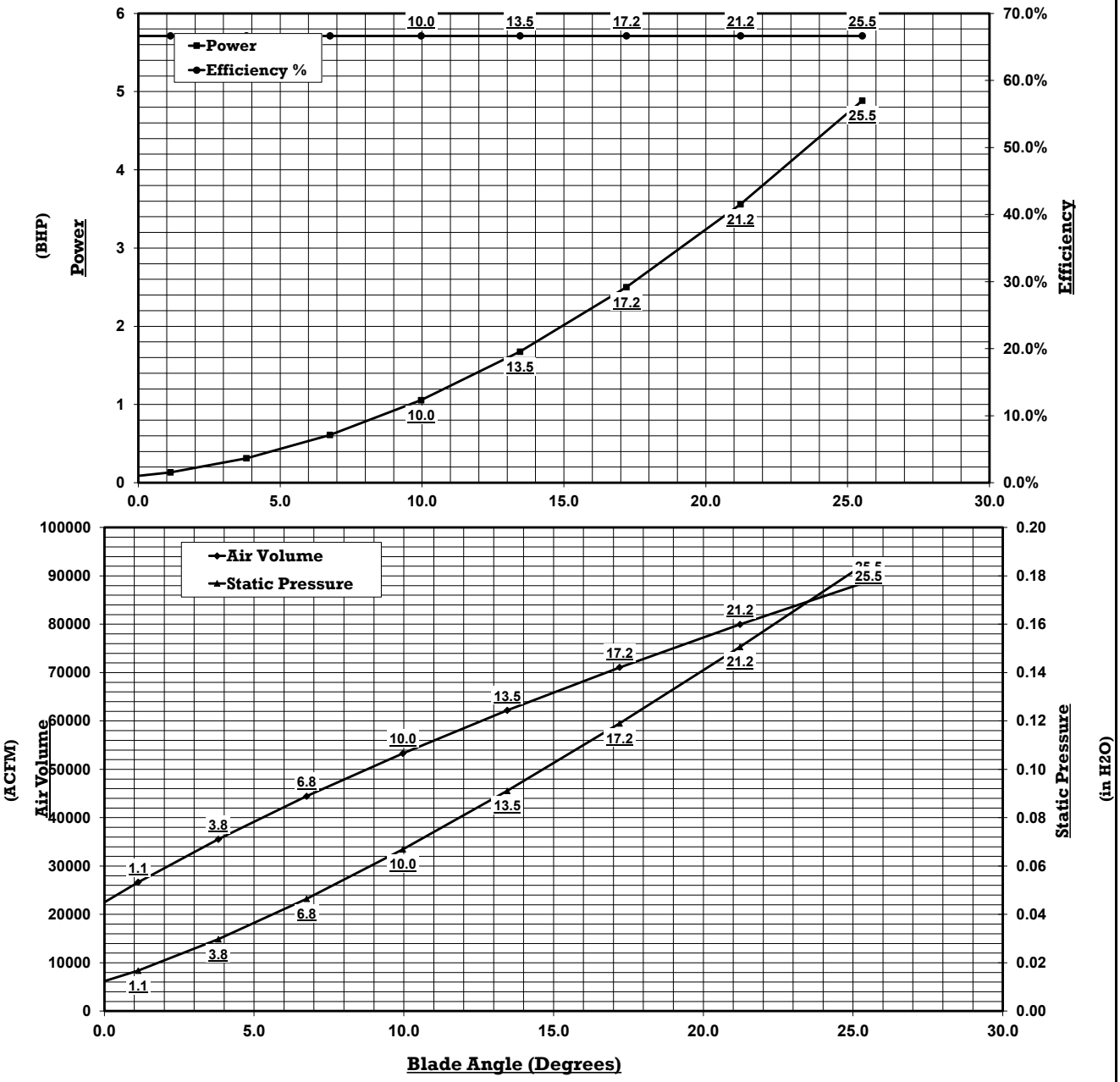
Dominion Trans	Reference No.	Northamption	Item No.	D2.2C

System Performance Curve



Design Angle= 21.5

Est. API Angle= 25.4

Maximum Angle= 25.5

Design Conditions

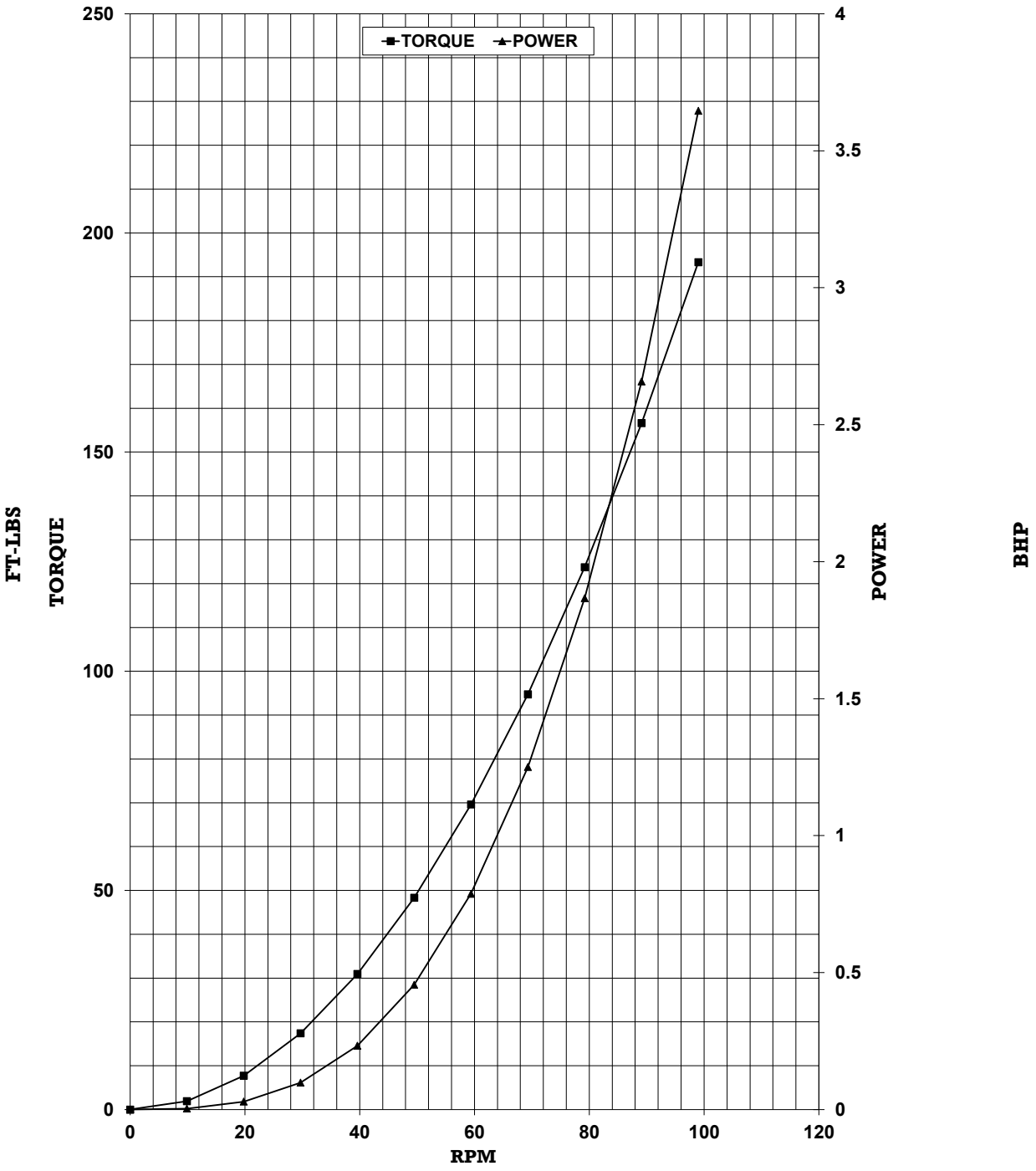
Class:	10000	**Blade Type:**	MAG	**Temperature:**	60	Deg. F	**Static Pr.:**	0.153	in H2O
Series:	48	**Blade Tip:**	AM	**Elevation:**	145	feet	**Power Req'd:**	3.65	bhp
Diameter:	12.00 feet	**Adjustment:**	MAN	**Density Ratio:**	1.014		**Design Angle:**	21.5	deg
RPM:	99	**Blades:**	3	**Air Volume:**	80600.00	ACFM	**Weight:**	282	lbs

Moore Fans LLC

Phone: (660) 376-3575 www.moorefans.com Fax: (660) 376-2909

Dominion Trans **Reference No.** **Northamption** **Item No.** **D2.2C**

Class 10000 Speed-Torque Curve



Design Conditions

Class:	10000	**Blade Type:**	MAG	**Temperature:**	60	Deg. F	**Static Pr.:**	0.153	in H2O
Series:	48	**Blade Tip:**	AM	**Elevation:**	145	feet	**Power Req'd:**	3.65	bhp
Diameter:	12.00	feet	**No. Blades:**	3	**Density Ratio:**	1.014		**Design Angle:**	21.5	deg
RPM:	99	**Rotation:**	RH	**Air Volume:**	80600.00	ACFM	**Weight:**	282	lbs

Moore Class 10000 Heavy Duty Standard Chord (SC) and Extended Chord (EC)
Blade Droop and Clearance Dimensions

Class	10000 Heavy Duty
Series	48
Diameter (Ft)	12.00
Blade Chord	MAG
Type	MAN
Orientation	Horizontal
Bushing Type	U
RPM	99
Blade Load	92.2%
Design Angle	21.5
Blade Tip	AM

A= Blade tip profile height at specified design angle (Path Width)

B=Blade running droop at specifed RPM and Blade Load (C/L to bottom of blade)

C= Maximum droop position of blades (C/L to bottom of blade)

D= Minimum recommended obstacle clearance on air inlet side

E=Maximum height of blade at design angle. (C/L to Air Outlet Side)

H_1=Maximum height of blade at max. recommended angle (C/L to Air Outlet Side)

H_2=Maximum height of blade at 30 degrees (C/L to Air Outlet Side)

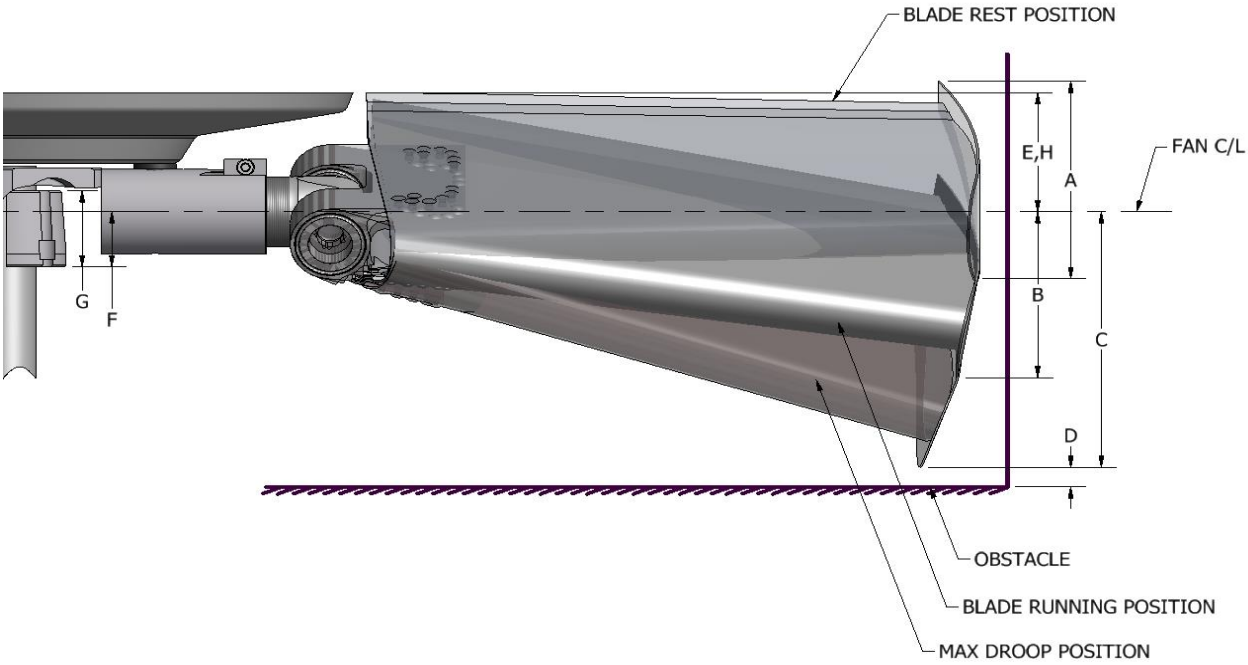
F= Fan centerline to Base of Bushing (Standard hub without extension)

G= Overall bushing height

S= Air Seal Diameter

(All dimensions shown are in inches)

A	B	C	D	E	H_1	H_2	F	G	S
7.6	2.7	3.2	2.0	5.7	6.2	6.9	2	2.7	47



CLASS 10000 FANS
OWNER'S MANUAL

CONTENTS

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.

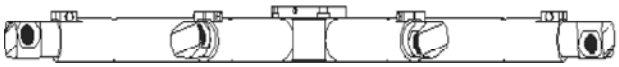
2.1.2 PLANNING THE INSTALLATION

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.

