General Operating, Maintenance and Reference Manual

ACE Model J54-7
Cooler Serial Number: 1721903

Table of Contents

Introduction

The purpose of this manual is to provide recommendations for the receipt, operation, and maintenance of cooler. Adherence to the general guidelines provided herein will help to ensure optimal mechanical and thermal performance over a maximized lifetime of the cooler.

As with any engineered product, any questions regarding the cooler not addressed within this manual should be posed to Alfa Laval Inc. – Air Cooled Exchangers, or through a qualified ACE representative. Assumptions regarding startup, operation or maintenance should not be made, as air-cooled heat exchangers can be hazardous in nature if general precautions are not observed.

Safety

It is imperative that a safety plan is established and observed prior to the operation of air-cooled heat exchangers. Safety guidelines are provided below, but it's the ultimate responsibility of the end user to observe any and all safety precautions as outlined by operating company's safety plan.

1. Always wear the proper personal protective equipment (PPE) when in the area of the air-cooled exchanger.
2. Never remove guards or protective equipment while the air-cooled exchanger is in operation. An established lock-out/tag-out procedure is preferred prior to any maintenance or removal of guarding.
3. Disconnect electric fan motor(s) or disable engine ignition systems (disconnect battery) prior to performing maintenance, especially maintenance involving the cooler fan(s).
4. Avoid "hot work" without obtaining a hot work permit or observing the operating company's policy thereof.
5. Use good, conservative and safe judgment when lifting cooler components.
6. Isolate, blow-down, vent, or purge gas sections prior to performing maintenance or work on the sections according to the operating company's procedures.
7. Use tools and lifting devices suitably rated for the work and subject components.
8. Use OEM parts provided by Alfa Laval Inc. – Air Cooled Exchangers to avoid any deviation from the design and operation intent, which could result an unsafe operating condition.

Receipt and Unloading of Cooler

Thoroughly inspect the air-cooled exchanger for damage incurred during transit or transfer between logistics equipment (trailers, vessels, etc.). The following items, if applicable, should be inspected closely:

1. Skid
2. Exposed structure
3. Sheet metal panels
4. Fan and tube section (bundle) guards
5. Electric motors
6. Louvers
7. Tube sections, including tubes, fins, headers, and especially flange faces
8. Lubrication lines
9. Controls, electric or pneumatic

Promptly note any damage on the bill of lading and present to the responsible party, who is typically the carrier, to ensure expedited filing of claims.

Review the packing list to ensure that any spare parts or items shipped loosed due to dimensional or weight restrictions are accounted for. These items may be found apart from the cooler, attached to the cooler skid/base, or inside of the cooler plenum. Assembly instructions accompany coolers requiring any assembly prior to operation. Contact ACE if additional instructions or guidance are needed.

Equipment Unloading and Handling

The air-cooled exchanger is to be lifted and unloaded using only lifting devices certified for the weight of the cooler. Unless designed otherwise, ACE lifting lugs are intended for straight vertical lifts. Therefore, any lifting plan that would result in bending of the lug(s) should not be used. Lifting plans are available from ACE upon request.

Site Orientation

Installation and site orientation of the cooler are the sole responsibility of the purchaser, end user or contractor. Air-cooled heat exchangers must be placed with careful consideration given to surrounding objects, which may impede air-flow into the fan(s). The cooler must be placed at a suitable distance from other coolers and/or heat sources to avoid potential warm-air recirculation and degradation of cooler performance.

To mitigate air-flow starvation and recirculation issues when placing air-cooled heat exchangers adjacent to each other, the coolers may be elevated using piers or leg extensions. The height of elevation is specified such that air-flow "area" eliminated from the blocked sides is compensated for as height added to the cooler ends. Contact ACE for recommendations, if needed.

Coolers with vertically-oriented fans are sensitive to wind direction, and should be placed such that the prevailing winds at the site flow towards (into) the backside of the fan. Coolers with fans forced to move air against the prevailing winds will likely experience less than desirable thermal performance, as well as an increased fan blade load and driver horsepower.

Pre-Start Up Check and Inspection

Prior to the beginning of any start-up procedure, a thorough inspection of the Air Cooled Exchanger should be made.

1.) Ensure that all bolted connections are properly tightened.

2.) After tube bundle and piping hydro-test, remove hydro-test connections. Be sure tube bundle is properly drained, and if required, dried. Connect process piping and any auxiliary connections.

3.) Inspect all process and auxiliary connections to ensure that they are plugged or connected properly.

4.) Check mechanical equipment before initiating and process through the tube bundle(s).

   a.) Thoroughly check the plenum and fan drive area to be sure all tools and construction materials are removed.

   b.) Rotate the fan by hand and check fan tip clearance and alignment of belts and sheaves.

   c.) If applicable, check V-belt tension using the manufacturer's recommendations.

   d.) Check all fan drive bolts to be sure they are properly tightened. This includes bearing bolts, fan and sheave bushing bolts, set screws, motor bolts and fan blade attachment bolts.

   e.) If air operated auto-variable pitch fans are used, check for proper pitch with the air off. Fans may go to either minimum or maximum pitch at air failure. Check specifications for requirements. If fan pitch is not satisfactory, set the pitch per manufacturer's instructions. If fan pitch is satisfactory, cycle the fan through its range, using plant air and an air regulator.

   f.) If air operated louvers are provided, it is advisable to disconnect the air motor linkage and cycle the louvers by hand to assure there is no binding or obstruction of the louvers blades. If binding occurs, check to be sure louver frames are square. Attaching bolts may need to be loosened and frames shifted to ease binding. If louvers

operate smoothly, reconnect air motor. Cycle the air motor, using plant air and an air regulator.

g.) If manually adjusted pitch fans are provided, check fan pitch and re-pitch per manufacturer's instructions if required.

h.) If manual operated louvers are provided, check for binding of the blades, as in instruction (f). Operate louvers to be sure there is no linkage obstruction or binding.

i.) Remove condensate drain plugs, if provided, from electric motors and other electrical components to drain any condensation that might have occurred during storage. If space heaters are furnished in electric motors, louver actuators, controls, etc., activate the space heaters and allow approximately 24 hours before starting equipment.

j.) After all the applicable steps previously stated are completed; the mechanical equipment may be cycled. Be sure all personnel and equipment are away from the fan and fan drive area. For safety reasons, equipment guards should be installed. Activate the drive motor(s) and allow it/them to achieve rated speed. Check for vibration and excessive noise. If vibration or excessive noise exists, immediately shut motor down, and check for loose connections or insufficient clearance between moving parts. If the system is running smoothly, replace any guards removed and move to the next drive and repeat above steps.

5.) This equipment shall not be operated at any time without safety relief device in the system. Ensure that each heat exchanger section has appropriate relieving capacity and a set pressure not to exceed the stamped MAWP.

6.) Start the process through the tube bundle(s). Open the inlet valves slowly to ensure gradual warming of the tube bundles. This will allow the components of the tube bundle to expand slowly and lessen the thermal shock.

Routine Maintenance

Bearing Lubrication

Bearings should be greased in accordance with the bearing manufacturer's recommendations. Over-lubrication is the most common cause of bearing failure.

Belt Tension

V-belt drives should be adjusted until tight enough to prevent excessive belt slippage. A general rule of thumb is to tighten the belt until it can only be twisted one-quarter of a turn with the thumb and fore-finger. Follow the belt manufacturer's tensioning recommendations for a precise method.

Fin Cleaning

Operating conditions sometimes cause an accumulation of dirt on the outside fin surface. This can be removed by directing compressed air, or a greaseless solvent followed by a water spray through the fins in a direction opposite the normal air flow. The inside of the tubes will require periodic inspection and cleaning as necessary. Removal of access plugs allows visual inspection, and if necessary, the use of mechanical tube cleaners.

Plug Leaks

Plugs are not sacrificial and may be re-used if not damaged. It is sound practice to mark plugs as they are removed and install removed plugs into the same holes. This is particularly useful if the possibility exists of an oversize plug having been used following the repair of a threaded hole.

ACE uses two different types of plugs in ASME code headers. Tapered plugs are used opposite 5/8" through 1" tubes unless specified otherwise by the customer. Shoulder plugs are used opposite 1.25" and 1.5" tubes, or when specified by the customer. In non-code sections, NPT plugs are used almost exclusively. Tightening requirements are dependent upon plug size and can vary with the plug material.

Tapered Plug Tightening Procedure

There is no standardized method of tightening an NPT threaded joint. Torque is not a good measure of how tight to make the joint, because the quality of the threads affects the friction between the two thread surfaces. Also, most threaded joints are assembled with a thread sealant, either liquid or tape, and the type of sealant can affect the friction between the mating threads. ACE uses a liquid thread sealant in conjunction with an impact wrench which initially tightens nominally-sized plugs to about 200 ft-lbs. The plugs are tightened further as required to stop leakage, if any exists.

CAUTION: *If using Teflon tape, it is easy to over-tighten the joint, particularly if you are working on an aluminum or brass tube sheet. Aluminum or brass tube sheets may develop cracks between plug holes if plugs are over-tightened. If the plugs and headers are stainless steel, make sure to use a thread sealant approved for use with SS, and limit the torque to only that required to stop leaks, as this material is very susceptible to galling.*

Shoulder Plugs

Shoulder plugs can be torqued to a set value, but since the goal of tightening the joint is to eliminate leaks, it is a good idea to torque to a lower value to start with, and then increase the torque if necessary until the gasket seals. Contact ACE prior to the tightening or removal of shoulder plugs for assistance specific to the air cooled heat exchanger in question.

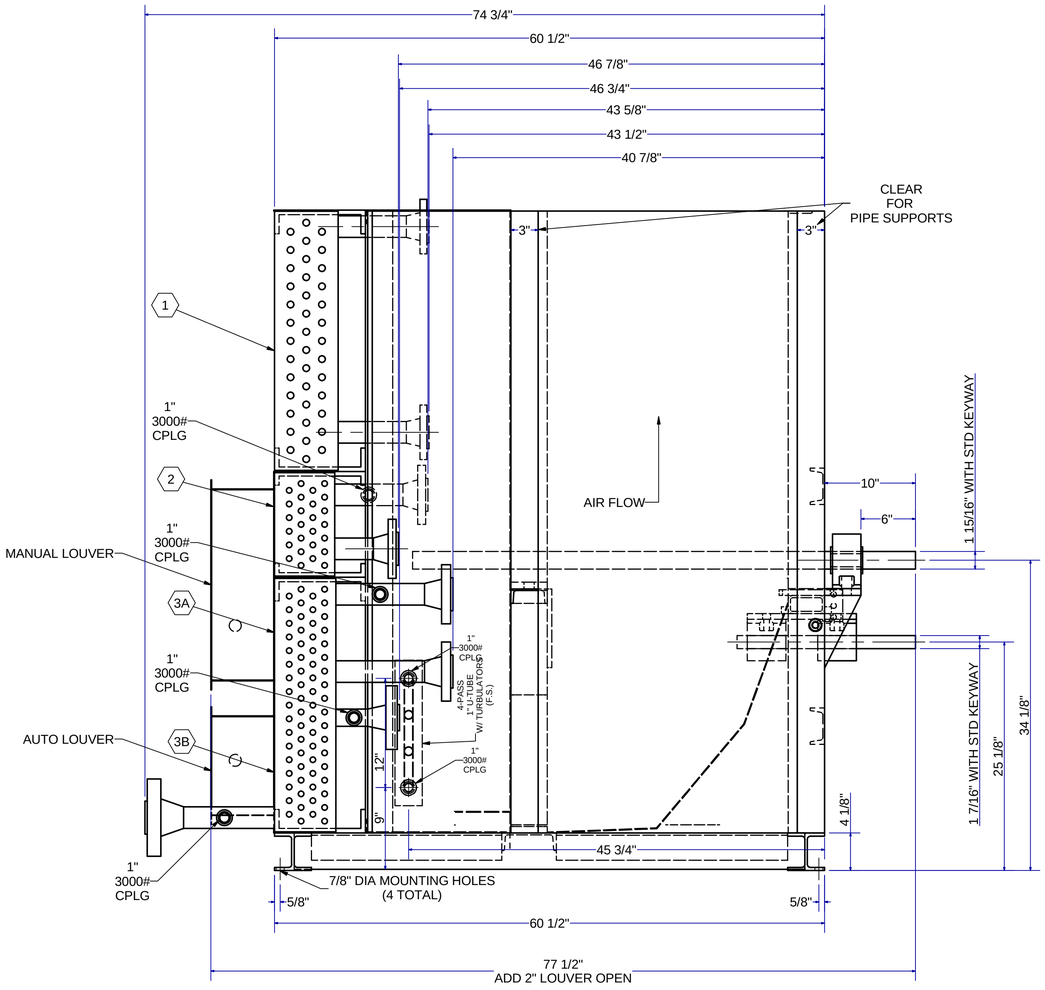
TUBE LEAKS

Tube Wall Leaks

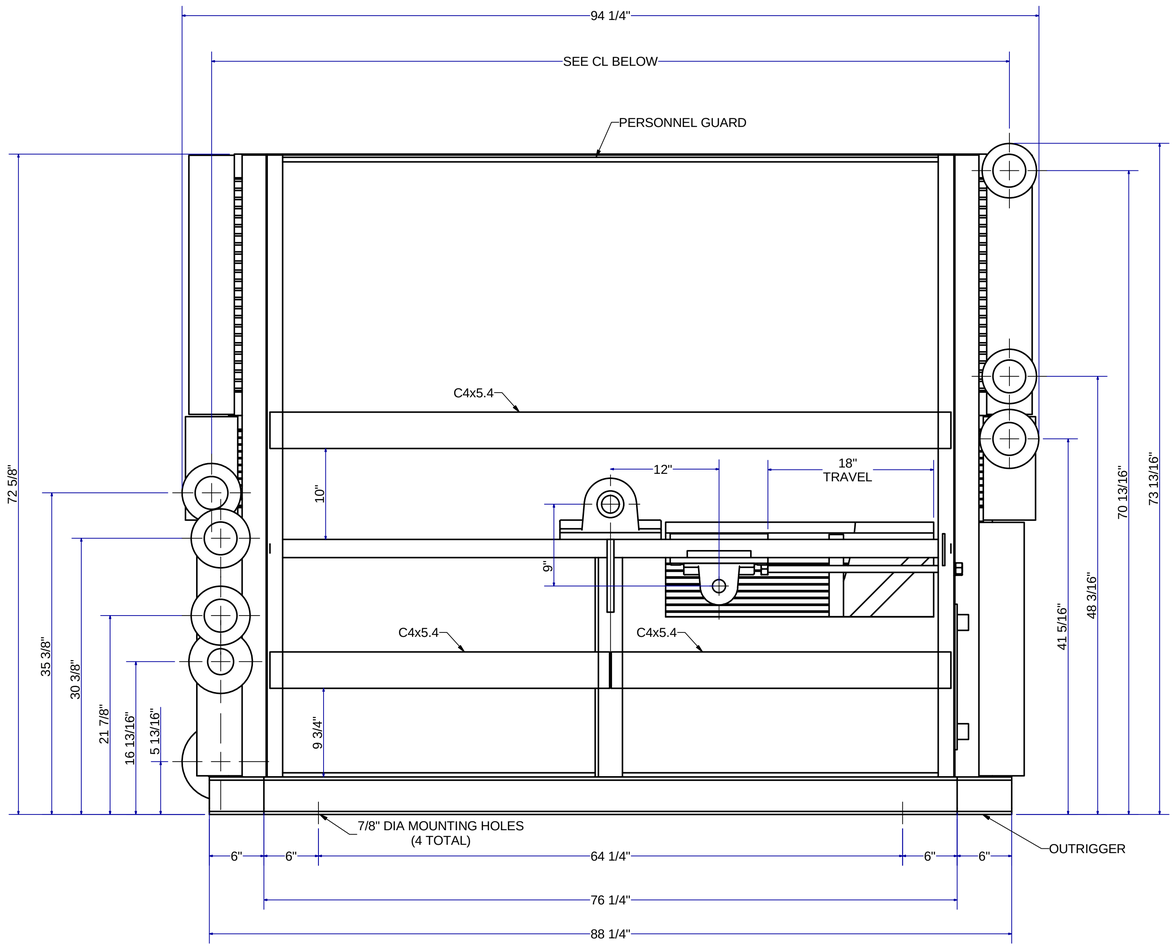
A leak originating from a tube wall (typically from corrosion) is a problem solved best by isolating the tube from the media being cooled through the use of tapered seal pins. It's important to note that removing tubes from service will result in a loss of cooling capacity. Sealing multiple tubes will eventually affect the cooling capability of the cooler to the point of which the deficiency is noticeable due to high outlet temperature or elevated pressure drop. When the reduced performance of the section can no longer be tolerated, the section must be re-tubed. As cooler sections may vary greatly in size and construction, please contact ACE directly for seal-pin and re-tube applications.