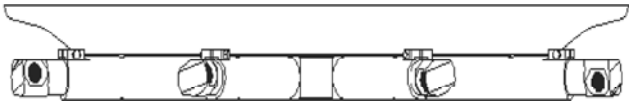
Class 10000 fans are suitable for horizontal or vertical mounting, for electric motor or engine drive and may be designed for clockwise (right hand) or counterclockwise (left hand) rotation. **Note: Automatic fans can only be installed for horizontal applications.** ***(Vertical shaft)***

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:

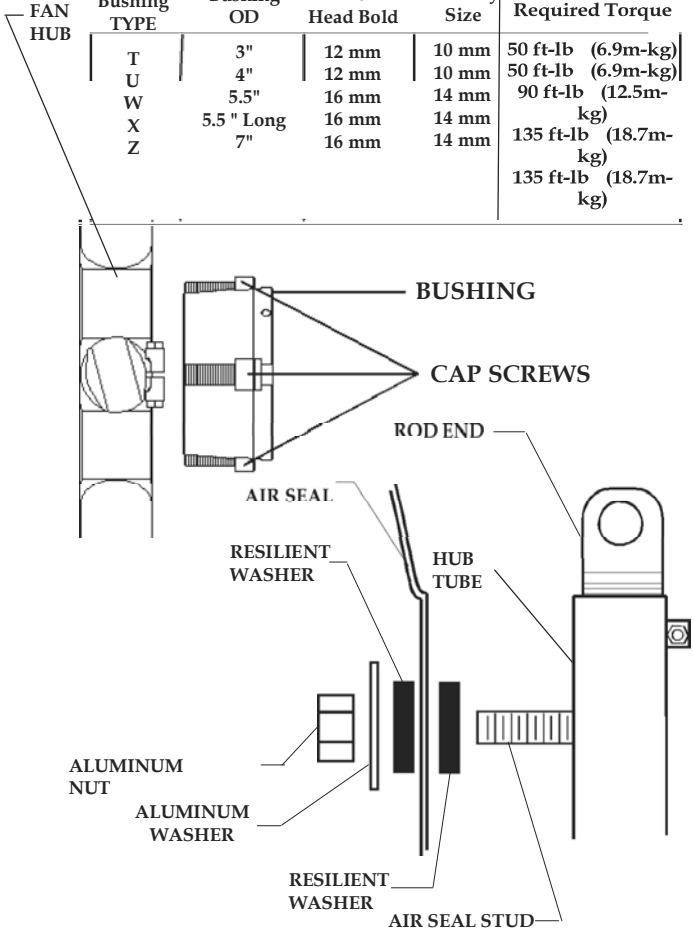
If the bushing was pre-installed in the hub at the factory, no further lubrication is required prior to installation.

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.

Bushing TYPE	Bushing OD	Allen Head Bold	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)



AIR SEAL INSTALLATION ON HUB

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.

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.

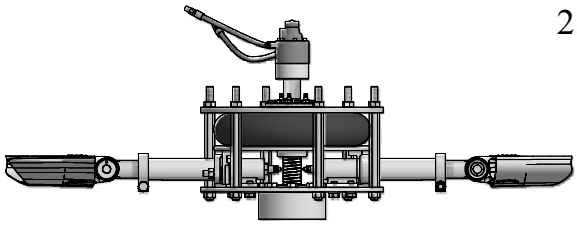
Place one resilient washer on each stud as shown in the drawings at left. Place the air seal onto the studs and install the remaining hardware, following the sequence shown in the drawings. Do not lubricate this end of the studs.

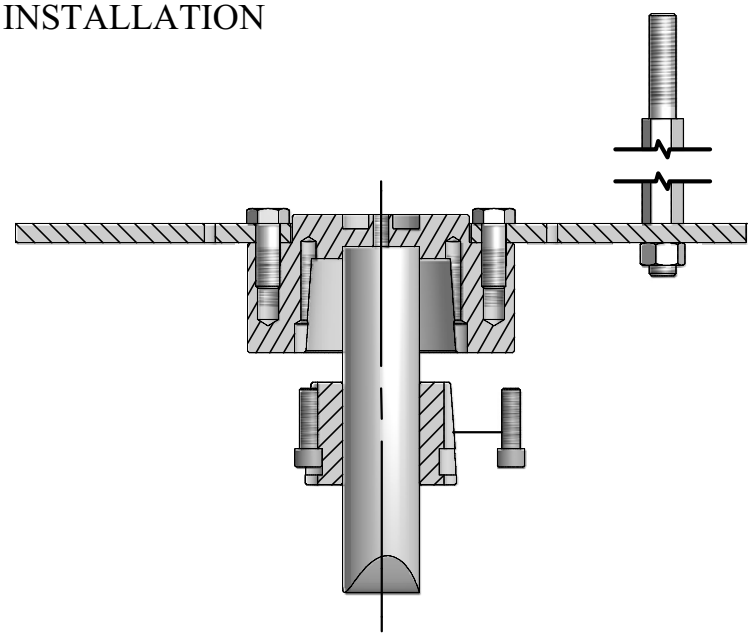
Note that the diameter of the resilient washers, before they are compressed, is slightly less than the diameter of the aluminum washer. Tighten each nut until the resilient washer's diameter is the same as the aluminum washer. Do not overtighten. Overtightness exists when the resilient washer has expanded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

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.

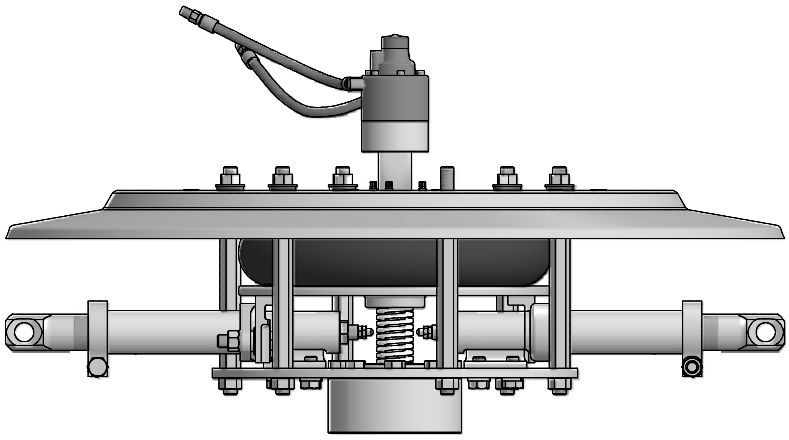
IF BUSHING IS PRE-INSTALLED INTO HUB

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.

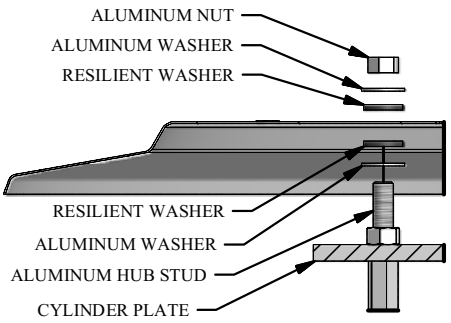
FAN SERIES	BUSHING TYPE	BUSHING OD	ALLEN HEAD BOLT	HEX KEY SIZE	REQ'D TORQUE
24	T	3"	12mm	10mm	50 ft-lb (6.9 m-kg)
30-72	U	4"	12mm	10mm	50 ft-lb (6.9 m-kg)
30-72	W	5.5"	16mm	14mm	90 ft-lb (12.5 m-kg)

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.

Note that the diameter of the resilient washers before they are compressed, is slightly less that 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 INSTALLED ON AUTOMATIC HUB WTH POSITIONER



AIR SEAL INSTALLATION ON AUTOMATIC HUB

2.4 INSTALL PNEUMATIC TUBING

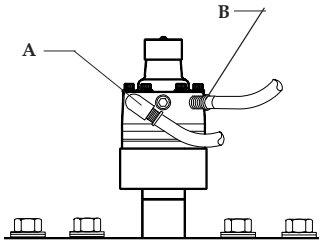
2.4.1 AUTOMATIC HUB WITH STANDARD POSITIONER

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

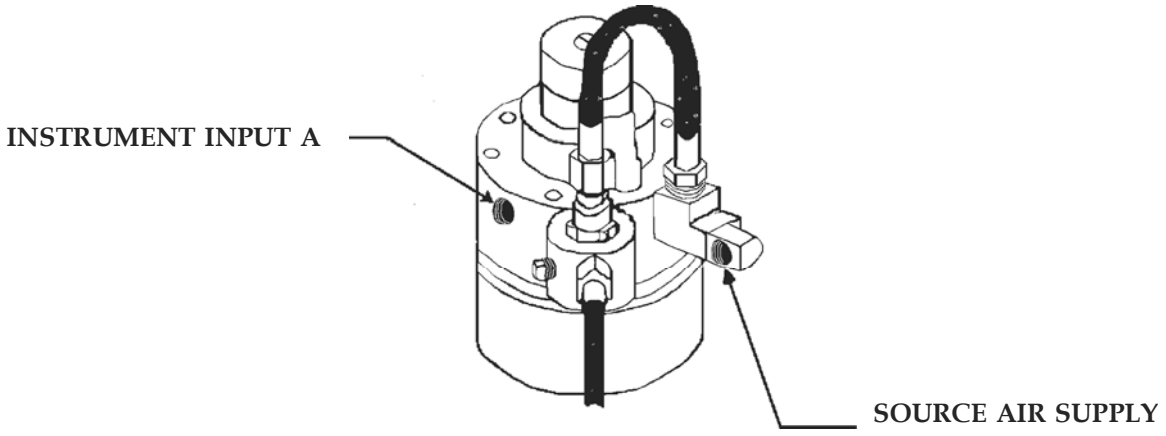
MAXIMUM SUPPLY PRESSURE:
60 P.S.I. (4.2 Kg/Cm^2)

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.

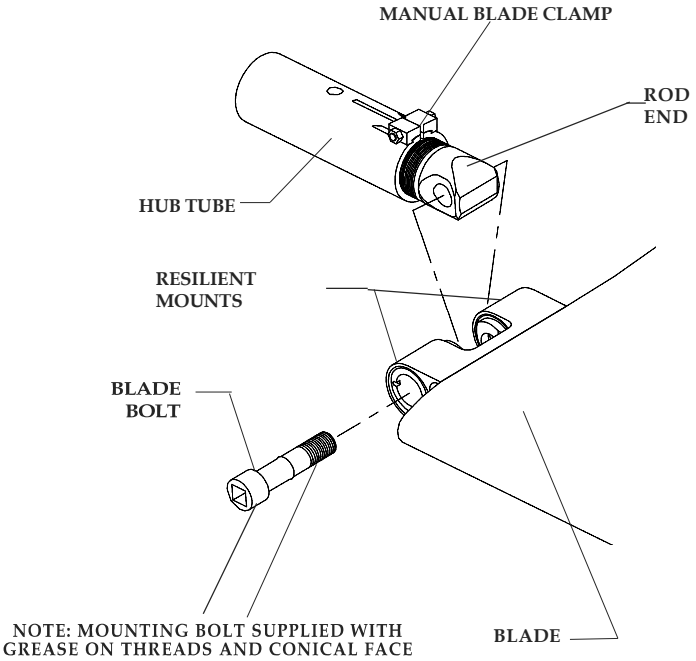


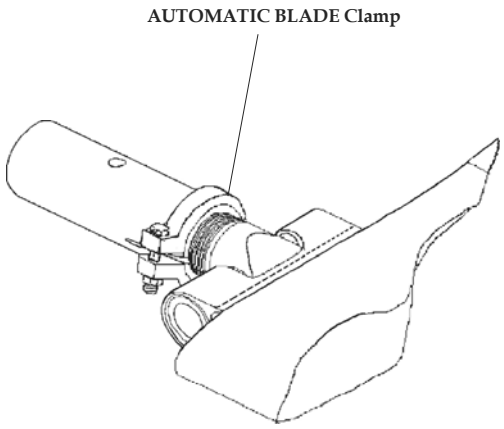
Note:

After installing hub onto bushing: Check the hub and positioner for run out.
Maximum run out of positioner in the horizonal direction is ±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

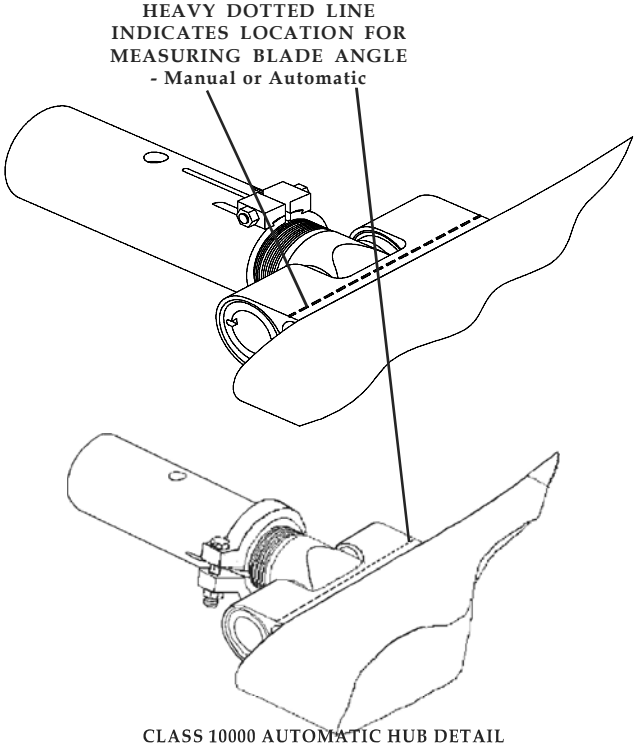
Hubs are shipped from the factory with the rod end set for the blade angle indicated by the design performance. A change in blade angle is sometimes necessary, however, to adjust to actual site conditions. Failure to adjust the blade angle when required may result in blade overload. The causes of improper 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 freqently 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 <u>ALL</u> 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 horsepowers, 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 x 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.