Tube/Tube Sheet Joint Leaks

A leak that originates from the joint between the tube outside diameter of the tube and the tube sheet may be eliminated by re-rolling the subject tube using a tube expander. Though a refundable deposit is typically required, ACE routinely loans expanding tools and instructions to service personnel, such that they can repair the leak in a timely manner. As cooler sections may vary greatly in size and construction, please contact ACE directly regarding tube expansion applications.



SIDE ELEVATION



SHAFT END ELEVATION

SEE CL BELOW - THESE DIMENSION (S) ARE SYMETRICAL ABOUT THE CENTER OF COOLER.

FLAG	SERVICE	CL	LOUVERS	DESIGN PRESSURE	DESIGN TEMPERATURE	NOZZLES IN	NOZZLES OUT	OTHER NOZZLE	NC
1	EJW	87.75	N/A	100 PSI	350 Deg F/-20 Deg F	(1)2-150RF	(1)2-150RF	N/A	N/A
2	IC1	87.75	AUTO	645 PSI	350 Deg F/-20 Deg F	(1)2-300RF	(1)2-300RF	N/A	N/A
3A	IC2	85.75	MANUAL	1287 PSI	350 Deg F/-20 Deg F	(1)2-600RF	(1)2-600RF	N/A	N/A
3B	AC	85.75	MANUAL	1800 PSI	350 Deg F/-20 Deg F	(1)1.5-900RF	(1)2-900RF	N/A	N/A

UNIT: 1721901-11
TAG: 990010042
JOB: 17219

RPM= 848
HP= 7 PER FAN
BLADE ANGLE= 37

NOTES

1. WEIGHT: 3803 POUNDS
2. FINISH: ACE std prep. w/ one coat ACE std primer
3. FAN DRIVEN BY V-Belt Drive By Others
4. ASME CODE WITH NATIONAL BOARD ON IC1,IC2,AC,
5. PERSONNEL GUARD,

"The 2015 Edition of ASME Section VIII, Div 1 requires hydrostatic testing of headers/sections prior to coating application. However, ACE's standard practice requires that the initial application of header coating precedes hydrostatic testing. Through the approval of this drawing, you (the customer) acknowledge and approve of this deviation from current ASME Section VIII, Div 1 requirements."

AIR COOLED EXCHANGERS

SCALE: 1:1 (FIT TO PLOT) | ACE MODEL J54-7 | DRAWN BY: AID
DATE: 10/4/2017 | CHECKED BY:
CUSTOMER: McClung Energy | P.O: 0014949-01

	BY	DATE	DESCRIPTION	CK'D
REV 1	MK	10/31/17	LOUVERS	
REV 2		12/4/17	LOUVERS	

DRAWING NUMBER 17219 -C | REV 2

Alfa Laval Inc.
Air Cooled Exchangers
1201 S. 9th Street – Broken Arrow, Oklahoma 74012
Phone: 918.251.7477
Email: ACE.sales@alfalaval.com

COOLER PERFORMANCE SPECIFICATION IS SHOWN FOR ONE BAY. (1) BAYS REQUIRED

CUSTOMER	McClung Energy	**PROPOSAL NUMBER**	17219R1.dat
REFERENCE	Standard J54-7{CAT 3306 NA 145HP 10.5:1 STD 1800 rpm}	**DATE**	10/26/2017
MODEL	J54-7	**PAGE**	1

PERFORMANCE OF ONE UNIT

SERVICE	EJW	IC1	IC2	AC
FLOW	45.0GPM	0.75MMSCFD	1.21MMSCFD	0.81MMSCFD
FLUID	50%GLY	.65	.65	.65
TEMPERATURE IN F	190.0	264.0	254.0	254.0
TEMPERATURE OUT F	164.2	130.0	130.0	120.0
INLET PRESSURE PSIG		203.60	707.28	810.00
PRESSURE LOSS PSI	3.79	3.92	3.80	5.00
DUTY, BTU/HR	515520.0	121393.2	191315.2	141118.9
CORRECTED MTD, F	48.3	57.5	51.8	45.0
OVER-ALL U BTU/(hr*sqft*F)	201.5	73.5	98.3	83.6
FOULING	0.000500	0.002000	0.002000	0.002000
BARE SURFACE FT2	53	29	38	38
TOTAL SURFACE FT2	1267	457	597	597

CONSTRUCTION

NO. SECTIONS	1	1	COMBINED	COMBINED
NO. TUBES/SECTION	40	26	34	34
TUBE LENGTH FEET	7.0	7.0	7.0	7.0
NO. ROWS	3	4	4	4
NO. PASSES	4	3	4	6
COUNTERFLOW				
TUBE OD INCH AND BWG	.75X16BWG	.625X16BWG	.625X16BWG	.625X16BWG
TUBE MATERIAL	SA214(WLD)	SA214(WLD)	SA214(WLD)	SA214(WLD)
DESIGN PRESSURE	100.00	645.00	1287.00	1800.00
DESIGN TEMPERATURE	350/-20	350/-20	350/-20	350/-20
NOZZLES-INLET	2-150RF	2-300RF	2-600RF	1.5-900RF
NOZZLES-OUTLET	2-150RF	2-300RF	2-600RF	2-900RF
HEADER TYPE	RECT TUBE	BOX W/PLUGS	BOX W/PLUGS	BOX W/PLUGS
HEADER MATERIAL	STEEL	SA-516-70	SA-516-70 NORM	SA-516-70 NORM
ASME CODE STAMP		YES	YES	YES
GROOVED TUBE SHEET	YES			YES
HEADER CORROSION INCH	0.000	0.000	0.000	0.000
PLUGS, TYPE	TAPER	TAPER	TAPER	TAPER
PLUGS, MATERIAL	STEEL	SA-105	SA-105	SA-105
TURBULATORS				
ACCELERATORS				
LOUVER CONTROL		MANUAL	MANUAL	(1) JOHNSON 3153-5 W/T12 TC
STRESS RELIEVE	NONE	NO	NO	NO
NDE				
ADDITIONAL CODES				
CANADIAN REGISTRATION				
ADDITIONAL COUPLINGS		1	1	2
BYPASS NOZZLE				
FINS	HYPERF L-FOOT	HYPERF L-FOOT	HYPERF L-FOOT	HYPERF L-FOOT

AIR DATA

INLET AIR TEMPERATURE	105.0	**ELEVATION FEET:**	1500
OUTLET AIR TEMPERATURE	141.1	**AIR FLOW SCFM:**	24739

MECHANICAL EQUIPMENT

NO FANS 1	**HP PER FAN:** 7.0	**RPM** 849		**FAN DIA INCH:** 54
FAN CROWLEY 7WL	**FAN MATERIAL** PAG	**NUM BLADES** 6	**PITCH** 37°	**TSP, INCH WC:** 0.721
V-Belt Drive By Others				
DRAFT TYPE INDUCED				
WEIGHT LB: 3852	**WIDTH FEET:** 7.7	**LENGTH FEET:** 6.8		**HEIGHT FEET:** 6.5
ACCESSORIES Personnel Guard Over Air Discharge				
FINISH ACE std prep. w/ one coat ACE std primer				
SPECNOTES				

ACE does not offer metallurgical advisement. Please confirm material suitability for both process and atmospheric conditions.

Alfa Laval Inc.

Air Cooled Exchangers

Recommended Spare Parts

ACE Job Number: 1721901-11
ACE Cooler Model: J54-7
Customer: McClung Energy

Pricing shown below is effective as of 2/21/2018, and is subject to change without notice. Contact your ACE sales representative prior to order placement for up-to-date pricing and availability.

Description	Recommended Quantity (Per Cooler)	Price, Each	Extended Price
Fan, Crowley Model 54/6-6/37/PAG/7WL/6.09, , 6 Blades Pitched at 37 Degrees (2/3 R), 4.50 ft diameter	1	$967.50	$967.50
Fan Shaft, 1.9375" Dia x 55.30" L, Keyway L x W x D, 7.00" X 0.5000" X 0.2500"	1	$522.00	$522.00
Idler Shaft, 1.4375" Dia x 18.00" L, Keyway L x W x D, 7.00" X 0.3750" X 0.1875"	1	$15.22	$15.22
Fan Bearing PN PU331N, 1.9375" Diameter	2	$238.45	$476.90
Idler Bearing PN PPCL223N, 1.4375" Diameter	1	$474.75	$474.75
Service IC1 Code Type Taper Plug For .625" O.D. Tube Carbon Steel	2	$1.31	$2.62
Service IC2 Code Type Taper Plug For .625" O.D. Tube Carbon Steel	3	$1.31	$3.93
Service AC Code Type Taper Plug For .625" O.D. Tube Carbon Steel	3	$1.31	$3.93
Service EJW Non-Code Type Taper Plug for .750" O.D. Tube Carbon Steel	4	$1.48	$5.92
Air Motor , JOHNSON 3153-5	1	$689.29	$689.29

Alfa Laval Inc.
1201 S. 9th Street Broken Arrow, Oklahoma 74012
Phone: 918.251.7477
Email: ACE.sales@alfalaval.com

FORM U-1A MANUFACTURER'S DATA REPORT FOR PRESSURE VESSELS
(Alternative Form for Single Chamber, Completely Shop or Field Fabricated Vessels Only)
As Required by the Provisions of the ASME Boiler and Pressure Vessel Code Rules, Section VIII, Division 1

1. Manufactured and certified by: Alfa Laval, Inc., 1201 South 9th St., Broken Arrow, Oklahoma 74012 (Name and address of Manufacturer)
2. Manufactured for: McClung Energy, 234 Johnny Clark Rd., Longview, TX 75603 (Name and address of Purchaser)
3. Location of installation: Unknown, USA (Name and address)

4. Type	(Manufacturer's serial number)	(CRN)	(Drawing number)	(National Board number)	(Year built)
Vertical (Horizontal or vertical, tank)	1721903-2	Not Req'd	17219-H2	15831	2018

5. ASME Code, Section VIII, Division 1	[Edition and Addenda, if applicable (date)]	(Code Case numbers)	[Special service per UG-120(d)]
	2015	None	None

6. Shell	(Material spec. number, grade)	(Nominal thickness)	(Corrosion allowance)	(Inner diameter)	[Length (overall)]
	SA-516-70	0.875 in.	0	5.375 in.	11.375 in.

Body Flanges on Shells

No.	Type	ID	OD	Flange Thk	Min Hub Thk	Material	How Attached	Location	Bolting: Num & Size	Bolting: Bolting Material	Bolting: Washer (OD, ID, thk)	Bolting: Washer Material
N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

7. Seams	[Long. (wld'd, dbl., sngl., lap, butt)]	[R.T. (spot or full)]	(Eff., %)	(H.T. temp.)	(Time, hr)	[Girth (wld'd, dbl., sngl., lap, butt)]	[R.T. (spot or full)]	(Eff., %)	(No. of courses)
	Single Bevel	N.A.	N.A.	N.A.	N/A	N.A.	N.A.	N.A.	N.A.

8. Heads: (a) Material: SA-516-70 (Spec. no., grade) (b) Material: SA-516-70 (Spec. no., grade)

	Location (Top, Bottom, Ends)	Minimum Thickness	Corrosion Allowance	Crown Radius	Knuckle Radius	Elliptical Ratio	Conical Apex Angle	Hemispherical Radius	Flat Diameter	Side to Pressure (Convex or Concave)
(a)	Top/Bottom	0.5.875 in.	0	N.A.	N.A.	N.A.	N.A.	N.A.	4 in.	N.A.
(b)	Ends	0.5 in.	0	N.A.	N.A.	N.A.	N.A.	N.A.	4 in.	N.A.

Body Flanges on Heads

	Location	Type	ID	OD	Flange Thk	Min Hub Thk	Material	How Attached	Bolting: Num & Size	Bolting: Bolting Material	Bolting: Washer (OD, ID, thk)	Bolting: Washer Material
(a)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
(b)												

9. MAWP: 645 psig (Internal) / N.A. (External) at max. temp.: 350 deg F (Internal) / N.A. (External)

Min. design metal temp. -20 deg F at 645 psig. Hydrostatic test pressure: 839 psig.

Proof test: N/A

10. Nozzles, inspection, and safety valve openings:

Purpose (Inlet, Outlet, Drain etc.)	No.	Diameter or Size	Type	Material: Nozzle	Material: Flange	Nozzle Thickness: Nom.	Nozzle Thickness: Corr.	Reinforcement Material	Attachment Details: Nozzle	Attachment Details: Flange	Location (Insp. Open.)
Inlet/Outlet Nozzle	2	2 In.	Pipe	SA-106-GR B	N.A.	.218 in.	0	Mat'l&Weld	UW16.1(a)	N.A.	N.A.
Inlet/Outlet Flange	2	2 In.	RFWN	N.A.	SA-105	300RF	N.A.	Mat'l&Weld	N.A.	Welded	N.A.
Auxiliary	1	1 In.	Cplg		N.A.	3000#	0	Mat'l&Weld	Welded	N.A.	N.A.

11. Supports: Skirt: No (Yes or no) Lugs: 0 (Number) Legs: 4 (Number) Other: N/A (Describe) Attached: Tubesheet/Welded (Where and how)

12. Remarks: Manufacturer's Partial Data Reports properly identified and signed by Commissioned Inspectors have been furnished for the following items of the report: See Next Line (Name of part, item number, Manufacturer's name and identifying stamp)

Constructed in conformance with Appendix 28. IMPACT EXEMPT PER UG-20(f). Section Volume = 0.6 cubic feet.

Tubes: (26) SA214(WLD) x 0.625 in. OD x 0.06 in. MW x 7 ft. Long, Straight Type

Plugs: (52) SA-105 Taper Plugs

NDE: N/A

FORM U-1A (Back)

CERTIFICATE OF SHOP/FIELD COMPLIANCE

We certify that the statements made in this report are correct and that ll details of design, material, construction, and workmanship of this vessel conform to the ASME BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 1. "U" Certificate of Authorization Number 7616 expires 4/30/2020.

Date 2-20-18 Co. name Alfa Laval, Inc. (Manufacturer) Signed [signature] (Representative)

CERTIFICATE OF SHOP/FIELD INSPECTION

Vessel constructed by Alfa Laval, Inc. at 1201 S. 9th St. Broken Arrow, OK 74012.

I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and employed by OneCIS Insurance Co., Lynn, Mass.

have inspeced the component described in this Manufacturer's Data Report on 2-20-18, and state that, to the best of my knowledge and belief, the Manufacturer has constructed this pressure vessel in accordance with ASME BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 1. By signing this certificate neither the inspector nor his/her empolyer makes and warranty, expressed or implied, concerning the pressure vessel described in this Manufacturer's Dala Report. Furthermore, neither the Inspector nor his/her employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.

Date 2-20-18 Signed [signature] (Authorized Inspector) Commissions NB-8432 (National Board (Incl. endorsements))

(07/13)

Service: IC1

FORM U-1A MANUFACTURER'S DATA REPORT FOR PRESSURE VESSELS
(Alternative Form for Single Chamber, Completely Shop or Field Fabricated Vessels Only)
As Required by the Provisions of the ASME Boiler and Pressure Vessel Code Rules, Section VIII, Division 1

1. Manufactured and certified by: Alfa Laval, Inc., 1201 South 9th St., Broken Arrow, Oklahoma 74012 (Name and address of Manufacturer)
2. Manufactured for: McClung Energy, 234 Johnny Clark Rd., Longview, TX 75603 (Name and address of Purchaser)
3. Location of installation: Unknown, USA (Name and address)
4. Type: Vertical (Horizontal or vertical, tank) | 1721903-3A (Manufacturer's serial number) | Not Req'd (CRN) | 17219-H3 (Drawing number) | 15832 (National Board number) | 2018 (Year built)
5. ASME Code, Section VIII, Division 1: 2015 [Edition and Addenda, if applicable (date)] | None (Code Case numbers) | None [Special service per UG-120(d)]
6. Shell: SA-516-70 NORM (Material spec. number, grade) | 1.625 (Nominal thickness) | 0 (Corrosion allowance) | 5.250 in. (Inner diameter) | 27.875 in. [Length (overall)]

Body Flanges on Shells

No.	Type	ID	OD	Flange Thk	Min Hub Thk	Material	How Attached	Location	Bolting: Num & Size	Bolting: Bolting Material	Bolting: Washer (OD, ID, thk)	Bolting: Washer Material
N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

7. Seams: Single Bevel [Long. (wld'd, dbl., sngl., lap, butt)] | N.A. [R.T. (spot or full)] | N.A. (Eff., %) | N.A. (H.T. temp.) | N/A (Time, hr) | N.A. [Girth (wld'd, dbl., sngl., lap, butt)] | N.A. [R.T. (spot or full)] | N.A. (Eff., %) | N.A. (No. of courses)
8. Heads: (a) Material: SA-516-70 NORM (Spec. no., grade) (b) Material: SA-516-70 NORM (Spec. no., grade)

	Location (Top, Bottom, Ends)	Minimum Thickness	Corrosion Allowance	Crown Radius	Knuckle Radius	Elliptical Ratio	Conical Apex Angle	Hemispherical Radius	Flat Diameter	Side to Pressure (Convex or Concave)
(a)	Top/Bottom	1.625 in.	0	N.A.	N.A.	N.A.	N.A.	N.A.	2 in.	N.A.
(b)	Ends	0.625 in.	0	N.A.	N.A.	N.A.	N.A.	N.A.	2 in.	N.A.

Body Flanges on Heads

	Location	Type	ID	OD	Flange Thk	Min Hub Thk	Material	How Attached	Bolting: Num & Size	Bolting: Bolting Material	Bolting: Washer (OD, ID, thk)	Bolting: Washer Material
(a)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
(b)												

9. MAWP: 1287 psig (Internal) | N.A. (External) at max. temp. 350 deg F (Internal) | N.A. (External)
Min. design metal temp. -20 deg F at 1287 psig. Hydrostatic test pressure: 1673 psig.
Proof test N/A

10. Nozzles, inspection, and safety valve openings:

Purpose (Inlet, Outlet, Drain etc.)	No.	Diameter or Size	Type	Material: Nozzle	Material: Flange	Nozzle Thickness: Nom.	Nozzle Thickness: Corr.	Reinforcement Material	Attachment Details: Nozzle	Attachment Details: Flange	Location (Insp. Open.)
Inlet/Outlet Nozzle	2	2 In.	Pipe	SA-106-GR B	N.A.	0.218	0	Mat'l&Weld	UW16.1(a)	N.A.	N.A.
Inlet/Outlet Flange	2	2 In.	RFWN	N.A.	SA-105	600RF	N.A.	Mat'l&Weld	N.A.	Welded	N.A.
Auxiliary	1	1 In.	Cplg	SA-105	N.A.	3000#	0	Mat'l&Weld	Welded	N.A.	N.A.

11. Supports: Skirt: No (Yes or no) Lugs: 0 (Number) Legs: 4 (Number) Other: N/A (Describe) Attached: Tubesheet/Welded (Where and how)
12. Remarks: Manufacturer's Partial Data Reports properly identified and signed by Commissioned Inspectors have been furnished for the following items of the report: See Next Line (Name of part, item number, Manufacturer's name and identifying stamp)

Constructed in conformance with Appendix 28. IMPACT EXEMPT PER UCS-66 Curve D(f). Section Volume = 0.6 cubic feet.

Tubes: (34) SA214(WLD) x 0.625 in. OD x 0.06 in. MW x 7 ft. Long, Straight Type
Plugs: (68) SA-105 Taper Plugs
NDE: N/A

FORM U-1A (Back)

CERTIFICATE OF SHOP/FIELD COMPLIANCE

We certify that the statements made in this report are correct and that ll details of design, material, construction, and workmanship of this vessel conform to the ASME BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 1. "U" Certificate of Authorization Number 7616 expires 4/30/2020.

Date 2-20-18 Co. name Alfa Laval, Inc. (Manufacturer) Signed (Representative)

CERTIFICATE OF SHOP/FIELD INSPECTION

Vessel constructed by Alfa Laval, Inc. at 1201 S. 9th St. Broken Arrow, OK 74012.

I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and employed by OneCIS Insurance Co., Lynn, Mass.

have inspeced the component described in this Manufacturer's Data Report on 2-20-18, and state that, to the best of my knowledge and belief, the Manufacturer has constructed this pressure vessel in accordance with ASME BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 1. By signing this certificate neither the inspector nor his/her empolyer makes and warranty, expressed or implied, concerning the pressure vessel described in this Manufacturer's Data Report. Furthermore, neither the Inspector nor his/her employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.

Date 2-20-18 Signed (Authorized Inspector) Commissions NB. 8432 [National Board (Incl. endorsements)]

(07/13)

Service: IC2

FORM U-1A MANUFACTURER'S DATA REPORT FOR PRESSURE VESSELS

(Alternative Form for Single Chamber, Completely Shop or Field Fabricated Vessels Only)

As Required by the Provisions of the ASME Boiler and Pressure Vessel Code Rules, Section VIII, Division 1

1. Manufactured and certified by: Alfa Laval, Inc., 1201 South 9th St., Broken Arrow, Oklahoma 74012 (Name and address of Manufacturer)
2. Manufactured for: McClung Energy, 234 Johnny Clark Rd., Longview, TX 75603 (Name and address of Purchaser)
3. Location of installation: Unknown, USA (Name and address)
4. Type: Vertical (Horizontal or vertical, tank) | 1721903-3B (Manufacturer's serial number) | Not Req'd (CRN) | 17219-H3 (Drawing number) | 15833 (National Board number) | 2018 (Year built)
5. ASME Code, Section VIII, Division 1 | 2015 (Edition and Addenda, if applicable (date)) | None (Code Case numbers) | None [Special service per UG-120(d)]
6. Shell: SA-516-70 NORM (Material spec. number, grade) | 1.625 in. (Nominal thickness) | 0 (Corrosion allowance) | 5.250 in. (Inner diameter) | 27.875 in [Length (overall)]

Body Flanges on Shells

No.	Type	ID	OD	Flange Thk	Min Hub Thk	Material	How Attached	Location	Bolting: Num & Size	Bolting: Bolting Material	Bolting: Washer (OD, ID, thk)	Bolting: Washer Material
N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

7. Seams: Single Bevel [Long. (wld'd, dbl., sngl., lap, butt)] | N.A. [R.T. (spot or full)] | N.A. (Eff., %) | N.A. (H.T. temp.) | N/A (Time, hr) | N.A. [Girth (wld'd, dbl., sngl., lap, butt)] | N.A. [R.T. (spot or full)] | N.A. (Eff., %) | N.A. (No. of courses)
8. Heads: (a) Material: SA-516-70 NORM (Spec. no., grade) (b) Material: SA-516-70 NORM (Spec. no., grade)

	Location (Top, Bottom, Ends)	Minimum Thickness	Corrosion Allowance	Crown Radius	Knuckle Radius	Elliptical Ratio	Conical Apex Angle	Hemispherical Radius	Flat Diameter	Side to Pressure (Convex or Concave)
(a)	Top/Bottom	1.625 in.	0	N.A.	N.A.	N.A.	N.A.	N.A.	2 in.	N.A.
(b)	Ends	0.625 in.	0	N.A.	N.A.	N.A.	N.A.	N.A.	2 in.	N.A.

Body Flanges on Heads

	Location	Type	ID	OD	Flange Thk	Min Hub Thk	Material	How Attached	Bolting: Num & Size	Bolting: Bolting Material	Bolting: Washer (OD, ID, thk)	Bolting: Washer Material
(a)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
(b)												

9. MAWP: 1800 psig (Internal) | N.A. (External) at max. temp. 350 deg F (Internal) | N.A. (External)

Min. design metal temp. -20 deg F at 1800 psig. Hydrostatic test pressure: 2340 psig.

Proof test: N/A

10. Nozzles, inspection, and safety valve openings:

Purpose (Inlet, Outlet, Drain etc.)	No.	Diameter or Size	Type	Material: Nozzle	Material: Flange	Nozzle Thickness: Nom.	Nozzle Thickness: Corr.	Reinforcement Material	Attachment Details: Nozzle	Attachment Details: Flange	Location (Insp. Open.)
Inlet Nozzle	1	1.5 In.	Pipe	SA-106-GR B	N.A.	0.2	0	Mat'l&Weld	UW16.1(a)	N.A.	N.A.
Inlet Flange	1	1.5 In.	RFWN	N.A.	SA-105	900RF	N.A.	Mat'l&Weld	N.A.	Welded	N.A.
Outlet Nozzle	1	2 In.	Pipe	SA-106-GR B	N.A.	0.218	0	Mat'l&Weld	UW16.1(a)	N.A.	N.A.
Outlet Flange	1	2 In.	RFWN	N.A.	SA-105	900RF	N.A.	Mat'l&Weld	N.A.	Welded	N.A.
Auxiliary	2	1 In.	Cplg	SA-105	N.A.	3000#	0	Mat'l&Weld	Welded	N.A.	N.A.

11. Supports: Skirt: No (Yes or no) Lugs: 0 (Number) Legs: 4 (Number) Other: N/A (Describe) Attached: Tubesheet/Welded (Where and how)
12. Remarks: Manufacturer's Partial Data Reports properly identified and signed by Commissioned Inspectors have been furnished for the following items of the report: See Next Line (Name of part, item number, Manufacturer's name and identifying stamp)

Constructed in conformance with Appendix 28. IMPACT EXEMPT PER UCS-66 Curve D(f). Section Volume = 0.5 cubic feet.

Tubes: (34) SA214(WLD) x 0.625 in. OD x 0.06 in. MW x 7 ft. Long, Straight Type

Plugs: (68) SA-105 Taper Plugs

NDE: N/A

FORM U-1A (Back)

CERTIFICATE OF SHOP/FIELD COMPLIANCE

We certify that the statements made in this report are correct and that ll details of design, material, construction, and workmanship of this vessel conform to the ASME BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 1. "U" Certificate of Authorization Number 7616 expires 4/30/2020.

Date 2-20-18 Co. name Alfa Laval, Inc. (Manufacturer) Signed (Representative)

CERTIFICATE OF SHOP/FIELD INSPECTION

Vessel constructed by Alfa Laval, Inc. at 1201 S. 9th St. Broken Arrow, OK 74012.

I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and employed by OneCIS Insurance Co., Lynn, Mass.

have inspeced the component described in this Manufacturer's Data Report on 2-20-18, and state that, to the best of my knowledge and belief, the Manufacturer has constructed this pressure vessel in accordance with ASME BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 1. By signing this certificate neither the inspector nor his/her empolyer makes and warranty, expressed or implied, concerning the pressure vessel described in this Manufacturer's Data Report. Furthermore, neither the Inspector nor his/her employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.

Date 2-20-18 Signed (Authorized Inspector) Commissions NB 8432 [National Board (Incl. endorsements)]

(07/13)

Service: AC

NB# 15831

ALFA LAVAL INC.

INSPECTOR'S PRODUCTION FLOW CHECKLIST

JOB NO. 1721903-2

	EXAMINATION		INSPECTION		
ITEM	QCI	DATE	AI	DATE	REMARKS
DRAWINGS	DA	10-23-17	DG	10-24-17	
WELD PROC.					
PLATE THICKNESS	DA	2-1-18			
MATERIAL CHECK					
EDGE PREP.					
FIT UP (ALL PLATES)	DA	2-3-18	DG	2-6-18	X
WELDING: T-W *					
P-W *					
T-E *					
P-E *					
NOZ					X
RT	NA				
UT					
PT	DA	2-1-18			
MT	NA				
HT					
HYDRO	DA	2-20-18	DG	2-20-18	X
STAMP NP					
NP RUB					
NP ATTACHED					
PAINT					
MANUFACTURER'S DATA REPORT					X

KEY:

1.) T-W* IS TUBE SHEET TO WRAPPER
2.) P-W* IS PLUG SHEET TO WRAPPER
3.) T-E* IS TUBE SHEET TO END PLATE
4.) P-W* IS PLUG SHEET TO WRAPPER

SIGNED _____
QUALITY CONTROL MANAGER

DATE 2/20/18

NB# 15832

ALFA LAVAL INC.