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

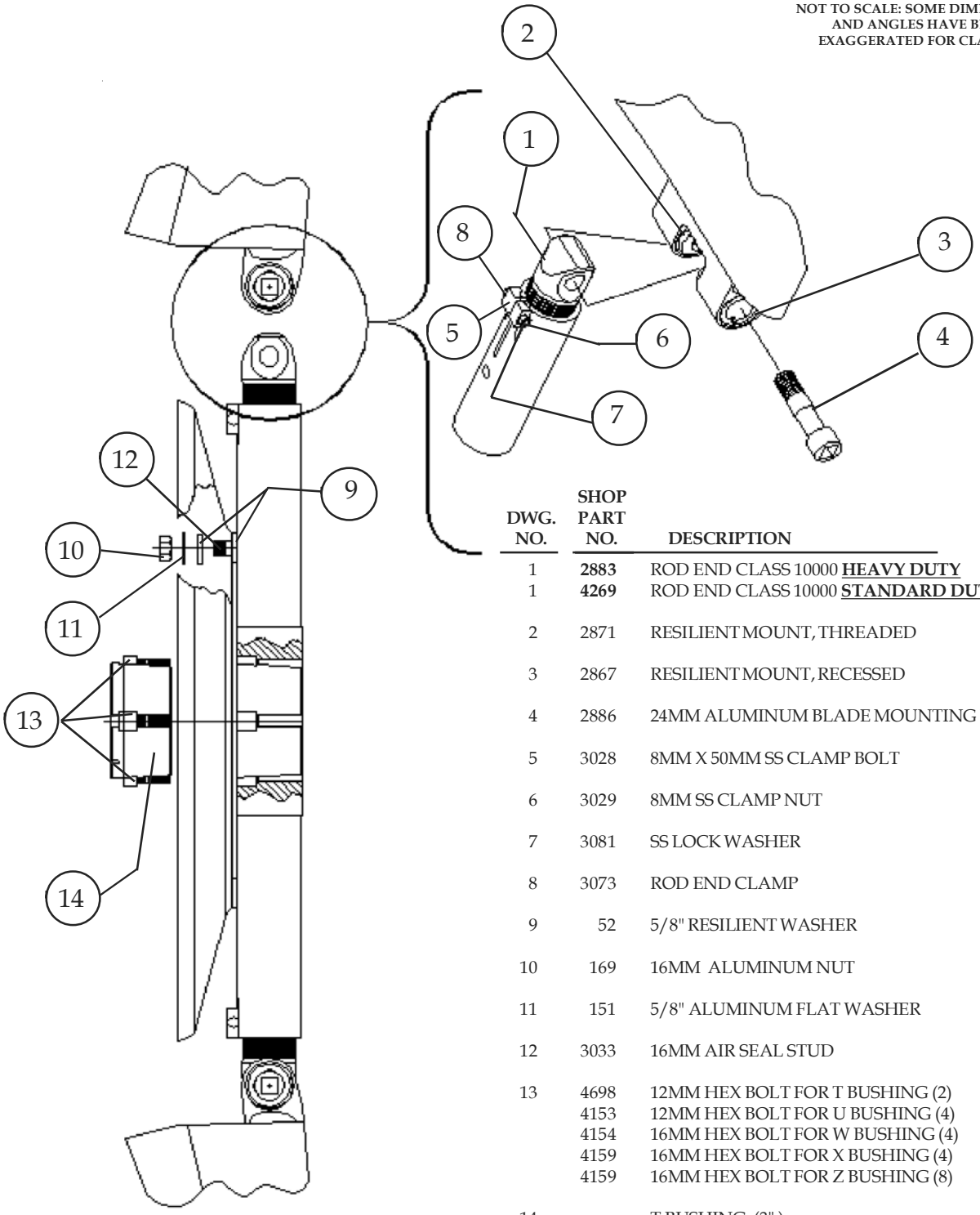
Unbalance in older fans may develop because of some structural change or by installing one new blade on an old fan where the existing blades had changed in weight in the course of operation.

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.

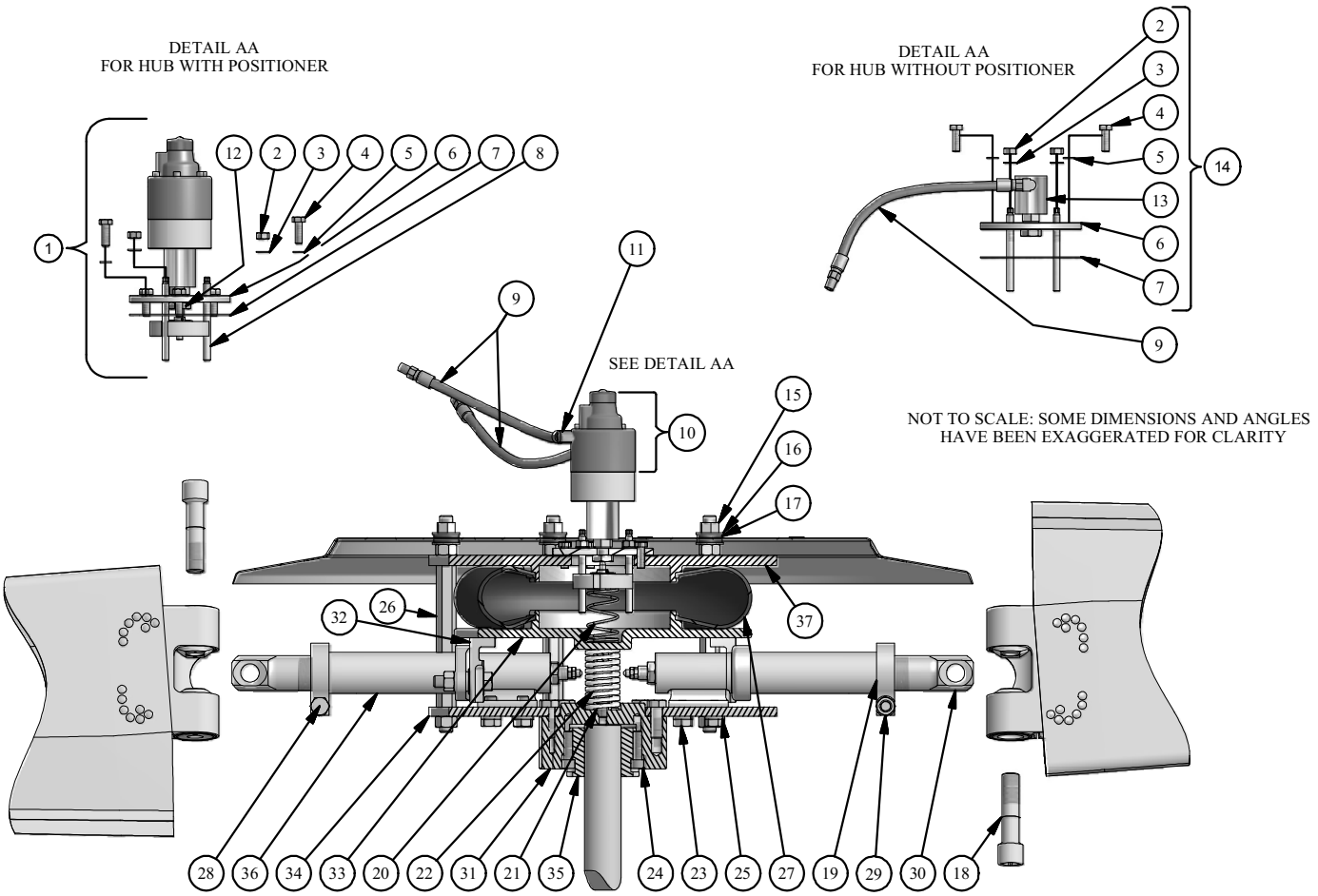
3.5 MANUAL FAN PARTS LIST



DWG. NO.	SHOP PART NO.	DESCRIPTION
1	**2883**	ROD END CLASS 10000 **HEAVY DUTY**
1	**4269**	ROD END CLASS 10000 **STANDARD DUTY**
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
1	2624	CSP UNION ASSEMBLY (WITH POSITIONER)
2	1625	10mm STAINLESS STEEL NUT (3)
3	733	3/8" SEALED WASHER (3)
4	771	10mm x 30mm STAINLESS STEEL BOLT (6)
5	179	3/8" FIBER WASHER (6)
6	162	UNION PLATE
7	163	UNION PLATE GASKET
8	159	STAINLESS STEEL STOP STUD (3)
9	257	12" STANDARD NEOPRENE AIR HOSE ASSEMBLY WITH 1/4" NPT EXTERNAL THREADS BOTH ENDS
10	21	POSITIONER
11	210	1/4" BRASS STREET ELL
12	344	5/8-18 LH LOCKNUT
13	264	CS ROTARY UNION
14	186	CS UNION ASSEMBLY WITH HARDWARE
15	1532	18mm ALUMINUM NUT
16	164	3/4" ALUMINUM FLAT WASHER
17	52	5/8" RESILIENT WASHER
18	2886	24MM ALUMINUM BLADE MOUNTING BOLT
19	644	SMALL CLEVIS CLAMP
20		RANGE SPRING
21		RETURN SPRING SHIM
22		RETURN SPRING
23	4515	16mm x 32mm ALUMINUM ANCHOR TEE BOLT (4 per BLADE)
24		12mm HEX BOLT FOR T BUSHING (2)
		12mm HEX BOLT FOR U BUSHING (4)
		16mm HEX BOLT FOR W BUSHING (4)
		16mm HEX BOLT FOR X BUSHING (4)
25	152	5/8" ALUMINUM LOCK WASHER (4 per BLADE)
26	1530	18mm x 302mm ALUMINUM HUB STUD
27	16	DIAPHRAGM ACTUATOR
28	167	16mm x 70mm ALUMINUM BOLT
29	169	16mm ALUMINUM NUT
30	4269	ROD END
31		AUTOMATIC FAN BUSHING ADAPTER
32		PISTON STRUT ASSEMBLY WITH HARDWARE
33		PISTON PLATE
34		AUTOMATIC HUB PLATE
35		T BUSHING (3")
		U BUSHING (4")
		W BUSHING (5.5")
		X BUSHING LONG (5.5")
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.

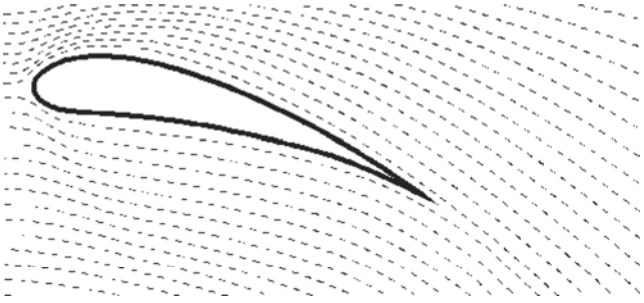
When this occurs, the wing loses a large portion of its lift. Flow, however, will re-establish briefly and break again, the cycle being repeated continuously, resulting in a severe vibration throughout the aircraft as the flow alternately makes and breaks. Anyone who has experienced a stall in an airplane 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.

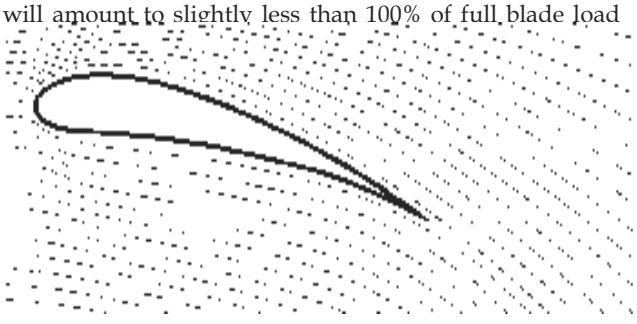
Another way of looking at this problem is to consider that the available number of blades are set at too steep an angle to be able to move air at the axial velocity which is necessary to maintain a smooth flow over the convex surface. In other words, to move air at the velocity necessary for this blade 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 do 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^{O} 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^{O}. 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.