INSPECTOR'S PRODUCTION FLOW CHECKLIST

JOB NO. 1721903-3A

ITEM	EXAMINATION QCI	EXAMINATION DATE	INSPECTION AI	INSPECTION DATE	REMARKS
DRAWINGS	DA	10-23-17	DAS	10-24-17	
WELD PROC.	1	1	1	1	
PLATE THICKNESS	DA	2-1-18	1		
MATERIAL CHECK	1	1			
EDGE PREP.	1	1			
FIT UP (ALL PLATES)	DA	2-3-18	DAS	2-6-18 ✓	
WELDING: T-W *	1	1	1	1	
P-W *	1	1	1	1	
T-E *	1	1	1	1	
P-E *	1	1	1	1	
NOZ	1	1	1	1	
RT	NA				
UT	1				
PT	DA	2-1-18			
MT	NA				
HT	1				
HYDRO	DA	2-20-18	DAS	2-20-18	
STAMP NP	1		1	1	
NP RUB	1	1			
NP ATTACHED	1	1			
PAINT	1	1			
MANUFACTURER'S DATA REPORT					

KEY:

1.) T-W* IS TUBE SHEET TO WRAPPER
2.) P-W* IS PLUG SHEET TO WRAPPER
3.) T-E* IS TUBE SHEET TO END PLATE
4.) P-W* IS PLUG SHEET TO WRAPPER

SIGNED _____
QUALITY CONTROL MANAGER

DATE 2-20-18

NB# 15839

ALFA LAVAL INC.

INSPECTOR'S PRODUCTION FLOW CHECKLIST

JOB NO. 1721903-3B

	EXAMINATION		INSPECTION		
ITEM	QCI	DATE	AI	DATE	REMARKS
DRAWINGS	DA	10-23-17	BOS	10-24-17	
WELD PROC.	〃	〃	〃	〃	
PLATE THICKNESS	DA	2-1-18			
MATERIAL CHECK	〃	〃			
EDGE PREP.	〃	〃			
FIT UP (ALL PLATES)	DA	2-3-18	BOS	2-6-18	
WELDING: T-W *	〃	〃	〃	〃	
P-W *	〃	〃	〃	〃	
T-E *	〃	〃	〃	〃	
P-E *	〃	〃	〃	〃	
NOZ	〃	〃	〃	〃	
RT	NA		〃	〃	
UT	〃		〃	〃	
PT	DA	2-1-18			
MT	NA				
HT	〃				
HYDRO	DA	2-20-18	AA	2-20-18	
STAMP NP	〃	〃	〃	〃	
NP RUB	〃	〃	〃	〃	
NP ATTACHED	〃	〃	〃	〃	
PAINT	〃	〃	〃	〃	
MANUFACTURER'S DATA REPORT	〃	〃	〃	〃	

KEY:

1.) T-W* IS TUBE SHEET TO WRAPPER
2.) P-W* IS PLUG SHEET TO WRAPPER
3.) T-E* IS TUBE SHEET TO END PLATE
4.) P-W* IS PLUG SHEET TO WRAPPER

SIGNED _____
QUALITY CONTROL MANAGER

DATE 2-20-18

MATERIAL TRACEABILITY RECORD

-E ✓ PLATE _____ TUBES _____ BY AWN DATE 2/13/15 JOB NO. 17219-03

SERIAL NO. / SERVICE	MATERIAL DESCRIPTION	HEAT OR CERTIFICATION NO. / Alfa Laval Inc. I.D. NUMBER
(2)	1. 2" 300 RF X H SA-105	B8990
	2. 2" X H SA-106-GR B	(TFO)
	3	
(3A)	1. 2" 600, RF, XH, SA, 105	605086H
	2. 2" X H SA-106-GR B	(TFD)
	3.	
(3B)	1. 5" 900, RF, XH, SA-105	B0597
	1-B 4" X H SA-106-GR B	(TFA)
	3 2" 900, RF, XH, SA-105	207590A
	2" X H SA 106-GR B	(TFI)
	2.	
	3.	
	1.	
	2.	
	3.	

TES:

MATERIAL TRACEABILITY RECORD

PLATE ✓ TUBES _____ BY PT DATE 2.7.18 JOB NO. 1721903

SERIAL NO. / SERVICE		MATERIAL DESCRIPTION		HEAT OR CERTIFICATION NO. Alfa Laval Inc. I.D. NUMBER
(2) BK	1.	SA - 516 - 70	7/8	SL152N
FR	2	SA - 516 - 70	1/2	NU397N
	3	SA - 516 - 70	1/2	NU343N
	1.			
	2			
	3.			
	1.			
	2			
	3.			
	1.			
	2			
	3.			
	1.			
	2.			
	3.			

TES:

MATERIAL TRACEABILITY RECORD

= PE _____ PLATE ✓ TUBES _____ BY R.E.J DATE 2-5-18 JOB NO. 1721903

SERIAL NO. SERVICE	MATERIAL DESCRIPTION	HEAT OR CERTIFICATION NO. Alfa Laval Inc. I.D. NUMBER
	1.	
	2.	
	3	
	1.	
	2.	
	3.	
3	1. SA-516-70 Norm 15/8"	M755N
	2. SA-516-70 Norm 5/8"	NW390N
	3.	
	1.	
	2.	
	3.	
	1.	
	2.	
	3.	

NOTES:

MATERIAL TRACEABILITY RECORD

PIPE _____ PLATE _____ TUBES ✓ BY PETER DATE 2-15-18 JOB NO. 1721903

SERIAL NO. / SERVICE	MATERIAL DESCRIPTION	HEAT OR CERTIFICATION NO. / Alfa Laval Inc. I.D. NUMBER
1. EJW	1. 3/4 x 7'-0" SA214 060	WA709419 WEBCO
	2.	
	3.	
2. IC1	1. 5/8 x 7'-0" SA214 060	WA711201 WEBCO
	2.	
	3.	
3. IC2	1. 5/8 x 7'-0" SA214 060	WA711201 WEBCO
	2.	
	3.	
4. AC	1. 5/8 x 7'-0" SA214 060	WA711201 WEBCO
	2.	
	3.	
5.	1.	
	2.	
	3.	

NOTES:


15831
CERTIFIED BY
Alfa Laval Inc.
Broken Arrow, Oklahoma 74012 USA
MAWP 645 PSI @ 350 °F
MDMT -20 °F @ 645 PSI
SERIAL NO. 172903-2
MODEL J54-7
YEAR BUILT 2018
SERVICE IC1
ACE


15832
CERTIFIED BY
Alfa Laval Inc.
Broken Arrow, Oklahoma 74012 USA
MAWP 1287 PSI @ 350 °F
MDMT -20 °F @ 1287 PSI
SERIAL NO. 172903-3A
MODEL J54-7
YEAR BUILT 2018
SERVICE IC2
ACE


15833
CERTIFIED BY
Alfa Laval Inc.
Broken Arrow, Oklahoma 74012 USA
MAWP 1800 PSI @ 350 °F
MDMT -20 °F @ 1800 PSI
SERIAL NO. 172903-3B
MODEL J54-7
YEAR BUILT 2018
SERVICE AC
ACE

[| C180077 | | | 1017395445] | [LN: 4] | T0405083-1 | FSVAT2XHPSL2 |

voestalpine Tubulars GmbH & Co KG

Alpinestrasse 17
8652 Kindberg-Aumuehl
T. +43/050304/23-0
F. +43/050304/63-532
www.voestalpine.com/tubulars

Legal Structure: Limited Partnership
Location: Kindberg/Austria
Company Registry Number 165400k
Commercial Court of Leoben
DPR 0592684, VAT Nr. ATU 43630406

General Partner: voestalpine Tubulars GmbH
Legal Structure: Limited Liability Company
Location: Linz, Company Registry Number 106933f
Commercial Court of Linz

FSVAT2XHPSL2

MILL TEST CERTIFICATE 3.1

(according to EN 10204)

ABNAHMEPRUEFZEUGNIS 3.1

(gem. EN 10204)

No. 134199 Rev.: 0

CERTIFICAT DE CONTROLE DES PRODUITS PAR L'USINE 3.1

(selon EN 10204)

Hersteller: Manufacturer: Producteur:	voestalpine Tubulars GmbH & Co KG, Austria
Besteller: Purchaser: Acheteur:	VOEST-ALPINE TUBULAR CORPORATION HOUSTON, TEXAS 77077, US INDUSTRIAL PIPING SPECIALISTS. INC. TULSA OK 74158-1270, US
Pruefgegenstand: Object of tests: Eprouvette:	**Line Pipe** **LP-USA-02-PSL2** **LINEPIPE-01.0** **non upset ends (API-5-L) - non upset** **UV coating**
Werkstoff: Material: Matières:	GRADE B / GRADE BN /GRADE X42N / GRADE C
Anforderungen: Requirements: Exigence:	Grade B acc. to ASTM A 53 / A 53M-2012 ASME SA 53-2015 Grade B acc. to ASTM A 106 / A 106M-2015, ASME SA 106-2015 GRADE BN / X42N acc. to API 5 L, 45.edt.-2012 (PSL2) NACE MR 0175 / ISO 15156-2015 NACE MR 0103-2015 LINEPIPE-01.0; LP-USA-02-PSL2
Ausführung: Condition: Cond. de livraison:	NU, PLAIN END, PE, both ends bevelled acc. to API/ASTM (30°)
Wärmebehandlung: Heat treatment: Traitment de chaleur:	NORMALIZED ROLLED
Coupl.die stamped: Coupl.paint stencilling: Coupl.Colour coding:	Fully painted: Bands:
Tube die stamped: Tube paint stencilling:	va SPEC 5L-0033 "API" 06.2017 2.375" x 0.216" BN/X42N PSL2 SMLS 2970 PSI Length FT Heat No. Lot No. A/SA 53 Grade B S A/SA 106 Grade B Sched.80 PO# HR0745145 MADE IN AUSTRIA
Tube Colour coding:	Fully painted: Bands: purple
Label:	PO No.: HR074514, DAT Port of Houston, TX
Remarks:	*) Grade C without marking on tubes *) SI units have been converted to US customary units *) (Nb+V) <= 0,06%

Auftrags-Nr.: Our works order No.: No usine:	23534 / 5
Bestellnr.: Your order No.: No de la commande:	HR074514/VATC PO# 702631
Zeichen des Lieferwerks: Marking of producer: Marque du fabricant:	va
Erschmelzungsart: Melting process: Procédé d'élaboration:	**BOF** fully killed, produced to fine grain practice

LD/TFI

Carbon Pipe.
2" x H SA53
Ht=1017395445

RECEIVED
JAN 24 2018
C180077 Stock.
PO #_____ JOB #_____
BM.

Kindberg, 21.07.2017

No. 134199

Abnahmeprüfzeugnis wurde digital signiert und ist ohne Originalunterschrift gültig/
Inspection certificate has been signed digitally and is valid without an original signature

voestalpine Tubulars GmbH & Co KG
Qualitätsstelle / Quality Department
WEITZER
Abnahmebeauftragter
authorized inspection representative
représentant autorisé du controle

voestalpine
ONE STEP AHEAD.

voestalpine Tubulars GmbH & Co KG

Umfang der Lieferung / Volume of delivery / Contenu de la livraison:

Versandanzeige: Dispatch advice No. Avis d'expédition:	Pos.: Pos.:	Abmessung: Dimension: Dimension:	Bundnr.: Bundle No.: Nombre Fret:	Stückzahl: Number Of: Pièces:	Länge: Length: Longueur:	Gewicht: Weight: Poids:	Los: Lot: Lot:
	5	2,375 in x 0,218 in; 5,02 lbs/ft SCHED.80	1-61	2318	99266,925 ft	225443,50 kg	

Volume of delivery

Heat	Lot		Remark
1017395101	216622	AD 01	
1017395448	216620	AD 01	
1017395447	216621	AD 01	
1017395446	216624	AD 01	
1017395445	216623	AD 01	

Kindberg, 21.07.2017

No. 134199

Abnahmeprüfzeugnis wurde digital signiert und ist ohne Originalunterschrift gültig/
Inspection certificate has been signed digitally and is valid without an original signature

voestalpine Tubulars GmbH & Co KG
Qualitätsstelle / Quality Department
WEITZER
Abnahmebeauftragter
authorized inspection representative
représentant autorisé du controle

voestalpine
ONE STEP AHEAD.

voestalpine Tubulars GmbH & Co KG

Additional tests and inspections performed on pipe

1 Biegeversuch/Bend test: bestanden/passed

2 Dimensionskontrolle/ Dimensional Inspection: bestanden/passed

3 Streuflusspruefung/Diverted flux acc. API 5 L (old version - SR 4) OD + ID, longitudinal 12.5 %: bestanden/passed

4 Streuflusspruefung gem. ASTM E570/Flux leakage testing acc. to ASTM E570: bestanden/passed

5 Ultraschallpruefung gem. Norm (Wanddicke - 100 % Umfang)/Ultrasonic inspection acc. to standard (wallthickness - 100 % circumference): bestanden/passed

6 Visuelle Inspektion/ Visual Inspection: bestanden/passed

7 Wasserinnendruckversuch/Hydrostatic test: bestanden/passed, Mindestpruefdruck/min test pressure: 2970 PSI, min.Haltezeit/min duration: 5 sec

Test remarks

Wir bestätigen, dass die gelieferten Erzeugnisse den Anforderungen der Bestellung entsprechen.
We hereby certify that the goods delivered are in compliance with the requirements of the order.

Kindberg, 21.07.2017

No. 134199

Abnahmeprüfzeugnis wurde digital signiert und ist ohne Originalunterschrift gültig/
Inspection certificate has been signed digitally and is valid without an original signature

voestalpine Tubulars GmbH & Co KG
Qualitätsstelle / Quality Department
WEITZER
Abnahmebeauftragter
authorized inspection representative
représentant autorisé du controle

voestalpine
ONE STEP AHEAD.

voestalpine Tubulars GmbH & Co KG

Tensile testing

Lot No		Test Type	Heat treatment	Loc.	Temp		Specimen				Yield Strength	Tensile Strength	Elong.	gage-length	Reduct. in area	Rt/Rm
					[°F]	No.	Type	Pipe	Dimension	[inch]	[PSI]	[PSI]	[%]	[inch]	[%]	
											Requ. from	42061	60190	22.00		
											Requ. to	71793	94999			0.93
216620	AD01	Standard	normalized rolled	Rear	68	1	Strip-long	0.76	x	0.22	Rt0.50	53954	75999	30.90	2	0.71
216620	AD01	Standard	normalized rolled	Rear	68	2	Strip-long	0.75	x	0.22	Rt0.50	54679	76144	30.70	2	0.72
216621	AD01	Standard	normalized rolled	Rear	68	1	Strip-long	0.75	x	0.22	Rt0.50	52503	75129	31.20	2	0.70
216621	AD01	Standard	normalized rolled	Rear	68	2	Strip-long	0.75	x	0.22	Rt0.50	53809	76144	31.80	2	0.71
216622	AD01	Standard	normalized rolled	Rear	68	1	Strip-long	0.75	x	0.22	Rt0.50	54389	77015	31.00	2	0.71
216622	AD01	Standard	normalized rolled	Rear	68	2	Strip-long	0.75	x	0.22	Rt0.50	53664	76579	30.50	2	0.70
216623	AD01	Standard	normalized rolled	Rear	68	1	Strip-long	0.75	x	0.23	Rt0.50	50038	72663	31.50	2	0.69
216623	AD01	Standard	normalized rolled	Rear	68	2	Strip-long	0.75	x	0.22	Rt0.50	52213	75274	30.70	2	0.69
216624	AD01	Standard	normalized rolled	Rear	68	1	Strip-long	0.75	x	0.22	Rt0.50	52648	75274	31.20	2	0.70

yield strength:
GR B/ BN / X42N: 42100-71800 PSI
Gr C: min. 40000 PSI
tensile strength:
GR B/ BN / X 42N: 60200-95000 PSI
Gr C: min. 70000 PSI

Kindberg, 21.07.2017

No. 134199

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Qualitätsstelle / Quality Department
WEITZER
Abnahmebeauftragter
authorized inspection representative
représentant autorisé du controle

voestalpine
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voestalpine Tubulars GmbH & Co KG

Hardness testing

Lot No	Test Type	Heat treatment	Specimen Loc.	No.	Location	Test Method	Hardness Number from	to	Mean Hardness Number from	to	Variation
						Requ.:				99.50	
216620	AD01 Standard	normalized rolled	Rear	1	Body	HRB	81.30	82.50	81.47	82.17	0.70
Quadrant	1_Outer	2_Outer	3_Outer	AVG_Outer	1_Mid	2_Mid	3_Mid	AVG_Mid	1_Inner	2_Inner	3_Inner	AVG_Inner	AVG_Variation
1	82.10	81.50	81.30	81.63	82.50	82.00	82.00	82.17	81.30	81.70	81.40	81.47	0.70
216621	AD01 Standard	normalized rolled	Rear	1	Body	HRB	81.20	82.30	81.37	82.07	0.70
Quadrant	1_Outer	2_Outer	3_Outer	AVG_Outer	1_Mid	2_Mid	3_Mid	AVG_Mid	1_Inner	2_Inner	3_Inner	AVG_Inner	AVG_Variation
1	81.20	81.50	81.40	81.37	81.70	82.20	82.30	82.07	82.10	81.70	82.00	81.93	0.70
216622	AD01 Standard	normalized rolled	Rear	1	Body	HRB	81.80	83.20	82.10	82.77	0.67
Quadrant	1_Outer	2_Outer	3_Outer	AVG_Outer	1_Mid	2_Mid	3_Mid	AVG_Mid	1_Inner	2_Inner	3_Inner	AVG_Inner	AVG_Variation
1	82.50	81.80	82.00	82.10	83.20	82.70	82.40	82.77	83.00	82.60	82.70	82.77	0.67
216623	AD01 Standard	normalized rolled	Rear	1	Body	HRB	80.00	81.70	80.73	81.30	0.57
Quadrant	1_Outer	2_Outer	3_Outer	AVG_Outer	1_Mid	2_Mid	3_Mid	AVG_Mid	1_Inner	2_Inner	3_Inner	AVG_Inner	AVG_Variation
1	80.00	81.20	81.00	80.73	81.50	81.70	80.70	81.30	81.00	80.30	81.60	80.97	0.57
216624	AD01 Standard	normalized rolled	Rear	1	Body	HRB	81.40	82.50	81.53	82.27	0.74
Quadrant	1_Outer	2_Outer	3_Outer	AVG_Outer	1_Mid	2_Mid	3_Mid	AVG_Mid	1_Inner	2_Inner	3_Inner	AVG_Inner	AVG_Variation
1	81.70	81.50	81.40	81.53	82.10	82.00	82.50	82.20	82.30	82.20	82.30	82.27	0.74

Kindberg, 21.07.2017

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Impact testing

Requirement:	Length [inch] 2.165	Wide [inch] .394	Height [inch] .13	Specimen Orientation long.	Type CH-V	Temp. [°F] - 20	[	Single ft-lbs	]	[	Average ft-lbs	Factor]

Lot No	Test Type	Heat Treatment	Loc.	No.	Pipe		Single1	Single2	Single3	Average	Unit
216620 AD01	Standard	normalized rolled	Rear	1	long.	Imp. Values:	36	40	40	39	ft-lbs
for information!						Including Factor:					
						Shear-Area [%]:					
						Lateral Expansion (un-/broken):					
						Lateral Expansion: [inch]				H: 0.130	[inch]

Lot No	Test Type	Heat Treatment	Loc.	No.	Pipe		Single1	Single2	Single3	Average	Unit
216620 AD01	Standard	normalized rolled	Rear	2	long.	Imp. Values:	39	40	39	39	ft-lbs
for information!						Including Factor:					
						Shear-Area [%]:					
						Lateral Expansion (un-/broken):					
						Lateral Expansion: [inch]				H: 0.130	[inch]

Lot No	Test Type	Heat Treatment	Loc.	No.	Pipe		Single1	Single2	Single3	Average	Unit
216621 AD01	Standard	normalized rolled	Rear	1	long.	Imp. Values:	36	37	33	36	ft-lbs
for information!						Including Factor:					
						Shear-Area [%]:					
						Lateral Expansion (un-/broken):					
						Lateral Expansion: [inch]				H: 0.130	[inch]

Lot No	Test Type	Heat Treatment	Loc.	No.	Pipe		Single1	Single2	Single3	Average	Unit
216621 AD01	Standard	normalized rolled	Rear	2	long.	Imp. Values:	36	39	35	36	ft-lbs
for information!						Including Factor:					
						Shear-Area [%]:					
						Lateral Expansion (un-/broken):					
						Lateral Expansion: [inch]				H: 0.130	[inch]

Lot No	Test Type	Heat Treatment	Loc.	No.	Pipe		Single1	Single2	Single3	Average	Unit
216622 AD01	Standard	normalized rolled	Rear	1	long.	Imp. Values:	37	32	33	34	ft-lbs
for information!						Including Factor:					
						Shear-Area [%]:					
						Lateral Expansion (un-/broken):					
						Lateral Expansion: [inch]				H: 0.130	[inch]

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Impact testing

Lot No	Test Type	Heat Treatment	Loc.	No.	Pipe	long.	Imp. Values:	Single1	Single2	Single3	Average	Unit
216622 AD01	Standard	normalized rolled	Rear	2				34	36	36	35	ft-lbs
49for information!							Including Factor:					
							Shear-Area [%]:					
							Lateral Expansion (un-/broken):					
							Lateral Expansion: [inch]				H: 0.130	[inch]

Lot No	Test Type	Heat Treatment	Loc.	No.	Pipe	long.	Imp. Values:	Single1	Single2	Single3	Average	Unit
216623 AD01	Standard	normalized rolled	Rear	1				30	30	30	30	ft-lbs
for information!							Including Factor:					
							Shear-Area [%]:					
							Lateral Expansion (un-/broken):					
							Lateral Expansion: [inch]				H: 0.130	[inch]

Lot No	Test Type	Heat Treatment	Loc.	No.	Pipe	long.	Imp. Values:	Single1	Single2	Single3	Average	Unit
216623 AD01	Standard	normalized rolled	Rear	2				31	29	30	30	ft-lbs
for information!							Including Factor:					
							Shear-Area [%]:					
							Lateral Expansion (un-/broken):					
							Lateral Expansion: [inch]				H: 0.130	[inch]

Requirement:	Length [inch]	Wide [inch]	Height [inch]	Specimen Orientation	Type	Temp. [°F]	[	Single ft-lbs	]	[	Average ft-lbs	Factor]
	2.165	.394	.13	long.	CH-V	- 20						0.33

Lot No	Test Type	Heat Treatment	Loc.	No.	Pipe	long.	Imp. Values:	Single1	Single2	Single3	Average	Unit
216624 AD01	Standard	normalized rolled	Rear	1		long.	Imp. Values:	32	30	31	31	ft-lbs
Mechanische Werte informativ !							Including Factor:	98	93	95	95	
							Shear-Area [%]:					
							Lateral Expansion (un-/broken):					
							Lateral Expansion: [inch]				H: 0.130	[inch]

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Chemical testing

Heat analysis

C	Si	Mn	P	S	Cr	Ni	Cu	Al	Ti	Mo	V	Sn	B	N2	Nb	Ca	CEQ
min. Requ.																	
0.0000	0.1000	0.2900															
max. Requ.																	
0.2300	0.4000	1.0600	0.0250	0.0150	0.3000	0.3000	0.4000		0.0400	0.1500	0.0500		0.0010		0.0500		0.4000
1017395101																	
0.1799	0.2472	0.9527	0.0096	0.0044	0.0305	0.0155	0.0182	0.0176	0.0015	0.0022	0.0010	0.0004	0.0001	0.0043	0.0341	0.0019	0.3477
1017395445																	
0.1872	0.2461	0.9551	0.0146	0.0055	0.0165	0.0149	0.0193	0.0247	0.0018	0.0018	0.0005	0.0002	0.0003	0.0044	0.0382	0.0013	0.3526
1017395446																	
0.1804	0.2461	0.9501	0.0148	0.0040	0.0206	0.0185	0.0194	0.0263	0.0017	0.0023	0.0006	0.0004	0.0002	0.0046	0.0417	0.0012	0.3460
1017395447																	
0.1893	0.2626	0.9621	0.0171	0.0081	0.0274	0.0157	0.0301	0.0292	0.0016	0.0019	0.0007	0.0003	0.0003	0.0040	0.0440	0.0015	0.3587
1017395448																	
0.1812	0.2466	0.9714	0.0133	0.0063	0.0306	0.0152	0.0206	0.0263	0.0017	0.0035	0.0006	0.0001	0.0002	0.0074	0.0395	0.0016	0.3524

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Chemical testing

Product analysis

C	Si	Mn	P	S	Cr	Ni	Cu	Al	Ti	Mo	V	Sn	B	N2	Nb	CEQ
Lot No. 216620 AD 01 1 Standard Heat No. 1017395448																
0.1783	0.2353	0.9710	0.0124	0.0061	0.0291	0.0147	0.0193	0.0255	0.0024	0.0029	0.0037	0.0011	0.0003	0.0061	0.0385	0.3495
Lot No. 216620 AD 01 2 Standard Heat No. 1017395448																
0.1784	0.2377	0.9651	0.0127	0.0065	0.0289	0.0158	0.0216	0.0251	0.0020	0.0027	0.0032	0.0008	0.0003	0.0059	0.0394	0.3487
Lot No. 216620 AD 01 3 Standard Heat No. 1017395448																
0.1736	0.2380	0.9657	0.0128	0.0061	0.0293	0.0155	0.0206	0.0254	0.0021	0.0024	0.0031	0.0010	0.0003	0.0061	0.0390	0.3439
Lot No. 216620 AD 01 4 Standard Heat No. 1017395448																
0.1787	0.2357	0.9656	0.0131	0.0058	0.0300	0.0163	0.0199	0.0252	0.0021	0.0033	0.0029	0.0005	0.0002	0.0063	0.0383	0.3493
Lot No. 216621 AD 01 1 Standard Heat No. 1017395447																
0.1840	0.2506	0.9552	0.0161	0.0075	0.0283	0.0153	0.0292	0.0280	0.0019	0.0017	0.0032	0.0005	0.0003	0.0038	0.0434	0.3528
Lot No. 216621 AD 01 2 Standard Heat No. 1017395447																
0.1857	0.2578	0.9593	0.0167	0.0092	0.0273	0.0157	0.0312	0.0281	0.0019	0.0011	0.0031	0.0006	0.0003	0.0038	0.0431	0.3550
Lot No. 216621 AD 01 3 Standard Heat No. 1017395447																
0.1841	0.2562	0.9594	0.0166	0.0101	0.0273	0.0156	0.0316	0.0280	0.0018	0.0011	0.0032	0.0007	0.0003	0.0039	0.0439	0.3535
Lot No. 216621 AD 01 4 Standard Heat No. 1017395447																
0.1828	0.2579	0.9571	0.0165	0.0097	0.0282	0.0150	0.0294	0.0283	0.0018	0.0012	0.0029	0.0009	0.0003	0.0033	0.0425	0.3517
Lot No. 216622 AD 01 1 Standard Heat No. 1017395101																
0.1765	0.2346	0.9419	0.0089	0.0041	0.0306	0.0176	0.0186	0.0170	0.0018	0.0018	0.0033	0.0007	0.0001	0.0038	0.0339	0.3430
Lot No. 216622 AD 01 2 Standard Heat No. 1017395101																
0.1751	0.2326	0.9427	0.0081	0.0037	0.0299	0.0169	0.0179	0.0177	0.0017	0.0016	0.0032	0.0008	0.0001	0.0033	0.0339	0.3415
Lot No. 216622 AD 01 3 Standard Heat No. 1017395101																
0.1753	0.2316	0.9439	0.0085	0.0049	0.0307	0.0177	0.0184	0.0172	0.0018	0.0021	0.0030	0.0006	0.0001	0.0037	0.0340	0.3422
Lot No. 216622 AD 01 4 Standard Heat No. 1017395101																
0.1738	0.2387	0.9420	0.0085	0.0044	0.0304	0.0180	0.0177	0.0171	0.0017	0.0018	0.0030	0.0006	0.0001	0.0032	0.0343	0.3402
Lot No. 216623 AD 01 1 Standard Heat No. 1017395445																
0.1774	0.2202	0.9344	0.0123	0.0043	0.0148	0.0151	0.0171	0.0220	0.0022	0.0013	0.0032	0.0008	0.0003	0.0042	0.0365	0.3391
Lot No. 216623 AD 01 2 Standard Heat No. 1017395445																
0.1775	0.2138	0.9257	0.0126	0.0045	0.0146	0.0153	0.0171	0.0219	0.0021	0.0012	0.0029	0.0009	0.0003	0.0041	0.0364	0.3377
Lot No. 216623 AD 01 3 Standard Heat No. 1017395445																
0.1757	0.2131	0.9207	0.0125	0.0039	0.0146	0.0155	0.0173	0.0218	0.0020	0.0014	0.0027	0.0007	0.0003	0.0040	0.0364	0.3351
Lot No. 216623 AD 01 4 Standard Heat No. 1017395445																
0.1747	0.2077	0.9207	0.0123	0.0041	0.0143	0.0157	0.0168	0.0218	0.0018	0.0013	0.0025	0.0006	0.0003	0.0040	0.0360	0.3339
Lot No. 216624 AD 01 1 Standard Heat No. 1017395446																
0.1771	0.2251	0.9459	0.0138	0.0036	0.0201	0.0188	0.0187	0.0251	0.0023	0.0020	0.0033	0.0008	0.0003	0.0042	0.0401	0.3423
Lot No. 216624 AD 01 2 Standard Heat No. 1017395446																
0.1769	0.2203	0.9339	0.0135	0.0041	0.0199	0.0191	0.0184	0.0241	0.0022	0.0020	0.0031	0.0007	0.0003	0.0041	0.0398	0.3401

Kindberg, 21.07.2017

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représentant autorisé du controle

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CERTIFICATE OF INSPECTION & TEST (EN 10204 3.1)

ST&H CORPORATION
74, Jwadongsunhwan-ro, Haeundae-gu, Busan, Korea
Tel : +82.51.744-4680(5 line) Fax : +82.51.744-4670
E-mail :qm@stnhcorp.com