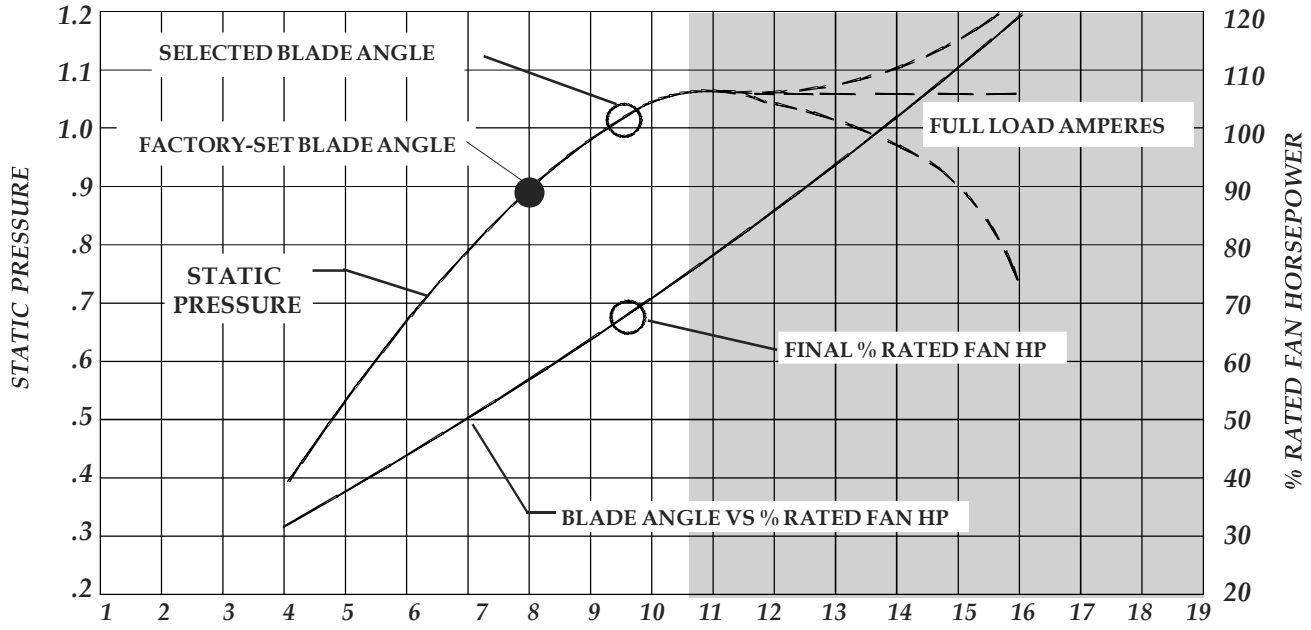
Start the fan and record on the chart provided the blade angle and he static pressure indicated. Advance the blade angle by one or two degrees and repeat the performance, recording again these readings. Keep increasing the angle and following this procedure until the motor is fully loaded, in which case 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.

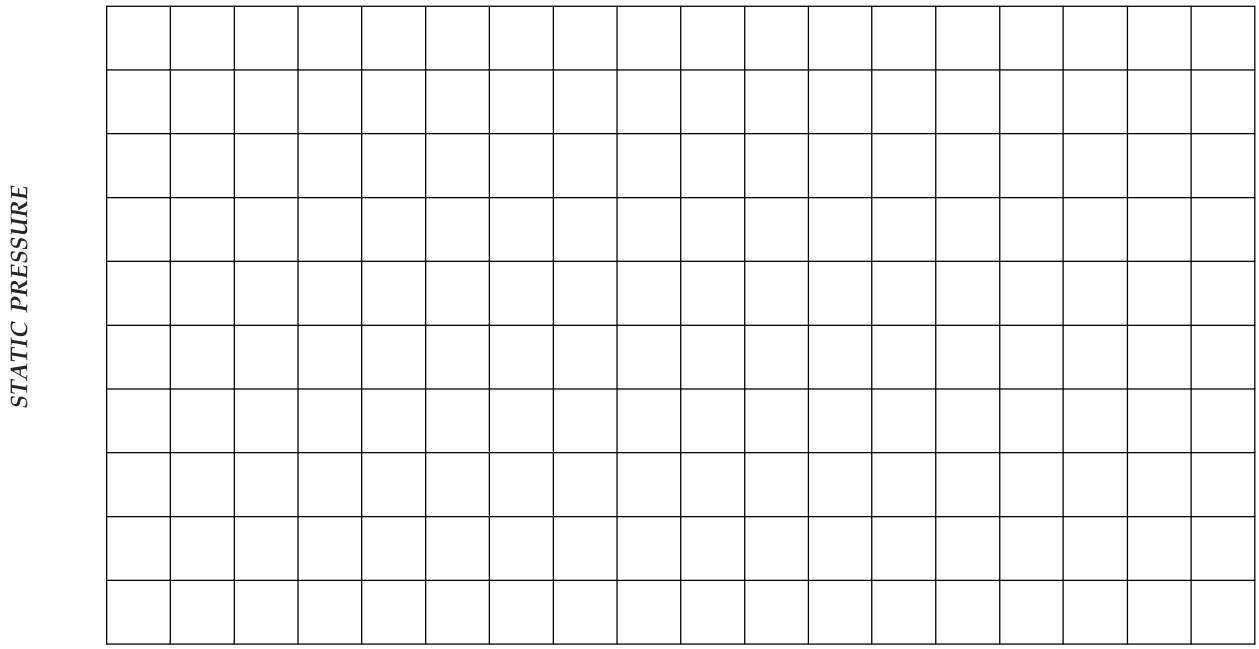
The point so selected will also approximate the point of the most efficient operation of the fan. Due to possible error in static pressure predictions, or in readings which are intended only to be relative, as well as other variables, the final blade setting chosen may fall below or above the specified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

A typical performance chart is shown opposite for a fan capable of a higher blade loading than origianally 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.

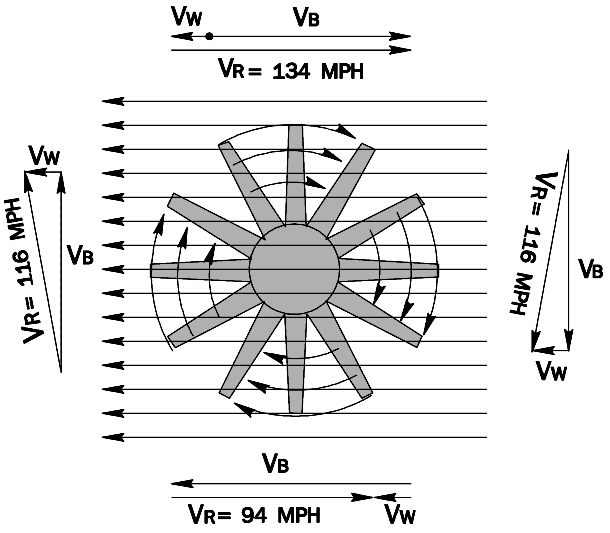
Ideally, air should approach a fan in an axial direction and at a uniform velocity over the area of the fan. Air approaching a fan at an angle tends to increase the relative velocity of the blades to the air on one side of the fan and decrease the relative velocity on the other side. This means that 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.

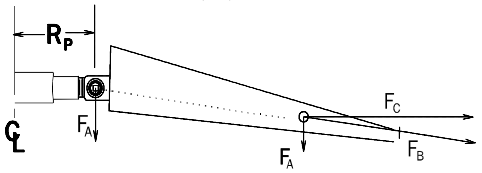
In the case of a fan blowing inward in a short ring, the condition is even more critical. In such an installation, the air on the inlet side of the fan has a horizontal velocity which may be quite high. It is necessary for the fan to pick up this air and direct it inward. In a strong wind, the angle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

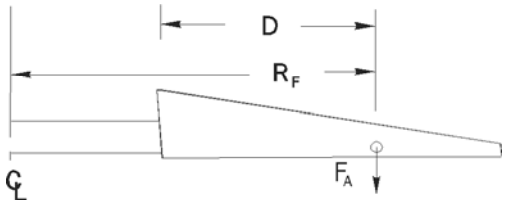


THE EFFECT OF AIR LOAD ON HUB AND DRIVE

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 positions 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 conditions.



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 beind 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.

Industrial Belt Design - Drive Detail Report

Unlaub® Problem Solver using Gates DF-Pro

Designed For:

Provided By: Lynn Kleine
The Unlaub Company
1722 East King Place
Tulsa, Oklahoma 74110
United States
lkleine@unlaub.com
918-895-8813 Phone
918-585-8219 Fax

Application: **SMIT 16B286**

INPUT

			DriveR	DriveN
Known Belt:	**Super HC** 5VX1320 - 2	Known Size:	4.4 in Outside	37.5 in Outside
Speed Ratio:	8.70 Down	RPM:	860.0	98.9
Input Load:	5 hp, Efficiency: 87.00 %			
Service Factor:	1.4	Shaft Diameter:	1.625 in	2.9375 in
Design Power:	7 hp			
Center Distance:	28.05 in	Bushings Checked:	QD, No MPB	
Motor Standards:	NEMA Electric Motor, NEMA 254T frame	Belts Checked:	Super HC	
				Single Belts

SELECTED DRIVE

			Belt	DriveR	DriveN
Belt Type:	**Super HC - 5VX**	Total # of Strands/Ribs:	2		
Speed Ratio:	**8.70 Down**	Part No:	2-5VX1320	QD2/5V4.40	**QD3/5V37.50**
dN RPM:	**98.9**	Product No:	9414-1320	7874-2044	7874-3375
Rated Load:	**8.19 hp**	Top Width:	--	1.69 in	2.38 in
ODR:	**1.17**	Weight:	2.4 lb	3.3 lb	144 lb
Belt Pull:	**324 lbf**	Rim/Belt Speed:	968 ft/min	991 ft/min	971 ft/min
Center Distance:	28.05 in	RPM:	88.0	860.0	98.9
Install/Take-Up Range:	27.05 in to 30.25 in	Bushing Part No:	--	SH 1 5/8	F 2 15/16
		Bushing Product No:	--	7838-1110	7839-2215
		Bore:	--	1.625 in	2.9375 in
		Bolt Torque	--	108 lb-in	1320 lb-in
		Pitch Diameter:	--	4.30 in	37.40 in

TENSION

	New Belt	Used Belt
Static Tension (per rib/strand):	122 to 131 lbf	105 to 113 lbf
Static Belt Pull (total pull):	394 to 423 lbf	338 to 366 lbf
Rib/Strand Deflection Distance:	0.35 in	0.35 in
Rib/Strand Deflection Force:	8.5 to 9.0 lbf	7.4 to 7.9 lbf
Sonic Tension Meter:	543 to 582 N	466 to 504 N
Belt Frequency:	54 to 56 Hz	50 to 52 Hz
507C/508C Model STM Settings:	Mass 140.38g/m,Width: 1 mm/#R, Span: 575 mm	
Powerband Multiplier:	1.0041 to 1.0044	1.0035 to 1.0038

NOTES

- The belt width was user specified.
- This drive was not selected by Design Flex; the belt width/length was specified by the user.
- User requested non-PowerBand belts.
- The DriveR pulley bushing requires a shallow keyseat.
- The DriveN pulley/bushing weight exceeds 50 lb. Exercise care during installation.~
- This report: (1) only applies to Gates' products; (2) contains confidential information; (3) may only be disclosed to support the sale or maintenance of our products; and (4) is not a guarantee of performance.
- products are not designed, manufactured, or tested for use on aircraft applications, including aircraft propeller or rotor drive systems, and all manned or unmanned airborne applications of any type. Lift and Braking systems have special considerations. Buyer has sole responsibility for the selection and testing of products for any intended use.

Shock and Vibration Switch – VS2 Series

Features

- Designed to Detect Shock/Vibration in 3-Planes of Motion
- Fully Adjustable
- Includes Magnetic Latching Feature
- Manual or Electric Reset

* Selected Configurations are Third Party Listed

The VS2 Series switches are shock sensitive mechanisms for shutdown of engine or electric motor powered equipment. These switches use a magnetic latch to ensure reliable operation. Explosion-proof "EX" models for hazardous locations are available.

Applications

Ideal for use on engines, pumps, compressors, heat exchangers and pumping units, the VS2 Series can be used anywhere shutdown protection from damaging shock/vibration is desired. Switches are field adjustable to sensitivity required in each application.

Specifications

VS2 and VS2C
Case: Environmental Protection: Ingress protected to IP54 (when mounted on a horizontal surface with drain holes down). Suitable for non-hazardous areas.
VS2C: C-clamp mount, includes 45 ft. (13.7 m) 2-conductor cable, and 5 cable clamps
Contacts: SPDT-double make leaf contacts, 3A @ 240 VAC; 10A @120 VAC; 10A @ 32 VDC
Shipping Weight:
VS2: 2 lb 8 oz. (1.1 kg)
VS2C: 7 lb (3.2 kg)
Shipping Dimensions:
VS2: 8-1/4 x 9-1/4 x 5 in. (210 x 235 x 127 mm)
VS2C: 12 x 7 x 5-1/2 in. (305 x 178 x 140 mm)

VS2EX
Case: Base mount, explosion-proof aluminum alloy housing; meets IP54 specifications; Class I, Division 1, Groups C & D; UL and CSA listed
Certification: CSA, UL
Snap-switches: 2-SPDT snap-switches; 5A @ 480 VAC;* 2A resistive, 1A inductive, up to 30 VDC
Normal Operating Temperature: -40°F to 185°F (-40°C to 85°C)
Shipping Weight: 4 lb 8 oz. (2 kg)
Shipping Dimensions: 8-1/4 x 9-1/4 x 5 in. (210 x 235 x 127 mm)

VS2EXR
Case: Same as VS2EX
Certification: CSA, UL
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)
Shipping Weight: 5 lb 8 oz. (2.2 kg)
Shipping Dimensions: 8-1/4 x 9-1/4 x 5 in. (210 x 235 x 127 mm)

VS2EXRB
Case: Explosion-proof aluminum alloy housing; rated Class I, Division 1, Group B hazardous areas
Certification: No third party certification
Snap-switch: 1-SPDT snap-switch with reset coil (option available for 2-SPDT switches); 5A @ 480 VAC; 2A resistive, 1A inductive, up to 30 VDC
Remote Reset: 115 VAC or 24 VDC (specify)
Shipping Weight: 17 lb 8 oz. (7.9 kg)
Shipping Dimensions: 12 x 12 x 10 in. (305 x 305 x 254 mm)

Basic Operation

Pushing the reset button moves the tripping latch into a magnetically held position. A shock/vibration will move the magnet beyond this holding position, thus freeing the spring loaded tripping latch to transfer the contacts and shutdown the machinery (see dimensional diagrams in the following pages for visual representation of parts).