CE
RPS 0160300 / 01

Certificate No. MJM9728-08/17 Date : OCT. 17. 2017
Customer INDUSTRIAL PIPING SPECIALISTS.
Contract No. TP548969 Certified to ISO9001:2008, ISO14001:2004,PED2014/68/EC by LRQA
Spec. For Material ASTM A105N-14,ASME SA105N-15,NACE MR0175/ISO15156-1-2015,NACE MR0103/ISO17495-1-2016
Heat Treatment 930℃ NORMALIZED & A.C Dimensional inspection ASME B16.5 - 2013

ITEM / SIZE		Q'ty	Heat No./ Batch No.	Size of Test Specimen D mm	Size of Test Specimen GL mm	Tension Test	Y.S MPa	T.S MPa	E.L %	R.A %	Hardness Test (HB)		Charpy Impact Test (10X10mm Specimen Size) Indiv. 21J	Ave. 27J	Notch V	Temp. -29℃
				12.5	50.0	Max					187		Test Result (J)			Ave.(J)
						Min	250	485	22.0	30.0						
FK215CRFWN160	1500LBS WN RF S160 2"	40	207590A	12.5	50.0		341	533	30	72	163	167	68	72	79	73
FK215CRFWNXH	1500LBS WN RF XH 2"	150	207590A	12.5	50.0		341	533	30	72	163	167	68	72	79	73
FK325CRJWNXXH	2500LBS WN RTJ XXH 3"	5	207590A	12.5	50.0		341	533	30	72	163	167	68	72	79	73
FK390RFWN160	900LBS WN RF S160 3"	10	207590A	12.5	50.0		341	533	30	72	163	167	68	72	79	73
FK.515RFSO	150LBS SO RF 1/2"	50	207590C	12.5	50.0		341	533	30	72	163	167	68	72	79	73
FK515RFSO	150LBS SO RF 5"	25	207590C	12.5	50.0		341	533	30	72	163	167	68	72	79	73
FK315RFWN160	150LBS WN RF S160 3"	20	207590C	12.5	50.0		341	533	30	72	163	167	68	72	79	73
FK515RFWNSTD	150LBS WN RF STD 5"	50	207590C	12.5	50.0		341	533	30	72	163	167	68	72	79	73
FK330RFSO	300LBS SO RF 3"	10	207590C	12.5	50.0		341	533	30	72	163	167	68	72	79	73
FK630RFSO	300LBS SO RF 6"	10	207590C	12.5	50.0		341	533	30	72	163	167	68	72	79	73

Heat No./ Batch No.		Chemical Composition (%) C	Si	Mn	P	S	Ni	Cr	Mo	Cu	V	CE	NDE UT	MT	PT
	Max	0.350	0.350	1.050	0.035	0.040	0.400	0.300	0.120	0.400	0.080				
	Min		0.100	0.600											
	H	0.171	0.241	1.020	0.017	0.008	0.015	0.156	0.002	0.013	0.001	0.374			
207590A	P	0.180	0.237	1.040	0.016	0.007	0.008	0.024	0.002	0.025	0.001	0.360			
	H	0.171	0.241	1.020	0.017	0.008	0.015	0.156	0.002	0.013	0.001	0.374			
207590C	P	0.180	0.237	1.040	0.016	0.007	0.008	0.024	0.002	0.025	0.001	0.360			

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REMARK
* H : Heat Analysis P : Product Analysis
* Impact Test performed according to ASTM A370 & MESC 76/210/2017 Paragraph 8.5 / Table 4 & 5.
* C:Mn = 1≤5
* PRODUCT OF KOREA

We hereby certify that the material herein has been made and tested in accordance with the above specification and also with the requirements called for by the above order.

Witnessed by / H. J. LEE

ST&H CORPORATION J.M.KIM QUALITY MANAGEMENT

Manager of Q.A Dept. / J. M. KIM

ST-801-14-02

ST&H CORPORATION

Carbon flange
2" 1500 XH A105
HT#207590A

RECEIVED
JAN 24 2018

C180022 JOB # 1721009-10-11-
PO # 1721901-02-03-04-
RS 1724101-02-03-04-05
06-07-08-09-10-11

[| C180022 | | | 207590A] | [LN: 13] | T0405193-1 | FK215CRFWNXH |

CERTIFICATE OF INSPECTION & TEST (EN 10204 3.1)

ST&H CORPORATION
74, Jwadongsunhwan-ro, Haeundae-gu, Busan, Korea
Tel : +82.51.744-4680(5 line) Fax : +82.51.744-4670
E-mail :qm@stnhcorp.com

Certificate No. MJM9728-16/17 Date : OCT. 17. 2017
Customer INDUSTRIAL PIPING SPECIALISTS,
Contract No. TP548969
Certified to ISO9001:2008, ISO14001:2004,PED2014/68/EC by LRQA
Spec. For Material ASTM A105N-14,ASME SA105N-15,NACE MR0175/ISO15156-1-2015,NACE MR0103/ISO17495-1-2016
Heat Treatment 930℃ NORMALIZED & A.C
Dimensional inspection ASME B16.5 - 2013

ITEM / SIZE		Q'ty	Heat No./ Batch No.	Size of Test Specimen D mm	Size of Test Specimen GL mm	Tension Test	Y.S MPa	T.S MPa	E.L %	R.A %	Hardness Test (HB)		Charpy Impact Test (10X10mm Specimen Size) Indiv. 21J	Ave. 27J	Notch V	Temp. -29℃
						Max					187		Test Result (J)			Ave.(J)
				12.5	50.0	Min	250	485	22.0	30.0						
FK130RFWNXH	300LBS WN RF XH 1"	30	605086H	12.5	50.0		349	521	33	76	160	164	77	93	114	95
FK260RFTHRD	600LBS TH RF 2"	40	605086H	12.5	50.0		349	521	33	76	160	164	77	93	114	95
FK260RFWNXH	600LBS WN RF XH 2"	500	605086H	12.5	50.0		349	521	33	76	160	164	77	93	114	95
FK315RFWNSTD	150LBS WN RF STD 3"	300	605086I	12.5	50.0		349	521	33	76	160	164	77	93	114	95
BLANK			BLANK				BLANK				BLANK					

Heat No./ Batch No.		Chemical Composition (%) C	Si	Mn	P	S	Ni	Cr	Mo	Cu	V	CE	NDE UT	MT	PT
	Max	0.350	0.350	1.050	0.035	0.040	0.400	0.300	0.120	0.400	0.080				
	Min		0.100	0.600											
	H	0.172	0.217	1.100	0.013	0.007	0.007	0.016	0.002	0.017	0.001	0.360			
605086H	P	0.180	0.216	1.080	0.014	0.002	0.009	0.024	0.002	0.025	0.001	0.367			
	H	0.172	0.217	1.100	0.013	0.007	0.007	0.016	0.002	0.017	0.001	0.360			
605086I	P	0.180	0.216	1.080	0.014	0.002	0.009	0.024	0.002	0.025	0.001	0.367			
		BLANK													

HT# →

REMARK * H : Heat Analysis P : Product Analysis
* Impact Test performed according to ASTM A370 & MESC 76/210/2017 Paragraph 8.5 / Table 4 & 5.
* C:Mn = 1≤5
* Mn is Permitted up to Max 1.65% (ASTM A105-14 TABLE 1, NOTE 1.)
* PRODUCT OF KOREA

We hereby certify that the material herein has been made and tested in accordance with the above specification and also with the requirements called for by the above order.

Witnessed by / H. J. LEE

ST&H CORPORATION QUALITY MANAGEMENT

Manager of Q.A Dept. / J. M. KIM

ST-801-14-02

ST&H CORPORATION

Carbon flange
2" 600 XH A105
HT# 605086H

RECEIVED
JAN 24 2018

C180022
PO #
JOB # 179

1721009-10-11
1721901-02-03-04-05-06-07-08-09
1724102-03-04-05-18-19
1721910-11

[| C180022 | | 605086H] | [LN: 11] | T0405193-1 | FK260RFWNXH |

CERTIFICATE OF INSPECTION & TEST (EN 10204 3.1)

ST&H CORPORATION
74, Jwadongsunhwan-ro, Haeundae-gu, Busan, Korea
Tel : +82.51.744-4680(5 line) Fax : +82.51.744-4670
E-mail :qm@stnhcorp.com

Certificate No. MJH9820-04/13 Date : NOV. 28. 2017
Customer INDUSTRIAL PIPING SPECIALISTS,
Contract No. TP557977 Certified to ISO9001:2008, ISO14001:2004,PED2014/68/EC by LRQA
Spec. For Material ASTM A105N-14,ASME SA105N-15,NACE MR0175/ISO15156-1-2015,NACE MR0103/ISO17495-1-2016
Heat Treatment 930℃ NORMALIZED & A.C Dimensional inspection ASME B16.5 - 2017

ITEM / SIZE		Q'ty	Heat No./ Batch No.	Size of Test Specimen D mm	Size of Test Specimen GL mm	Tension Test	Y.S MPa	T.S MPa	E.L %	R.A %	Hardness Test (HB)		Charpy Impact Test (10X10mm Specimen Size) Indiv. 21J	Ave. 27J	Notch V	Temp. -29℃ Ave.(J)
						Max					187		Test Result (J)			
				12.5	50.0	Min	250	485	22.0	30.0						
FK230RFWNXH	300LBS WN RF XH 2"	1500	B8990	12.5	50.0		370	545	31.5	70.5	143	144	149	188	180	172
FK160RFBL	600LBS BL RF 1"	35	B8990	12.5	50.0		370	545	31.5	70.5	143	144	149	188	180	172
FK260RFBL	600LBS BL RF 2"	200	B8990	12.5	50.0		370	545	31.5	70.5	143	144	149	188	180	172
FK160RFSW160	600LBS SW RF S160 1"	50	B8990	12.5	50.0		370	545	31.5	70.5	143	144	149	188	180	172
FK160RFSWXH	600LBS SW RF XH 1"	50	B8990	12.5	50.0		370	545	31.5	70.5	143	144	149	188	180	172
FK160RFTHRD	600LBS TH RF 1"	50	B8990	12.5	50.0		370	545	31.5	70.5	143	144	149	188	180	172
FK260RFTHRD	600LBS TH RF 2"	100	B8990	12.5	50.0		370	545	31.5	70.5	143	144	149	188	180	172
FK1.560RFWN160	600LBS WN RF S160 1 1/2"	10	B8990	12.5	50.0		370	545	31.5	70.5	143	144	149	188	180	172
FK260RFWNXH	600LBS WN RF XH 2"	300	B8990	12.5	50.0		370	545	31.5	70.5	143	144	149	188	180	172
FK2415RFBL	150LBS BL RF 24"	15	B9437	12.5	50.0		360	570	37.5	75.5	140	144	170	150	184	168

Heat No./ Batch No.		Chemical Composition (%) C	Si	Mn	P	S	Ni	Cr	Mo	Cu	V	CE	NDE UT	MT	PT
	Max	0.350	0.350	1.050	0.035	0.040	0.400	0.300	0.120	0.400	0.080				
	Min		0.100	0.600											
B8990	H	0.190	0.246	1.010	0.017	0.010	0.039	0.051	0.002	0.013	0.002	0.372	✓		
	P	0.181	0.246	1.020	0.015	0.009	0.036	0.054	0.004	0.013	0.002	0.366			
B9437	H	0.174	0.220	0.991	0.016	0.010	0.009	0.027	0.002	0.015	0.001	0.346			
	P	0.176	0.209	0.997	0.014	0.009	0.012	0.041	0.003	0.017	0.001	0.353			
BLANK															

REMARK * H : Heat Analysis P : Product Analysis
* Impact Test performed according to ASTM A370 & MESC 76/210/2017 Paragraph 8.5 / Table 4 & 5.
* C:Mn = 1≤5

We hereby certify that the material herein has been made and tested in accordance with the above specification and also with the requirements called for by the above order.

Witnessed by / H. J. LEE

ST&H CORPORATION QUALITY MANAGEMENT

Manager of Q.A Dept. / JAY KIM

ST-801-14-02 ST&H CORPORATION

Carbon flange
2" 300 XH A105
HT# B8990

RECEIVED
JAN 29 2018

PO # C180022 JOB # 171901-02-03-04-05-06-07-09-10-11
19

[| C180022 | | B8990] | [LN: 10] | T0405193-5 | FK230RFWNXH |

09/29/2017 From: AMERICAN ALLOY STEEL, INC. To: ALFA LAVAL

P.O.#: C170959 S.O.#: 582688 AA PL#: 5189764

Item: 2 (1 PC) 1-5/8" X 96" X 240"

TAG: STOCK

Carbon Plate

1 5/8" ID/M755N

Ht=811X08010

ArcelorMittal Burns Harbor Plate

QUALITY ASSURANCE
REPORT OF TEST AND ANALYSES

US HWY 12 Burns Harbor, Indiana

SHIPMENT NO.	DATE SHIPPED	CAR OR VEHICLE NO.		PAGE
802-31310	08-30-17	CN-CHGO-BNSF	CN 622295	2

SOLD TO:
AMERICAN ALLOY STEEL INC
PO BOX 40469
HOUSTON TX 77240-0469

SHIP TO:
AMERICAN ALLOY STEEL INC
C/O SKOL TRACK #21
6350 N ERIE AVE
OWASSO OK

NOTE	SERIAL NUMBER	PAT NO.	HEAT NUMBER	NO. PCS.	SIZE AND QUANTITY: THICKNESS	WIDTH OR DIA.	LENGTH	WEIGHT	YIELD POINT	TENSILE STRENGTH	AF FRAC. ELONG.	RED.
					INCHES	INCHES	INCHES	POUNDS	PSI	PSI	IN	% %

QUALITY STEEL MELTED & MANUFACTURED IN THE U. S. A.
PLATES - ASTM A516-06 GR 70 PVQ KLD FINE GRAIN PRAC, ASTM A516-06 GR 65 PVQ, ASTM A516-06 GR 60 PVQ, ASME SA516 GR 70 PVQ 2015 EDITION, ASME SA516 GR 65 PVQ 2015 EDITION, ASME SA516 GR 60 PVQ 2015 EDITION, CH-V SA20S5 PLT L 15/12 FTLBS AT -50F, VACUUM DEGASSED --- GAS CUT 4 SIDES PLT NORMALIZED & COOLED IN STILL AIR --- TEST CERTS ARE PREPARED IN ACCORD WITH PROCEDURES OUTLINED IN EN 10204:2004 TYPE 3.1
NO WELD REPAIR WAS PERFORMED ON BELOW PLATE(S)
CO# 111953-OK GH 354-5639G
PLATES HEAT TREATED - TEST SPECIMENS ATTACHED & YIELD STRENGTH @ .5% EUL

E931612	811X08010	1	1.625	96	480	21236	48600	74400	2	34
			N 1650 DEG F - 78 MIN							
(M55)MFST REF#:8											
E931613	821X08030	1	1.625	96	480	21236	47000	73400	2	35
			N 1650 DEG F - 78 MIN							
(M55)MFST REF#:8											
E931614	821X08030	1	1.625	96	480	21236	46400	73800	2	35
			N 1650 DEG F - 78 MIN							
(M55)MFST REF#:8											

RECEIVED
SEP 29 2017

MATERIAL CONFORMS TO
NACE MR0175

Q-QUENCH TEMPERATURE BHN 143 TO 149 T-TEMPER TEMPERATURE N-NORMALIZE TEMPERATURE

CERTIFIED BY
AMERICAN ALLOY STEEL
BY VB DATE 9/29/17

PO # C170959 JOB # stock
BM

SERIAL NUMBER	PAT NO.	HEAT NUMBER	HARD BHN	BEND	THICKNESS INCHES	TYPE	SIZE	DIR	TEST TEMP °F	CHARPY IMPACT: ENERGY FT LBS 1	2	3	SHEAR(%) 1	2	3	LAT. EXP MILS 1	2	3
E931612		811X08010			1.625	V	FULL	L	-50	98	106	19						
E931613		821X08030			1.625	V	FULL	L	-50	45	72	44						
E931614		821X08030			1.625	V	FULL	L	-50	105	97	98						

Certified a true copy of the original received in our file.
ARCELORMITTAL ALLOY STEEL, INC.
Reviewed By:
JP 9/27/2017

HEAT NUMBER	CHEMICAL ANALYSIS C	Mn	P	S	Si	Cu	Ni	Cr	Mo	V	Ti	Al	B	Cb	N	Sn	AQUAD GRAIN SIZE
811X08010	.18	1.10	.010	.004	.322	.028	.01	.12	.080	.002	.002	.035	.0002	.002	.004	.007	
821X08030	.17	1.08	.012	.004	.306	.024	.01	.11	.078	.002	.002	.032	.0002	.002	.003	.004	

CEQ = .419 JB

I certify that the above results are a true and correct copy of actual results contained in records maintained by ArcelorMittal Burns Harbor and are in full compliance with the requirements of the specification cited above. This test report cannot be altered and must be transmitted intact with any subsequent third party test reports, if required.

R. SPANGLER II PER LSS

BHPLTRPT.TF

SUPV. QUALITY ASSURANCE

AMERICAN ALLOY PLATE #5189764

ArcelorMittal South Africa Limited
Tubular Products
273 Genl. Hertzog Rd,
Peacehaven Vereeniging 1939
P O Box 48 Vereeniging 1930
South Africa

Telephone +27 (0)16 450 4220
Fax +27 (0)16 423 4906

MATERIAL TEST CERTIFICATE
SEAMLESS TUBE

Licensed under API Spec 5L and 5CT
5L - 0319
5CT - 0419

ISO 9001: 2008
DE-395997 QM

Test Certificate
EN 10204:2004: TYPE 3.1

ArcelorMittal

Customer:	Mattsco Supply Company	Customer Order/Contract No:	SUS1 154992
Order No:	4000022888	Material No:	1000042004
Certificate Reference No:	040062066546	Cast/Heat No:	1607852
Product:	FULLY KILLED HOT FINISHED CARBON STEEL SEAMLESS TUBES		Page 1 of 2
Specification:	ASTM A333.15/A106B:15/A53B:12 A999.15 ASME SA333.15/SA106B:15/SA53B:15 A999.15		
Product Marking:	ARCELORMITTAL SA ASTM A106 GR B/ASME SA106 GR B ASTM A333 GR 6/ASME SA333 GR 6 HFS LT M50F 1.900 0.200 21.000 TESTED 3000 psi CAST NO: 1607852 PROD/O NO: TI242288810 NDE MADE IN SOUTH AFRICA		

General Information

Quantity	Mass	Dimensions			Total Length
		Tube OD	Thickness	Length	
283	21,618.197(lb)	1.900(")	0.200(")	21.000 (ft)	5,943.000(ft)

Steel making process	Final Rolling Operation
Electric Arc	As Rolled Normalised rolled with finishing in the range of 1,553-1,733°F and cooled in still air

Chemical Composition

Element(%)	C	Si	Mn	S	P	Cr	Ni	Mo	Cu	V	Al	Ti	Sn	Ca	N	B	Nb	CE
Minimum	-	0.10	0.29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Maximum	0.230	-	1.35	0.025	0.025	0.30	0.40	0.120	-	0.080	-	-	-	-	-	-	-	0.43
Heat	0.130	0.20	1.21	0.004	0.013	0.04	0.01	0.001	0.005	0.057	0.023	0.013	0.001	0.0006	0.0081	0.0003	0.0005	0.35
Product	0.1300	0.2000	1.2100	0.0036	0.0130	0.0400	0.0100	0.0010	0.0050	0.0570	0.0230	-	-	-	-	-	-	0.3523
Product (ADD)	0.1300	0.2000	1.2100	0.0036	0.0130	0.0400	0.0100	0.0010	0.0050	0.0570	0.0230	-	-	-	-	-	-	0.3523

Mechanical Properties

Specification Limits	UTS (Rm) MPa	UTS (Rm) psi	Yield (0.5%) MPa	Yield (0.5%) psi	% EL 2 inch
Minimum		60000		35000	30.0
Maximum		-		-	-
(1) Actual		70633		52648	35.0
(2) Actual		71793		54824	37.0
(3) Actual					
(4) Actual					

	UTS (Rm) MPa	UTS (Rm) psi	Yield (0.5%) MPa	Yield (0.5%) psi	% EL 2 inch
(5) Actual					
(6) Actual					
(7) Actual					
Orientation & type of tensile test	Longitudinal, Strip				
Width of tensile piece (inch)	0.75 inch				
Orientation of impact test piece	0.394 X 0.130" - long				

OTHER TESTS	
Category	Result
Flattening	Passed
Hydrostatic	3000 psi. for 5 Sec
NDI: EMI	PASS - ASTM E570 - 12.5% NOTCH
NDI: UT	UT not required
HV 22 lbs	147 155 157

Remarks:

Material in accordance with NACE MR0175:2015/ISO15156-2:2015, MR0103:2015. Dimensions to ASME B36.10M-2015. The material conform to the hot yield strength requirements as per ASME, Sect II, Pt D, Table Y-1, 2015. All the material conform to the visual and dimensional requirements and is made to a suitable fine grain practice.

Quality Assurance Manager: PJ Venter *Date of Release: 2016.12.20* *Certified by:*

We hereby certify that the material was manufactured, tested and inspected to and fully comply with the requirements of referenced specifications. No changes, amendments or additions may be made to this document. Any changes which are effected shall invalidate this certificate.

Carbon Pipe
1-½" XH
ID/TFA
HT#1607852

RECEIVED
JAN 11 2018
C180023
PO # JOB # Stock.

01/11/2018 From:MATTSCO SUPPLY COMPANY To:AIR COOLED EXCHANGERS, LLC

ArcelorMittal South Africa Limited
Tubular Products
273 Genl. Hertzog Rd,
Peacehaven Vereeniging 1939
P O Box 48 Vereeniging 1930
South Africa

Telephone +27 (0)16 450 4220
Fax +27 (0)16 423 4906

MATERIAL TEST CERTIFICATE
SEAMLESS TUBE

Licensed under API Spec 5L and 5CT
5L - 0319
5CT - 0419

ISO 9001: 2008
DE-395997 QM

Test Certificate
EN 10204:2004 TYPE 3.1

ArcelorMittal

Customer:	Mattsco Supply Company	Customer Order/Contract No:	SUS1 154992
Order No:	4000022888	Material No:	1000042004
Certificate Reference No:	040062066546	Cast/Heat No:	1607852
Product:	FULLY KILLED HOT FINISHED CARBON STEEL SEAMLESS TUBES		Page 2 of 2
Specification:	ASTM A333.15/A106B:15/A53B:12 A999.15 ASME SA333.15/SA106B:15/SA53B:15 A999.15		
Product Marking:	ARCELORMITTAL SA ASTM A106 GR B/ASME SA106 GR B ASTM A333 GR 6/ASME SA333 GR 6 HFS LT M50F 1.900 0.200 21.000 TESTED 3000 psi CAST NO: 1607852 PROD/O NO: T1242288810 NDE MADE IN SOUTH AFRICA		

Mechanical Properties

Specification	UTS (Rm)		Yield (0,5%)		% EL
Limits	MPa	psi	MPa	psi	2 inch
Minimum		60000		35000	30.0
Maximum		-		-	-
(8) Actual					
(9) Actual					
(10) Actual					
(11) Actual					
(12) Actual					
(13) Actual					
(14) Actual					
(15) Actual					
(16) Actual					
(17) Actual					

	UTS (Rm)		Yield (0,5%)		% EL
	MPa	psi	MPa	psi	2 inch
(18) Actual					
(19) Actual					
(20) Actual					
(21) Actual					
(22) Actual					
(23) Actual					
(24) Actual					
(25) Actual					
(26) Actual					
(27) Actual					
(28) Actual					
(29) Actual					

Other Tests

Impact (ft.lbs)	111.0 115.0 115.0 Ave. 114.0 @ -50 °F
Shear Fracture (%)	40.0 40.0 40.0 Ave. 40.0
Impact (Spec)	5 ft.lbs min - Longitudinal

Remarks:

Material in accordance with NACE MR0175:2015/ISO15156-2:2015, MR0103:2015. Dimensions to ASME B36.10M-2015. The material conform to the hot yield strength requirements as per ASME, Sect II, Pt D, Table Y-1, 2015. All the material conform to the visual and dimensional requirements and is made to a suitable fine grain practice.

Quality Assurance Manager: PJ Venter *Date of Release: 2016.12.20* *Certified by:*

We hereby certify that the material was manufactured, tested and inspected to and fully comply with the requirements of referenced specifications. No changes, amendments or additions may be made to this document. Any changes which are effected shall invalidate this certificate.

01/11/2018 From:MATTSCO SUPPLY COMPANY To:AIR COOLED EXCHANGERS, LLC

CERTIFICATE OF INSPECTION & TEST (EN 10204 3.1)

ST&H CORPORATION
74, Jwadongsunhwan-ro, Haeundae-gu, Busan, Korea
Tel : +82.51.744-4680(5 line) Fax : +82.51.744-4670
E-mail :qm@stnhcorp.com

Certificate No. MJW8888 Date : APR. 10. 2015
Customer INDUSTRIAL PIPING SPECIALISTS,
Contract No. ELP14739 Certified to ISO9001:2008, ISO14001:2004,PED97/23/EC by LRQA
Spec. For Material ASTM A105N-14/ASME SA105N-13/NACE MR0175 & NACE MR0103/ISO 15156-1:2001
Heat Treatment 910℃ NORMALIZED & A.C Dimensional inspection ASME B16.5 - 2013

ITEM / SIZE		Q'ty	Heat No./ Batch No.	Size of Test Specimen D mm	Size of Test Specimen GL mm	Tension Test	Y.S MPa	T.S MPa	E.L %	R.A %	Hardness Test (HB)		Charpy Impact Test (10X10mm Specimen Size) Indiv.	Ave.	Notch	Temp.
						Max					187		Test Result (J)			Ave.(J)
				12.5	50.0	Min	250	485	22.0	30.0						
BA300WRXH6	300LBS WN RF XH 6"	65	B0355	12.5	50.0		335	510	34	71.5	143	145				
BA150BR8	150LBS BL RF 8"	25	B0355	12.5	50.0		335	510	34	71.5	143	145				
BA300WRSTD8	300LBS WN RF STD 8"	162	B0355	12.5	50.0		335	510	34	71.5	143	145				
BA300WRXH8	300LBS WN RF XH 8"	80	B0355	12.5	50.0		335	510	34	71.5	143	145				
BA300WRSTD2	300LBS WN RF STD 2"	18	B1572	12.5	50.0		355	525	32	68.5	138	140				
BA300WRXH2	300LBS WN RF XH 2"	37	B1572	12.5	50.0		355	525	32	68.5	138	140				
BA150SR3	150LBS SO RF 3"	250	B1572	12.5	50.0		355	525	32	68.5	138	140				
BA300BR3	300LBS BL RF 3"	5	B1572	12.5	50.0		355	525	32	68.5	138	140				
BA1500WRXH1.5	1500LBS WN RF XH 1 1/2"	70	B0597	12.5	50.0		355	530	35.5	69.5	145	149				
BA1500TR1.5	1500LBS TH RF 1 1/2"	112	B0597	12.5	50.0		355	530	35.5	69.5	145	149				

Heat No./ Batch No.		Chemical Composition (%) C	Si	Mn	P	S	Ni	Cr	Mo	Cu	V	CE	NDE UT	MT	PT
	Max	0.350	0.350	1.050	0.035	0.040	0.400	0.300	0.120	0.400	0.080				
	Min		0.100	0.600											
B0355		0.211	0.246	0.955	0.011	0.009	0.027	0.079	0.044	0.019	0.001	0.398			
B1572		0.185	0.243	0.941	0.014	0.003	0.008	0.026	0.001	0.018	0.001	0.349			
B0597		0.195	0.237	0.938	0.014	0.006	0.012	0.009	0.026	0.007	0.001	0.359			
		BLANK													

REMARK * PRODUCT OF KOREA

RECEIVED
JAN 24 2018

We hereby certify that the material herein has been made and tested in accordance with the above specification and also with the requirements called for by the above order.

Witnessed by / H. J. LEE Manager of Q.A Dept. / J. W. PARK

ST-801-14-01

Carbon flange
1 1/2" XHA105
HT# B0597

PO# C180022 JOB # 1721901-02-03-04-05-06 ST&H CORPORATION
RG 1724101-02-03-04-05-06-19
1721907-08-09-10-
1721010-11

[| C180022 | | B0597] | [LN: 12] | T0405193-3 | FK1.515CRFWNXH |

09/29/2017 From: AMERICAN ALLOY STEEL, INC. TO: ALFA LAVAL
P.O.#: C170958 S.O.#: 582690 AA PL#: 5190963
Item: 3 (1 PC) 7/8" X 96" X 240" EXISTING
TAG: STOCK

AMERICAN ALLOY
PLATE #5190963

SSAB

12400 Highway 43 North, Axis, Alabama 36505, US

Test Certificate

Form TC1: Revision 2: Date 23 Apr 2014

Customer: AMERICAN ALLOY STEEL, INC. P.O. BOX 40469 HOUSTON TX 77240 0469	**Customer P.O.No.:** 112258-OK	**Mill Order No.** 41-507647-04	**Shipping Manifest:** AR246886
	Product Description: ASME SA516-70/SA516-65/SA516-60(15) ASTM A516-70/A516-65/A516-60(10/15) LCVN 15 FT.LBS@-50F/A673-P;VACUUM DEGAS NORMALIZED	**Ship Date:** 15 Jul 17 **Cert Date:** 15 Jul 17	**Cert No:** 081615543 (Page 1 of 1)
	Size: 0.875 X 96.00 X 480.0 (IN)		

Tested Pieces:				Tensiles:						Charpy Impact Tests								
Heat Id	Piece Id	Tested Thickness	Tst Loc	YS (KSI)	UTS (KSI)	%RA	Elong % 2in 8in	Tst Dir	Hardness	Abs. Energy(FTLB) 1 2 3 Avg				% Shear 1 2 3 Avg				Tst Tmp	Tst Dir	Tst Siz (mm)	BDWTT Tmp %Shr
W7F836	A17	0.883 (DISCRT)	C	50	74		29	T		86	102	71	86					-60F	L	10.	