Remote Reset Option (VS2EXR and VS2EXRB)

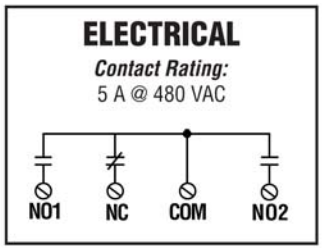
The remote reset option includes a built-in electric solenoid which allows reset of tripped unit from a remote location. Available for 115 VAC or 24 VDC.

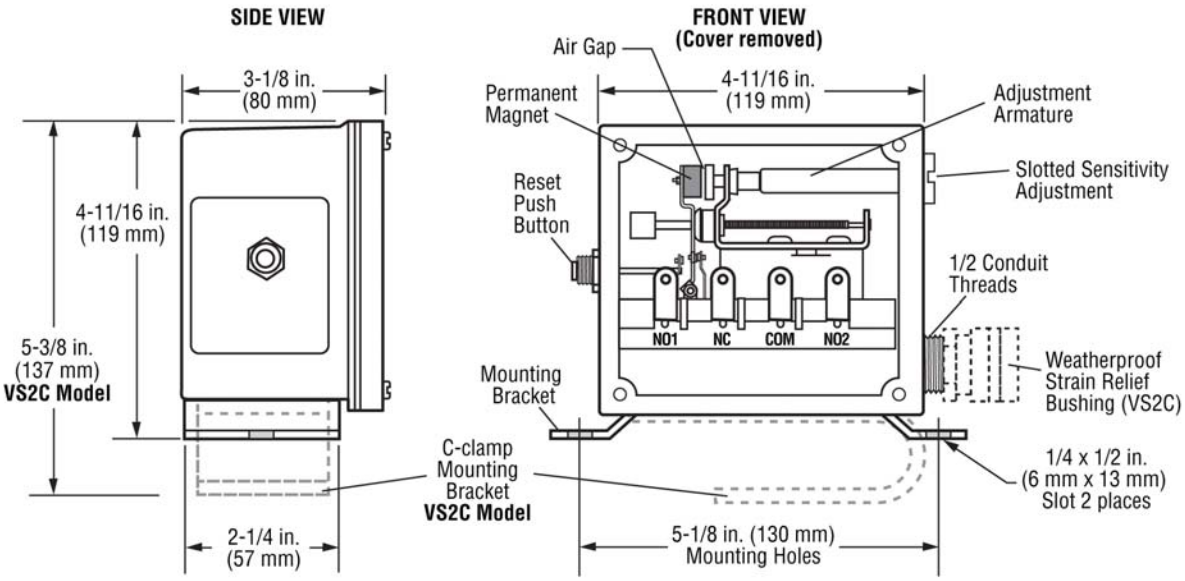
Dimensions

Environmental Protection: Ingress protected to IP54 (when mounted on a horizontal surface with drain holes down).

VS2 and VS2C

The VS2 and VS2C are designed for use in non-hazardous locations. They have leaf type SPDT, double make contacts that can be used for shutdown and/or alarm. They have a slotted sensitivity adjustment located on the side of the case (see drawing below).

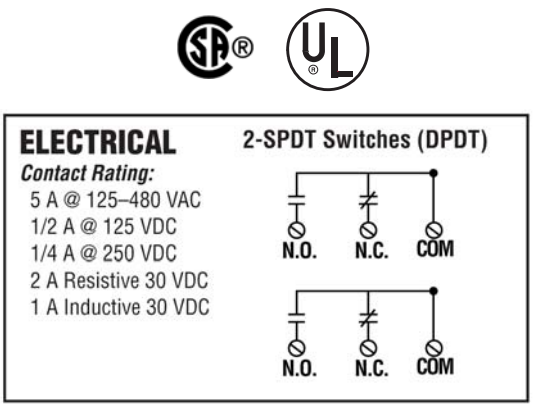


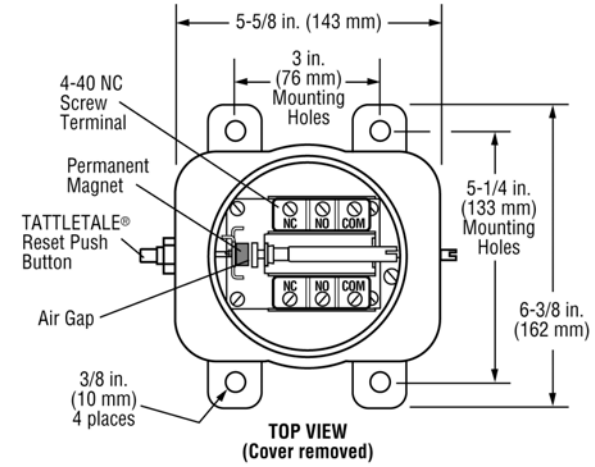


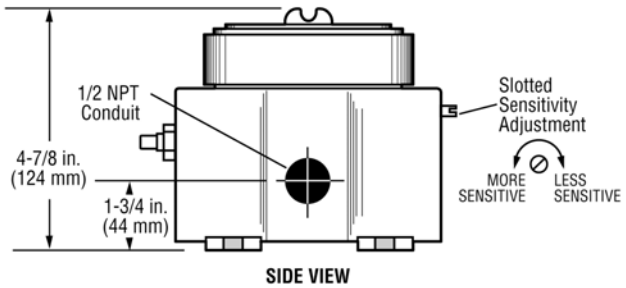
VS2EX

- **IP54 Specifications**
- **Snap-switch Contacts**
- **TATTLETALE® Reset Button**

Model VS2EX is housed in an explosion-proof enclosure with threaded cover. This enclosure is CSA and UL listed for Class I, Division 1, Groups C & D hazardous locations. In place of the leaf type contacts, 2-SPDT snap-switches are used in this model. Sensitivity is externally adjustable and, when tripped, the VS2EX gives a TATTLTALE® indication on the reset button. It is constructed to meet IP54 specifications.



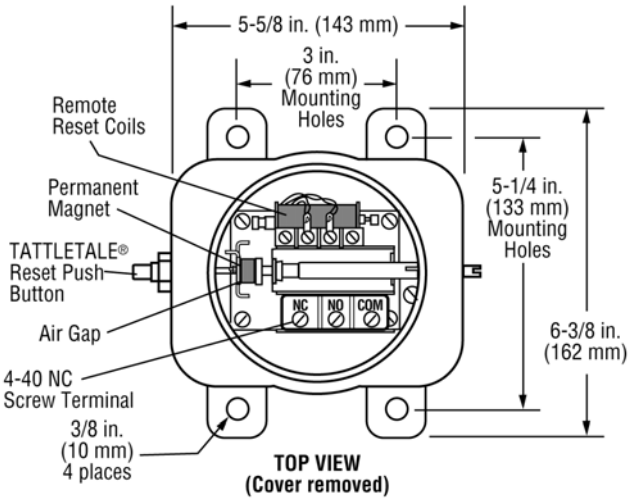




VS2EXR

- **Remote Reset Feature**
- **IP54 Specifications**
- **Snap-switch Contacts**
- **TATTLETALE® Reset Button**

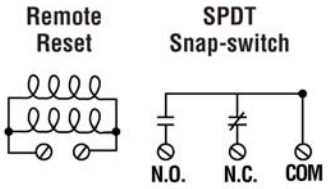
Model VS2EXR features an electric remote reset feature in addition to the TATTLETALE® reset button. The VS2EXR uses only one SPDT snap-switch and is CSA and UL listed for Class I, Division 1, Groups C & D hazardous locations. It is constructed to meet IP54 specifications.

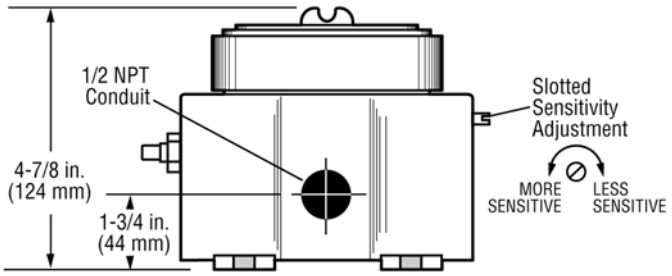


ELECTRICAL

Contact Rating:
5 A @ 125–480 VAC
1/2 A @ 125 VDC
1/4 A @ 250 VDC
2 A Resistive 30 VDC
1 A Inductive 30 VDC

Remote Reset Rating:
115 VAC or 24 VDC (Specify)
350 mA AC/DC





VS2EXRB

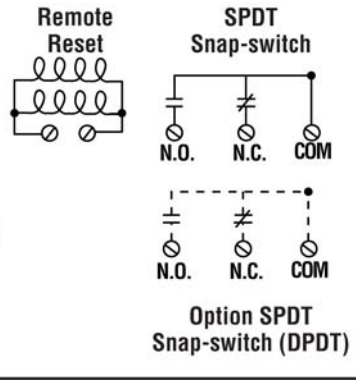
- **For Group B Locations**
- **Snap-switch Contacts**
- **DPDT Feature Optional**

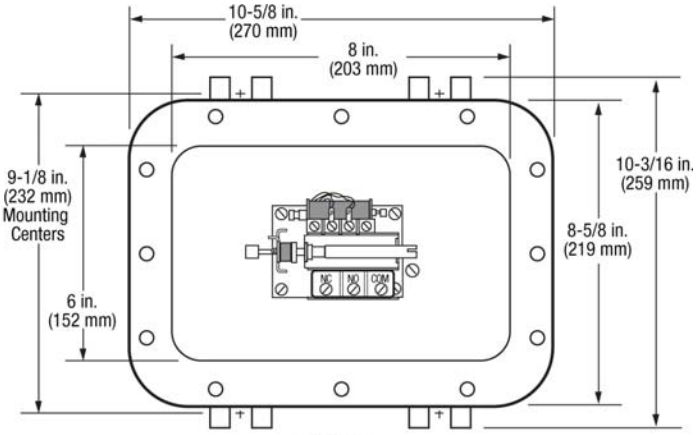
Model VS2EXRB is constructed for use in Class I, Division 1, Group B, hazardous locations. It has, as standard, a SPDT snap-switch and an electric remote reset. Option is available for DPDT snap-switch

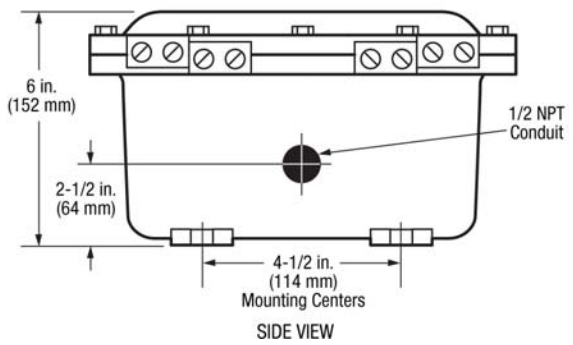
ELECTRICAL

Contact Rating:
5 A @ 125–480 VAC
1/2 A @ 125 VDC
1/4 A @ 250 VDC
2 A Resistive 30 VDC
1 A Inductive 30 VDC

Remote Reset Rating:
115 VAC or 24 VDC (Specify)
350 mA AC/DC







Service Parts

When ordering service parts, specify both part number and description in listing below.

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 (VS2C)
20-00-0261 Cable clamp assembly (1 each) (VS2C)
20-05-0465 2-Conductor electrical cable, 45 feet (13.7 meters) (VS2C)
20-00-0137 5 clamps and 45 feet (13.7 meters) of cable (VS2C)

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

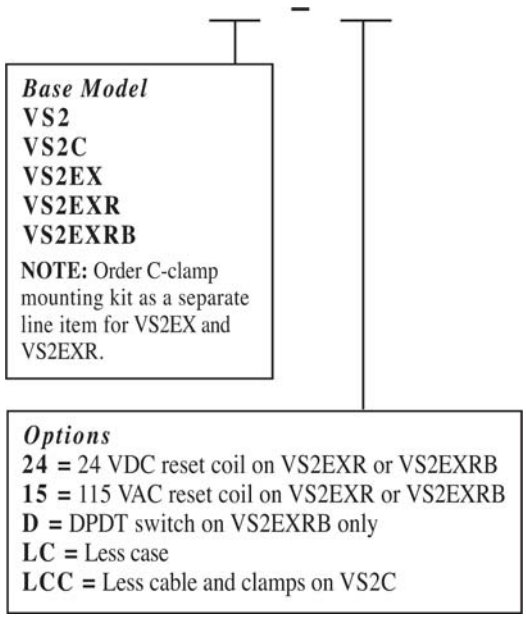
VS2EXR
20-00-0262 Movement assembly
20-05-0087 Cover
00-00-0309 Cover gasket
20-01-0090 Snap-switch and insulator kit (1 switch per kit)
prior to September 1, 1995.*
20-00-0288 Snap-switch and insulator kit (1 switch per kit) for models manufactured on September 1, 1995 or later.*
20-00-0049 Reset solenoid assembly (115 VAC)
20-00-0234 Reset solenoid assembly (24 VDC)
20-00-0289 C-clamp conversion mounting kit

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
20-00-0262 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.

How to Order

To order your VS2 Series model use the diagram below.
Part number example: **VS2EXR-24**



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, ¼" x 1¼" long, fine thread. Ensure a screw is in place on all corners and not greater than 18" centers on 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, refer to www.airtechproducts.com .
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)

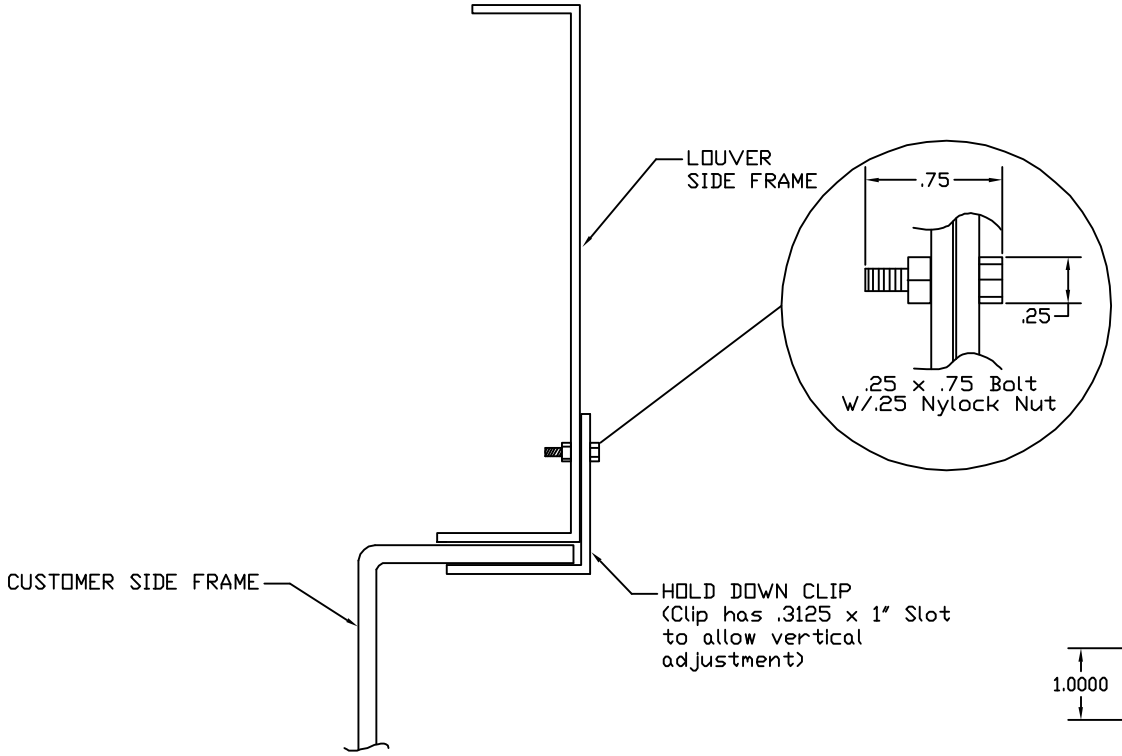
1. Visually inspect all blade pins to ensure the pin bearings are in place and do not have unacceptable wear.
2. Visually inspect all connections between blade horns and actuator rod to confirm all connecting bearing, bolts and nuts are in place and not showing unacceptable wear.
3. Visually inspect 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.

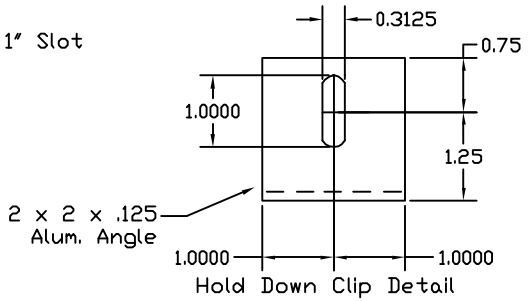
RECOMMENDED SPARE PARTS LIST

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

12-30-08

Mounting Clip Detail



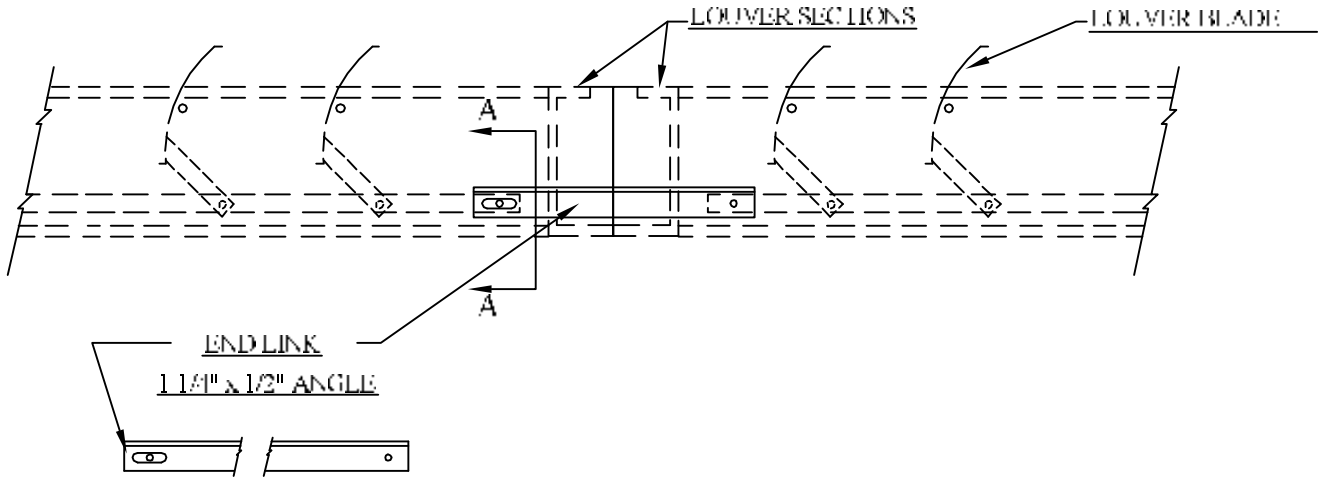


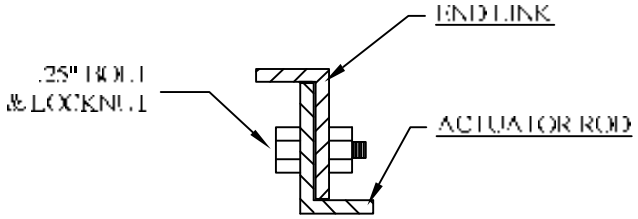
REFERENCE "A"

Airtech Products Inc.	
Mounting Clip Detail	
12/23/08	Stewart

All Dimensions in inches except as noted

700 / 740 / 900 SERIES





SECTION: A-A

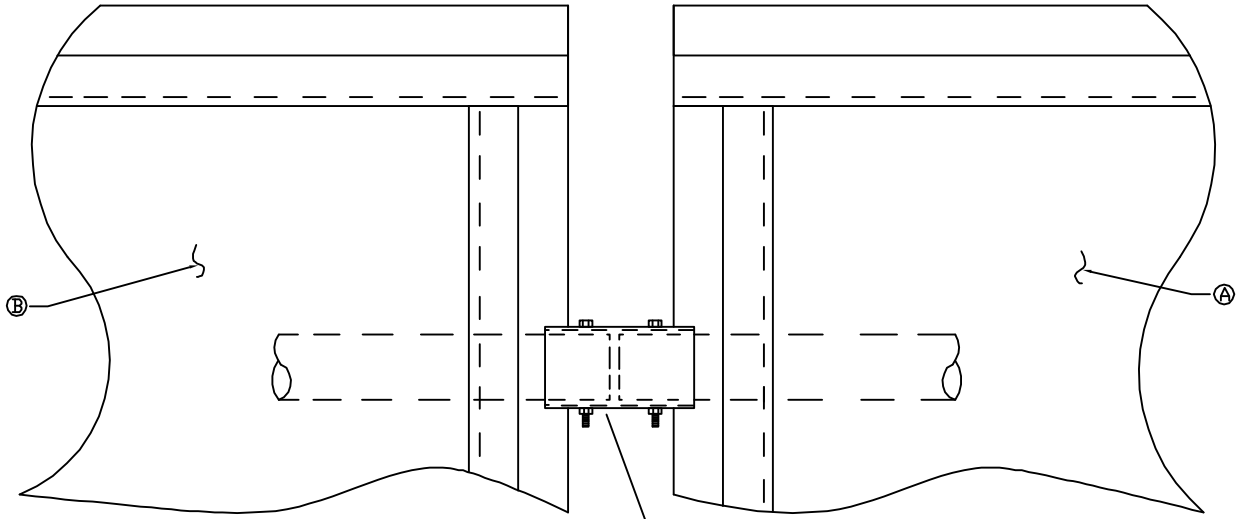
INSTALLATION:

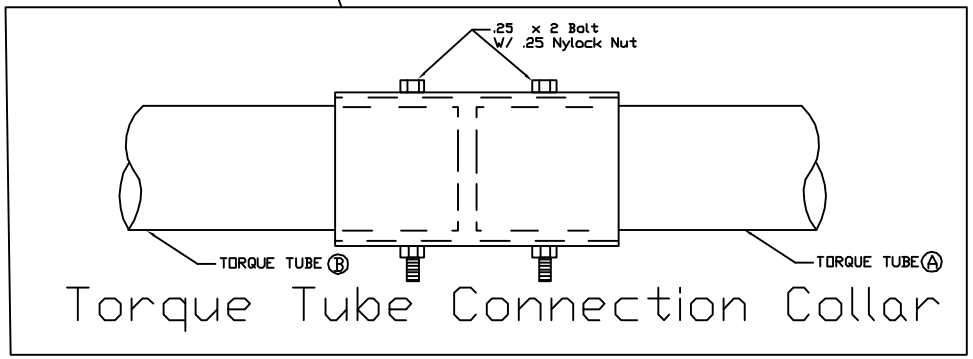
1. Position "Leading" section of louvers (closest to control end) to full open & attach end link to actuator rod using the included hardware.
2. Position blades in both louver sections to full closed.
3. Complete the installation by attaching the end link to actuator rod in "Trailing" section using the included hardware.

REFERENCE "B"

AIRTECH PRODUCTS, INC	
Dwg. Name: END LINK INSTALLATION	
Date: 12/23/08	By: Stewart

Connecting Collar Installation





Torque Tube Connection Collar

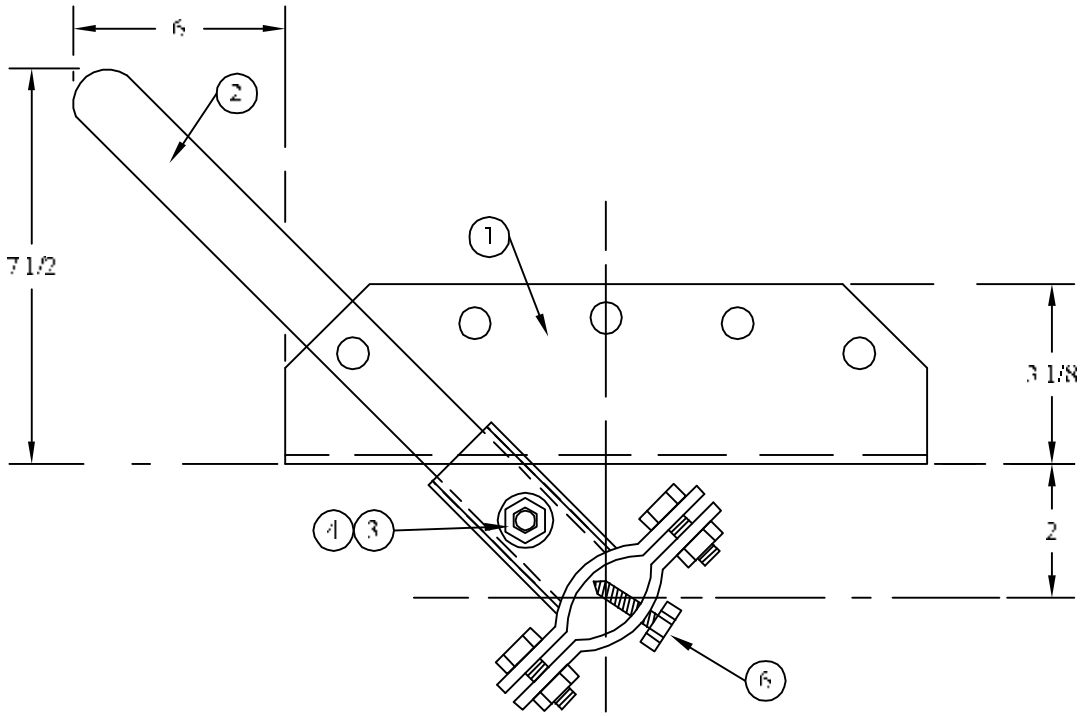
Installation:

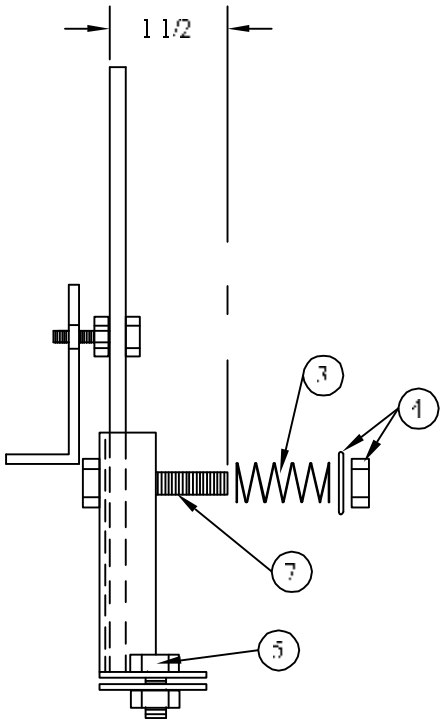
1. Attach louver section "A" to structure.
2. Remove 1/4" bolt and nut from end of connecting collar where section "B" torque tube will attach.
3. Slide section "B" torque tube into connection collar as section "B" is placed into position on structure.
4. Attach section "B" to structure.
5. Adust the blades in section "A" to the fully closed position. This will rotate the torque tube and the connecting collar so the empty hole (the bolt was removed in Step 2) will face to the front. Position the blades in Section B to the fully closed position. Using the existing hole in the connecting collar as a guide, drill a 9/32" hole thru the torque tube and out the other side of the collar. Insert the 1/4" x 2" bolt and securely tighten with Nylock nut

REFERENCE "C"

All Dimensions in inches except as noted

Airtech Products Inc.	
Connecting Collar Installation	
12/23/08	Stewart





PART #

(1) – MANUAL OPERATOR BRACKET / INDEX PLATE
(2) = MANUAL OPERATOR HANDLE
(3) – MANUAL OPERATOR HANDLE SPRING
(4) – MANUAL HANDLE NUT & WASHER
(5) = MANUAL HANDLE CLAMP BOLT & NUT
(6) – SET SCREW
(7) – 3/8"-16 x 1 1/2" PLTD. BOLT

REFERENCE "D"

All dimensions in inches except as noted

AIRTECH PRODUCTS, INC.	
Dwg. Name: MANUAL OPERATOR	
Date: 12/30/08	By: Stewart

SPARE PARTS

Serving the Industry Since 1952
Member of HTRI & ACHEMA

SMITHCO ENGINEERING
7718 E. 91st St. Suite #200
Tulsa, Oklahoma 74133
Phone: (918) 446-4406
Fax: (918) 446-7439

Co: Atlantic Coast Pipeline Date: 7/11/2018
Ref: 70301548

RECOMMENDED SPARE PARTS FOR 2 YEAR OPERATION
SMITHCO JOB NO. 2016B286

Item #	QTY	Description	Net Each	Total Net
001	142	A1051832 Plug	$7.00	$994.00
002	284	CS1813 gasket	$.50	$142.00
003	1	Fan Assembly, Class 10K, Series 48 MAG HD, 12 Ft. 3 Blade	$17,520.00	$17,520.00
004	1	2.9375 X 68.05 Shaft with 0.7500 X 0.3750 Keyway 3.18 one end 4.00 other end with keys (2) snap rings	$746.00	$746.00
005	1	5 HP Electric Motor, Smithco Job 2016B286	$2,502.00	$2,502.00
006	2	2.9375 SCM Flange Bearings	$399.56	$799.12
007	1	Matched set of (2) 5VX1320 V-Belt	$215.20	$215.20
008	1	3 groove 5V - 37.50 sheave with 2.9375 bore 0.7500 ks	$1,136.74	$1,136.74
009	1	2 groove 5V - 4.40 sheave with 1.6250 bore 0.3750 ks	$76.20	$76.20
010	1	VS-2EX Vibration Switch	$320.26	$320.26
			TOTAL	**$24,451.52**

Confirm parts before purchasing

The recommended quantities are for remote locations.

SECTION (4)

MAINTENANCE

WARRANTY CONTACTS

PARTS AND SERVICE MANAGER

Parts, Service and Warranty Manager
Smithco Engineering
6312 S. 39th West Ave.
Tulsa, OK 74132
Phone: (918) 388-0325
Fax: (918) 446-7439
E-mail: parts@smithco-eng.com

Parts Sales Associate
Smithco Engineering
6312 S. 39th West Ave.
Tulsa, OK 74132
Phone: (918) 388-0328
Fax: (918) 446-7439
E-mail: parts@smithco-eng.com

Equipment Warranty is based on negotiated Terms and Conditions as stated in

Customer PO # A6QJ-4-0405-00

Smithco Job # 2016B297

MAINTENANCE

This section of the manual contains information concerning service and maintenance of your air-cooled heat exchanger.

WARNING: Turn off and lock out or tag power source before proceeding with inspection of the cooler internal surfaces or mechanical equipment.

General Maintenance:

The interior and exterior of the air-cooled heat exchanger should be inspected periodically for safety, damage and cleanliness. All guards provided with the unit must be in place and properly attached. No buildup of grease or dirt should be allowed on any of the components. The finned tubes exterior should be checked for dirty fins and clogging of the fins with dirt or lint. The interior of the tubes should be checked for rust and scale. The thermal design is based on clean exterior and interior heat exchanger surfaces.

Mechanical Equipment References:

VENDOR WEBSITES

Electric Motors:	www.reliance.com www.sea.siemens.com/motors
Fans:	www.cofimco.com www.moorefans.com
Fan Shaft Bearings:	www.dodge-pt.com
V-Belts:	www.gates.com www.dayco.com
Vibration Switches:	www.fwmurphy.com www.metrix1.com www.icca.invensys.com (Robert Shaw)
Spiral Bevel Gear Boxes:	www.amarillogear.com www.hubcityinc.com
Louver Actuators/Controllers:	www.airtechproducts.com www.emersonprocess.com
Louvers:	www.airtechproducts.com

ELECTRICAL MOTOR MAINTANENCE

WARNING! Turn off and lock out or tag power source before proceeding

Inspection:

Each motor should be inspected at regular intervals. The frequency and thoroughness will depend on the amount of operation, nature of service and the environment.

Cleanliness:

The motor exterior should be kept free of oil, dust, dirt, water and chemicals. For fan-cooled motors, it is important to keep the air intake opening clear of debris.

Moisture:

On non-explosion proof TEFC motors, a removable plug in the bottom center of the motor frame permits removal of any accumulated moisture. Drain regularly.

Lubrication Schedule:

Check and re-lubricate bearings every six (6) months (more often if conditions require) as follows:

For best results, grease should be compounded from a lithium soap base and petroleum oil. It should be of No. 2 consistency and stabilized against oxidation. Operating temperature range should be from -15°F - +250°F for Class B insulation and to +300°F for Class F and H. Most major oil companies have special bearing greases that are satisfactory.

CAUTION! Adding grease to bearing when motor is operating may cause grease to go through clearance around inside end cap and be slung onto motor windings.

1. Thoroughly clean the grease connections at the ends of the extended lube lines
2. Remove plugs from drains
3. Remove hardened grease from drains with stiff wire or rod
4. Add grease to inlet with hand type gun until small amount of new grease is forced out of the drain
5. Clean excess grease from the drains and grease connections and run the motor thirty (30) minutes before replacing the drain plug

V-BELT TENSIONING INSTRUCTIONS

WARNING! Turn off and lock out or tag power source before proceeding

SIMPLIFIED BELT TENSIONING METHOD

This tensioning method assumes average static tensions for drives, thereby eliminating the need for calculating static tension. Use this method if the small sheave diameter, small sheave rpm and speed ratio fall within the limits as given in table number 1, the number of belts used corresponds to the number recommended in this manual and the drive has at least two (2) belts.

Step 1: from TABLE NUMBER 1, determine the force required to deflect one belt 1/64" per inch of span length (length from C to C sheaves along the belt).

- Measure the span length (t) of the drive
- At the center of the span, measure the force required to deflect one belt on the drive 1/64 per inch of span length from its normal position. The adjacent belt can be used as a reference for measuring the deflection. See the figure below TABLE NUMBER 1, PAGE 10. Be sure to apply the force perpendicular to the belt.
- Measure the force required to deflect a band of belts 1/64 per inch of span length as discussed above. Divide the value by the number of belt strands in the band to find the deflection force per belt.

Note: Lay a steel bar or a narrow block of wood across the belt and apply the deflection force to the bar so that all of the individual strands in the band are deflected the same amount. If more than one belt is used in the drive, the neighboring band can be used as a reference for measuring the deflection, just as is done with individual belts. If only one band is used, lay a straightedge or stretch a string from sheave to sheave to use as a reference for measuring the deflection. Lay the straightedge or string across the back of the belt on the sheaves.

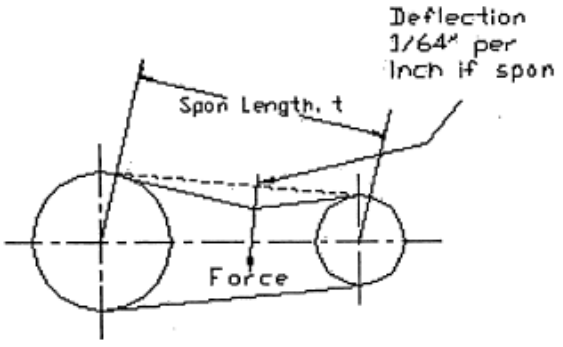
Step 2: Compare this deflection with the range of forces given in TABLE NUMBER 1.

- If it is less than the minimum recommended force, the belts tensioned must be increased
- If it is more than the maximum recommended force, the drive tension must be decreased

TABLE NUMBER 1

RECOMMENDED DEFLECTION FORCE PER BELT

Cross Section	Smallest Sheave Diameter Range	RPM Range	Belt Deflection Force				Cross Section	Smallest Sheave Diameter Range	RPM Range	Belt Deflection Force			
			S-L Classic & Polyband		Classic Cog					D-V Wrapped		D-V Cog	
			Normal	New Belt	Normal	New Belt				Normal New	New Belt	Normal	New Belt
A, AX	3.0-3.6	1000-2500 2501-4000	3.7 2.8	5.5 4.2	4.1 3.4	6.1 5.0	3VX	2.2-2.4	1000-2500 2501-4000			3.3 2.9	4.9 4.3
	3.8-4.8	1000-2500 2501-4000	4.5 3.8	6.8 5.7	5.0 4.3	74 6.4		2.65-3.65	1000-2500 2501-4000	3.8 3.0	5.1 4.4	4.2 3.8	6.2 5.6
	5.0-7.0	1000-2500 2501-4000	5.4 4.7	8.0 7.0	5.7 5.1	9.4 7.6		4.12-6.90	1000-2500 2501-4000	4.9 4.4	7.3 6.6	5.3 4.9	7.9 7.3
B, BX	3.4-4.2	860-2500 2501-4000			4.9 4.2	7.2 6.2	5V, 5VX	4.4-6.7	500-1749 1750-3000 3001-4000			10.2 8.8 5.6	15.2 13.2 8.5
	4.4-5.6	860-2500 2501-4000	5.3 4.5	7.9 6.7	7.1 7.1	10.5 9.1		7.1-10.9	500-1740 1741-3000	12.7 11.2	18.9 16.7	14.8 13.7	22.1 20.1
	5.8-8.6	860-2500 2501-4000	6.3 6.0	9.4 8.9	8.5 7.3	12.6 10.9		11.8-16.0	500-1740 1741-3000	15.5 14.6	23.4 21.8	17.1 16.8	25.5 25.0
C, CX	7.0-9.0	500-1740 1741-3000	11.5 9.4	17.0 13.8	14.7 11.9	21.8 17.5	8V	12.5-17.0	200-850 851-1500	33.0 26.8	49.3 39.9		
	9.5-16.0	500-1740 1741-3000	14.1 12.5	21.0 18.5	15.9 14.6	23.5 21.6		18.0-22.4	200-850 851-1500	39.6 35.3	59.2 52.7		
D	12.0-16.0	200-850 851-1500	24.9 21.2	37.0 31.3									
	18.0-20.0	200-850 851-1500	30.4 25.8	45.2 38.0									



HTD BELT TENSIONING INSTRUCTIONS

WARNING! Turn off and lock out or tag power source before proceeding

Belt Tension

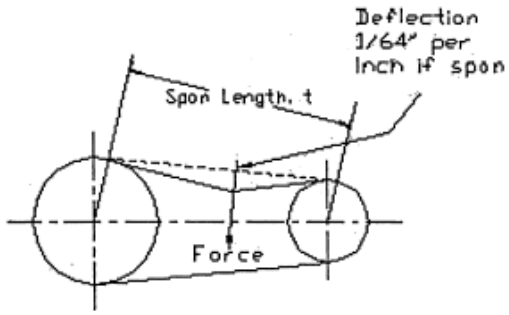
HTD drives do not require as much tension as V-belt drives that depend on friction to transmit the load. HTD belts should be installed with a snug fit, neither too taut nor too loose. After the belt has been so tensioned, a force to deflect the belt by an amount to assure proper tension can be measured. Measure the belt span (see scetch). Using a spring scale, apply force perpendicular to the center of the belt width and the center of the belt span. Measure the force necessary to deflect the belt 1/64" for each inch of belt span. For example, the deflection for a 32" belt span is 32 X 1/64= 1/2 inch deflection. The force required to deflect the belt the amount required at the proper tension is listed in table below.

DEFLECTION FORCE FOR POWER GRIP & POLY CHAIN GT2 BELTS

PITCH	WIDTH	FORCE
8mm	20mm	24 lbs.
	30mm	39 lbs.
	50mm	67 lbs.
	85mm	122 lbs.
14mm	40mm	99 lbs.
	55mm	156 lbs.
	85mm	266 lbs.
	115mm	378 lbs.
	170mm	581 lbs.

NOTE: For belts wider than 2" (50mm), it is suggested that a strip of key stock, or something similar, be placed across the belt under the point of force to prevent distortion.

For drives with shock loading or other unusual conditions, the force may have to be increased for proper operation of the drive.



LUBRICATION OF FAN BEARINGS

The bearings have been greased at the factory and are ready to run. The following table is a general guide for re-lubrication. Operating conditions may require different lubrication periods.

Bearings have been lubricated at the factory with number two consistency lithium base grease which is suitable for normal operating conditions.

Re-lubricate with lithium base grease or grease compatible with original lubricant and suitable for ball bearing service. In certain cases, such as low temperature or high temperature applications, it may be necessary to consult a lubrication supplier for recommendations.

LUBRICATION GUIDE

Read Preceding Paragraphs Before Establishing Lubrication Schedule.

Hours Run Per Day	Fan Shaft RPM and 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	1	1
24	10	5	3	2	1	1	1	1

GEAR MAINTENANCE

LUBRICATION INSTRUCTIONS

AMBIENT-DEGREES F	15 - 50	50 - 125
AGMA NUMBER	4EP	5EP
VISCOSITY RANGE	626 – 755 SSU @ 100°F	918 – 1122 SSU @ 100°F

Consult the gear manufacturer's data for a recommended oil and manufacturer.

SYNTHETIC GEAR LUBRICANTS

Synthetic oils have been used in enclosed gear drives for special operating conditions. Synthetic lubricants can be advantageous over standard oils in that they are generally more stable, have a longer life and operate over a wider temperature range.

INSTRUCTIONS FOR

INSTALLATION AND STARTING NEW UNIT

WARNING! Turn off and lock out or tag power source before proceeding.

1. When unites are shipped, internal parts are protected by rust preventive film. Flushing is not required since it is soluble in the lubricant. Fill the case with recommended lubricant to the proper oil level.
   NOTE: Unites may be shipped without oil and must be filled before starting.
2. Gear unites may be shipped with the breather port plugged. Prior to operation, a breather type plug (supplied with the unit) must be installed in the upper housing.
3. Coupling connections must be aligned for proper parallel and angular misalignment.
4. If it is required to shim the gearbox for alignment, care must be taken to prevent distortion of the housing. **NOTE: Coupling and unit alignment should be rechecked after two (2) weeks operation.**
5. When units furnished with force feed lubrication are started, it should be confirmed that oil is being pumped.

6. For low temperature operation, with oil viscosity at staring greater than 5000 SUV, heaters must be used. For units with pressure lubrication systems, confirm the pump is pumping the cold oil.
7. The minimum viscosity required under normal operating conditions ranges from 150 to 400 SUV. Oils having this viscosity under normal operating conditions may not be satisfactory for low temperature starting and heaters must be used.
8. Where unit will not warm up under intermittent operating conditions, low viscosity oil may be required for low temperature operation.

WARNING! Turn off and lock out or tag power source before proceeding

OIL CHANGES

After installation, the first oil change should occur after two weeks of operation. After the original oil has been drained, fill the case to the required level with SAE-10 straight run mineral flushing oil containing no additives. Start the fan and let it get up to speed, then stop it. This works as a flushing procedure. Drain the flushing oils and fill with the recommended lubricant to the proper level.

Change the oil every six months unless conditions warrant closer intervals. If the oil temperature is continuously above 200°, or if the unit is subjected to an unusually moist atmosphere, oil changes may be necessary at one, two or three month intervals, as determined by field inspection of the oil.

Prevent any foreign matter from entering the gear case. Dust, dirt, moisture and chemical fumes form sludge.

INSTRUCTIONS FOR MAINTENANCE

1. Stop the unit and check the oil level once a week. The lubricant level should be no more than 1/4" below specified level.
2. Units should be given daily visual inspections and observation for oil leaks or unusual noises. If either occurs, the cause must be found and corrected.
3. The operating temperature of the unit is the temperature of the oil inside the housing. The maximum operating temperature should not exceed 200°F.

INSTRUCTIONS FOR SHUTDOWN PERIODS

If units will be idle for a period longer than a week, it will be necessary to run the unit for ten (10) minutes every week it is idle. This short operation will keep the gears and bearings coated with oil and prevent rusting due to condensation of moisture resulting from temperature changes.

PLUG TIGHTENING PROCEDURE

PLUG TORQUING PROCEDURE

On plug type headers, plugs are installed at room temperature in our plant and have passed a hydrostatic test. Occasionally, field leak testing or heating up of the unit will indicate that some natural relaxation of the load on the gasket has occurred and therefore results in a leak. When this occurs, it is necessary to retighten the plugs in the field. The plugs are already tightened to a minimum torque in Smithco's shop as shown in the following table:

Plug Threaded Diameter	Max Plug Length	Minimum Torque Value (ft-lbs)
1 1/8"	1 1/4"	150
1 1/8"	1 1/2"	200
1 1/8"	1 3/4"	250
1 1/8"	2"	300
1 1/8"	> 2"	400
1 3/8"	1 1/2"	300
1 3/8"	>1 1/4"	400

The coefficient of friction in our shop is for new, well lubricated threads and so therefore field torque values will probably be higher. Giving precise torque values cannot be completely accurate due to the variation in the lubrication and smoothness of the surfaces. A better method of sealing the leaks is as follows:

1. Locate the leaking plug.
2. Administer an impact using an 18" swing of a 2 pound hammer to the outside face of the plug to assist in the plastic flow of the gasket into the microscopic surface irregularities.
3. Turn the plug ½ of a flat (30° rotation) clockwise. This results in approximately 0.007" additional compression on the gasket.
4. Repeat steps 1 through 3 just until the leak is sealed. Do not repeat steps 1 through 3 more than four (4) times. After the 4th time, remove the plug. Check the gasket surfaces and recondition if necessary. Replace the gasket and start the process from the initial torque step.

The plugs are NOT indestructible. The threaded surfaces should be in good condition. We recommend against the use of impact wrenches, however, any plugs damaged by use of an impact wrench should be replaced.

Box Wrenches

Striking-Face Box Wrenches

Rap the large striking surface with a hammer when extreme force is necessary to loosen and set large fasteners. Wrenches are made of forged steel with a black finish. Meet Fed. Spec. GGG-W-636e.

Offset—Handle is offset 45° to help clear obstructions.

Straight—Designed to apply maximum force directly through the handle to the fastener head and to keep wrench head on the fastener when wrench is struck.

Size	Head Thick.	O'all Lg.		Each
12-Point Offset				
1 1/16"(27mm)	1/16"	10"	5455A11	$31.16
1 1/8"	3/4"	11"	5455A12	32.72
1 3/16"(30mm)	3/4"	11"	5455A47	37.11
1 1/4"(32mm)	3/4"	11"	5455A13	34.37
1 5/16"	3/4"	11"	5455A14	35.67
1 3/8"	7/8"	11 17/32"	5455A36	39.80
1 7/16"	7/8"	11 17/32"	5455A15	41.47
1 1/2"	1"	12 1/32"	5455A16	43.03
36mm	7/8"	11 17/32"	5455A51	48.35
1 9/16"	1 1/8"	12 1/2"	5455A33	49.90
1 5/8"(41mm)	1"	12 1/32"	5455A17	49.70
1 11/16"	1 1/8"	12 9/16"	5455A18	52.41
1 3/4"	1 1/8"	12 9/16"	5455A42	56.58
1 13/16"(46mm)	1 1/8"	12 9/16"	5455A19	57.86
1 7/8"	1 1/4"	13 1/32"	5455A21	61.01
1 15/16"	1 1/4"	13 1/32"	5455A43	61.91
50mm	1 1/4"	13 1/32"	5455A52	70.74
2"	1 1/4"	13 1/32"	5455A22	63.31
2 1/16"	1 1/8"	12 3/4"	5455A34	63.60
2 1/8"	1 3/8"	13 19/32"	5455A44	64.94
2 3/16"(55mm)	1 3/8"	13 19/32"	5455A23	68.02
2 1/4"	1 3/8"	13 19/32"	5455A24	72.40
2 5/16"	1 3/8"	13 19/32"	5455A49	74.03
2 3/8"(60mm)	1 1/2"	14 1/8"	5455A25	76.76
2 1/2"	1 1/2"	14 1/8"	5455A46	94.52
2 9/16"(65mm)	1 1/2"	14 1/8"	5455A26	97.86
2 5/8"	1 5/8"	15 1/32"	5455A27	98.09
2 3/4"(70mm)	1 5/8"	15 1/32"	5455A28	98.09
2 7/8"	1 3/4"	16 1/32"	5455A48	140.00

Size	Head Thick.	O'all Lg.		Each
12-Point Offset (Cont.)				
2 15/16"(75mm)	1 3/4"	16 1/32"	5455A29	$115.67
3"	1 3/4"	16 1/32"	5455A31	119.08
3 1/8"(80mm)	1 3/4"	16 1/32"	5455A32	121.92
3 3/8"	2"	18 1/4"	5455A61	177.14
3 1/2"	2"	18 1/4"	5455A62	184.78
3 3/4"	2"	18 1/4"	5455A63	195.10
3 7/8"	2"	18 1/4"	5455A64	226.37
4 1/8"	2"	18 1/4"	5455A65	238.50
4 1/4"	2"	18 1/4"	5455A66	240.44
12-Point Straight				
1 1/16"(27mm)	5/8"	9 1/8"	5456A47	34.22
1 3/16"(30mm)	7/8"	7 9/16"	5456A43	32.97
1 1/4"(32mm)	7/8"	7 9/16"	5456A11	30.95
1 5/16"	7/8"	7 9/16"	5456A12	30.96
1 3/8"	15/16"	8 1/4"	5456A51	32.68
1 7/16"	15/16"	8 1/4"	5456A13	32.67
1 1/2"	31/32"	7 21/32"	5456A14	34.81
36mm	31/32"	7 21/32"	5456A53	36.73
1 5/8"(41mm)	1 1/32"	7 27/32"	5456A15	37.04
1 11/16"	1 1/32"	7 27/32"	5456A16	39.48
1 3/4"	1 1/8"	9"	5456A18	40.23
1 13/16"(46mm)	1 7/32"	7 15/16"	5456A17	40.46
1 7/8"	1 1/4"	10"	5456A21	42.85
50mm	1 13/32"	11 5/8"	5456A54	73.63
2"	1 13/32"	11 5/8"	5456A22	60.71
2 1/16"	1 3/8"	11"	5456A52	64.44
2 1/8"	1 7/16"	12"	5456A29	68.97
2 3/16"(55mm)	1 17/32"	11 3/4"	5456A23	74.48
2 1/4"	1 17/32"	11 3/4"	5456A24	79.13
2 3/8"(60mm)	1 21/32"	11 29/32"	5456A25	93.94

Size	Head Thick.	O'all Lg.		Each
12-Point Straight (Cont.)				
2 9/16"(65mm)	1 25/32"	13 1/32"	5456A26	$106.25
2 5/8"	1 13/16"	14"	5456A27	107.65
2 3/4"(70mm)	1 15/16"	14 5/16"	5456A31	125.12
2 15/16"(75mm)	2 1/16"	14 7/16"	5456A44	144.70
3"	2"	18"	5456A32	154.50
3 1/8"(80mm)	2 9/32"	17 5/8"	5456A33	198.20
3 3/8"(85mm)	2 9/32"	17 5/8"	5456A34	217.90
3 1/2"	2 7/16"	17 27/32"	5456A35	248.94
3 3/4"	2 3/8"	18"	5456A36	273.52
3 7/8"	2 3/8"	18"	5456A37	291.80
4 1/8"	2 3/8"	18"	5456A38	324.91
4 1/4"	2 3/8"	18"	5456A39	337.56
4 1/2"	2 3/4"	21"	5456A41	453.51
4 5/8"	2 3/4"	21"	5456A42	456.59
6-Point Straight				
1 1/16"	5/8"	9 7/8"	8341A41	25.76
1 1/4"	45/64"	10 1/4"	8341A42	25.76
1 7/16"	55/64"	10 9/16"	8341A43	31.45
1 5/8"	61/64"	11"	8341A44	38.00
1 13/16"	63/64"	11 5/16"	8341A45	38.00
2"	1 15/64"	11 11/16"	8341A46	45.63
2 3/16"	1 1/4"	12"	8341A47	57.12
2 3/8"	1 23/64"	12 3/8"	8341A48	60.83
2 9/16"	1 31/64"	12 11/16"	8341A49	66.21
2 3/4"	1 33/64"	13 1/16"	8341A51	91.47
2 15/16"	1 33/64"	13 7/16"	8341A52	100.41
3 1/8"	1 37/64"	13 13/16"	8341A53	117.04
3 1/2"	1 45/64"	14 1/8"	8341A54	153.10
3 7/8"	1 49/64"	14 1/2"	8341A55	216.69