Heat Id	Chemical Analysis C	Mn	P	S	Si	Tot Al	Sol Al	Cu	Ni	Cr	Mo	Cb	V	Ti	B	IIW	ORGN
W7F836	.19	1.00	.011	.002	.24	.025	.024	.26	.14	.13	.04	.002	.005	.008	.0001	.42	USA

CEQ = .429 JB

KILLED STEEL
MERCURY IS NOT A METALLURGICAL COMPONENT OF THE STEEL AND NO MERCURY WAS INTENTIONALLY ADDED DURING THE MANUFACTURE OF THIS PRODUCT.
CEV (IIW) = C + MN/6 + (CR+MO+V)/5 + (NI+CU)/15
EAF STEEL, CONTINUOUS CAST
KILLED STEEL, PRODUCED TO A FINE GRAIN PRACTICE
MTR EN 10204:2004 INSPECTION CERTIFICATE 3.1 COMPLIANT
100% MELTED AND MANUFACTURED IN THE USA.
WELD REPAIRING HAS NOT BEEN PERFORMED
NORMALIZED PLATES. HEATED AT 1665F FOR 39 MINUTES.
TEST COUPONS TAKEN FROM HEAT TREATED PLATE.
PRODUCTS SHIPPED:
→ *W7F836 A17 6726074 PCES: 1, LBS: 11435*

carbon steel plate
SL152N

MATERIAL CONFORMS TO
NACE MR0175
BHN 143 TO 149
CERTIFIED BY
AMERICAN ALLOY STEEL
BY VB DATE 9/29/17

RECEIVED
SEP 29 2017
PO# C170958 JOB# Stock
JB

Certified a true copy of the original, retained in our file.
AMERICAN ALLOY STEEL, INC.
Reviewed By:
8/11/2017

(P) Cust Part #:

WE HEREBY CERTIFY THAT THIS MATERIAL WAS TESTED IN ACCORDANCE WITH, AND MEETS THE REQUIREMENTS OF, THE APPROPRIATE SPECIFICATION

Justin Ward
SENIOR METALLURGIST - PRODUCT

MATERIAL TEST REPORT

Sold To: 4390000	Ship To: 4390000
ALFA LAVAL INC. ONE ACE AVENUE 85TH AVE. & LYNN LANE ROAD BROKEN ARROW OK 74012	ALFA LAVAL INC. ONE ACE AVENUE 85TH AVE. & LYNN LANE ROAD BROKEN ARROW OK 74012

Purchase Order: C 120017
Part Number: A13006250600269002
Sales Order: 2500909
Material: A13006250600269002 .A/SA 214 ERW O625OD 060M ACE 52'-1" (P)
Delivery / File Nbr: 80389779

5/8" Carbon Tubes

Description: ASTM A214-96(12) ASME SA214 2017 ERW
CARBON STEEL TUBING.

Test: FLATTENING TEST PASSED. REVERSE FLATTENING TEST PASSED. FLANGE TEST PASSED. NDT ELECTRIC TESTED TO ASTM A450 OR A1016 & APPLICABLE TEST METHOD E309 OR E426.

Heat Number:		WA709650 %	WA710152 %	WA711201 %	WB711093 %
CARBON	LDL	0.070	0.060	0.060	0.070
MANGANESE	LDL	0.380	0.350	0.350	0.360
PHOSPHORUS	LDL	0.014	0.012	0.013	0.015
SULFUR	LDL	0.004	0.001	0.001	0.005
Ultimate (PSI)					
Yield (PSI)					
Elongation (%)					
Hardness (RB)		49 / 54	51 / 54	54 / 54	52 / 55

Webco Industries, Inc. certifies that the material described was manufactured and tested and/or inspected in accordance with the specification and fulfills requirements in such respect.
This document conforms to the requirements of Specification EN 10204 Inspection Document Type 3.1.
This document was prepared by means of electronic processing and is valid without signature.

Date: 01/24/2018

Tony Stubblefield
Quality Manager
TSTUBBLE@WEBCOTUBE.COM

201 S. Woodland Dr.
Sand Springs OK 74063

Stock RS C20019

PO # JOB #

JAN 24 2018

RECEIVED

09/29/2017 From: AMERICAN ALLOY STEEL, INC. To: ALPA LAVAL
P.O.#: C170958 S.O.#: 582690 AA PL#: 5187896
Item: 1 (1 PC) 5/8" X 96" X 240" EXISTING
TAG: STOCK

AMERICAN ALLOY
PLATE #5187896

NUCOR PLATE MILL
P.O.Box 279
Winton, NC 27986
(252) 356-3700

Mill Test Report

Page 3

1505 River Rd
Cofield, NC 27922
(252) 356-3700
NUCOR It's Our Nature!

Issuing Date : 05/08/2017 **B/L No. :** 471328 **Load No. :** 480448 **Our Order No. :** 147218/5 **Cust. Order No. :** 111654-OK

Vehicle No: TTPX 804787

Sold To: AMERICAN ALLOY STEEL INC
6230 N HOUSTON ROSSLYN RD
PO BOX 40469
NORTH HOUSTON,TX 77091

Ship To: AMERICAN ALLOY STEEL
6350 N ERIE AVE
C/O SKOL TRACK #21
OWASSO,OK 74055

Specification: 0.6250" x 96.000" x 240.000"
ASTM A516 70/65/60-10(2015)/ASME SA516-70/65/60 PVQ 2013/2015
Normalized Plate NACE MR0175 Annex 2.1.2, MR0103 (2010) Section 2.1.2 Compliant (2015) 13.1.1, 13.1.2)Vacuum Degassed

Marking : 111654-OK

Heat No	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Al(tot)	V	Nb	Ti	N	Ca	B	Sn	Ceq	Pcm
7502814	0.20	1.15	0.008	0.001	0.18	0.15	0.06	0.10	0.03	0.029	0.006	0.001	0.002	0.0064	0.0031	0.0003	0.006	0.43	0.28

Plate Serial No	Pieces	Tons	Tensile Test Dir.	Yield (psi)	Tensile (psi)	Elong. % in 2"	Elong. % in 8"	Heat Treat Norm °F	Time (min)	Temper °F	Time (min)	Charpy Impacts Dir.	Absorbed Energy (Ft-lbs) 1	2	3	Ave	Min	Shear (%) 1	2	3	Ave	Min	Temp °F	Size
7502814-03	7	14.29	T	60,900	77,100	43.3		1650	27			H-L	126.6	145.3	184.9	152.2	15						-50	10mm

RECEIVED
SEP 29 2017

PO# C170958 JOB# Stock
LB

MATERIAL CONFORMS TO
NACE MR0175
BHN 153 TO 159
CERTIFIED BY
AMERICAN ALLOY STEEL
BY VB DATE 9/29/17

carbon steel plate
NU390N

Certified a true copy of the original, retained in our file.
AMERICAN ALLOY STEEL, INC.
Reviewed By:
DB 8/14/17

HOT ROLLED CARBON STEEL PLATE
Piece frequency charpy;

Manufactured to fully killed fine grain practice by Electric Arc Furnace. Welding or weld repair was not performed on this material. Mercury has not been used in the direct manufacturing of this material. Produced as continuous cast discrete plate, unless otherwise noted in Specification. For Mexico shipments: nhc-SalesMX@Nucor.com
Yield by 0.5EUL method unless otherwise specified. Ceq = C+(Mn/6)+((Cr+Mo+V)/5)+((Cu+Ni)/15)
Pcm = C+(Si/30)+(Mn/20)+(Cu/20)+(Ni/60)+(Cr/20)+(Mo/15)+(V/10)+5B
Melted and Manufactured in the USA. ISO 9001:2008 certified (#010940) by SRI Quality System Registrar (#0985-09). PED 97/23/EC 7/2 Annex 1, Para. 4.3 Compliant. DIN 50049 3.1.B/EN 10204 3.1B(2004), DIN EN 10204 3.1(2005) compliant. For ABS grades only, Quality Assurance certificate 14-MMPQA-723

We hereby certify that the contents of this report are accurate and correct. All test results and operations performed by the material manufacturer are in compliance with the applicable specifications, including customer specifications.

T. A Depretis
T. A. Depretis, Metallurgist

6/8/2017 3:02:22 PM

MATERIAL TEST REPORT

Sold To: 4390000	Ship To: 4390000
ALFA LAVAL INC. ONE ACE AVENUE 85TH AVE. & LYNN LANE ROAD BROKEN ARROW OK 74012	ALFA LAVAL INC. ONE ACE AVENUE 85TH AVE. & LYNN LANE ROAD BROKEN ARROW OK 74012

Purchase Order: C 120017
Part Number: A13007500600269002
Sales Order: 2500909
Material: A13007500600269002 A/SA 214 ERW O750OD 060M ACE 52'-1" (P)
Delivery / File Nbr: 80383833 3/4" Carbon Tubes

Description: ASTM A214-96(12) ASME SA214 2015 ERW CARBON STEEL TUBING.

Test: FLATTENING TEST PASSED. REVERSE FLATTENING TEST PASSED. FLANGE TEST PASSED. NDT ELECTRIC TESTED TO ASTM A450 OR A1016 & APPLICABLE TEST METHOD E309 OR E426.

Heat Number:		WA709073	WA709419	WA709648	WA710149
		%	%	%	%
CARBON	LDL	0.060	0.060	0.060	0.070
MANGANESE	LDL	0.360	0.360	0.360	0.360
PHOSPHORUS	LDL	0.015	0.014	0.015	0.016
SULFUR	LDL	0.005	0.003	0.002	0.002
Ultimate (PSI)					
Yield (PSI)					
Elongation (%)					
Hardness (RB)		53 / 53	53 / 56	54 / 56	52 / 53

Webco Industries, Inc. certifies that the material described was manufactured and tested and/or inspected in accordance with the specification and fulfills requirements in such respect.
This document conforms to the requirements of Specification EN 10204 Inspection Document Type 3.1.
This document was prepared by means of electronic processing and is valid without signature.

Date: 11/07/2017

Tony Stubblefield
Quality Manager
TSTUBBLE@WEBCOTUBE.COM

201 S. Woodland Dr.
Sand Springs OK 74063

RECEIVED
NOV 08 2017
PO# C120017 S JOB #
RJS

NV 397N ½" Carbon Plate

AMERICAN ALLOY PLATE #5192305

NUCOR PLATE MILL
P.O.Box 279
Winton, NC 27986
(252) 356-3700

Mill Test Report
Page 1

1505 River Rd
Cofield, NC 27922
(252) 356-3700

NUCOR It's Our Nature!

Issuing Date : 08/06/2017 B/L No. : 479479 Load No. : 489100 Our Order No. : 149769/2 Cust. Order No. : 112684-OK

Vehicle No: LW 62159

Sold To: AMERICAN ALLOY STEEL INC
6230 N HOUSTON ROSSLYN RD
PO BOX 40469
NORTH HOUSTON,TX 77091

Ship To: AMERICAN ALLOY STEEL
6350 N ERIE AVE
C/O SKOL TRACK #21
OWASSO,OK 74055

Specification: 0.5000" x 96.000" x 240.000"
ASTM A516 70/65/60-10(2015)/ASME SA516-70/65/60 PVQ 2013/2015
Normalized Plate NACE MR0175 Annex 2.1.2, MR0103 (2010) Section 2.1.2 Compliant (2015) 13.1.1, 13.1.2)Vacuum Degassed

Marking : 112684-OK

Heat No	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Al(tot)	V	Nb	Ti	N	Ca	B	Sn	Ceq	Pcm
7505075	0.19	1.04	0.007	0.001	0.22	0.24	0.09	0.10	0.02	0.032	0.006	0.002	0.002	0.0071	0.0035	0.0002	0.009	0.41	0.27
7505076	0.19	1.06	0.007	0.000	0.19	0.24	0.10	0.11	0.02	0.027	0.005	0.002	0.001	0.0078	0.0030	0.0001	0.009	0.41	0.27

Plate Serial No	Pieces	Tons	Tensile Test Dir.	Yield (psi)	Tensile (psi)	Elong. % in 2"	Elong. % in 8"	Heat Treat Norm (°F)	Time (min)	Temper (°F)	Time (min)
7505075-07	4	6.53	T	51,900	77,300	39.0		1650	23		
7505076-01	12	19.60	T	52,900	78,000	40.5		1650	23		
7505075-07	4	6.53	T	51,900	77,300	39.0		1650	23		
7505076-01	12	19.60	T	52,900	78,000	40.5		1650	23		

MATERIAL CONFORMS TO
NACE MR0175
BHN 153 TO 159
CERTIFIED BY
AMERICAN ALLOY STEEL
BY VB DATE 10/13/17

Plate Serial No	Pieces	Tons	Charpy impacts Dir.	Absorbed Energy (Ft-lbs) (ft-lbs) 1	(ft-lbs) 2	(ft-lbs) 3	(ft-lbs) Ave	Min	Lateral Expansion (in.) (in.) 1	(in.) 2	(in.) 3	(in.) Ave	(in.) Min	Shear (%) (%) 1	(%) 2	(%) 3	(%) Ave	Min	Temp (°F)	Size
7505075-07	4	6.53	H-L	127.3	127.2	118.4	124.3	15											-50	10mm
7505076-01	12	19.60	H-L	95.4	72.5	81.8	83.2	15											-50	10mm

RECEIVED
OCT 13 2017

Certified a true copy of the original, retained in our file.
AMERICAN ALLOY STEEL, INC.
Reviewed By:
JK 9/29/2017

HOT ROLLED CARBON STEEL PLATE
Piece frequency charpy;

C170998 Stock
PO # JOB #

Manufactured to fully killed fine grain practice by Electric Arc Furnace. Welding or weld repair was not performed on this material. Mercury has not been used in the direct manufacturing of this material. Produced as continuous cast discrete plate, unless otherwise noted in Specification. For Mexico shipments:mhc-SalesMX@Nucor.com
Yield by 0.5EUL method unless otherwise specified. Ceq = C+(Mn/6)+((Cr+Mo+V)/5)+((Cu+Ni)/15)
Pcm = C+(Si/30)+(Mn/20)+(Cu/20)+(Ni/60)+(Cr/20)+(Mo/15)+(V/10)+5B
Melted and Manufactured in the USA. ISO 9001:2008 certified (#010940) by SRI Quality System Registrar (#0985-09). PED 97/23/EC 7/2 Annex 1, Para. 4.3 Compliant. DIN 50049 3.1.B/EN 10204 3.1B(2004), DIN EN 10204 3.1(2005) compliant. For ABS grades only, Quality Assurance certificate 14-MMPQA-723

We hereby certify that the contents of this report are accurate and correct. All test results and operations performed by the material manufacturer are in compliance with the applicable specifications, including customer specifications.

T. A. Depretis

T. A. Depretis, Metallurgist

8/6/2017 11:08:17 AM

10/13/2017 From: AMERICAN ALLOY STEEL, INC. S.O.#: 583847
P.O.#: C170998
Item: 2 (1 PC) 1/2" X 96" X 240"
TAG: STOCK
To: ALFA LAVAL AA PL#: 5192305

AMERICAN ALLOY
PLATE #5192308

NUCOR
PLATE MILL

P.O.Box 279
Winton, NC 27986
(252) 358-3700

Mill Test Report

Page 1

1505 River Rd
Cofield, NC 27922
(252) 356-3700

NUCOR
It's Our Nature

TO: ALFA LAVAL AA PL#: 5192308
S.O.#: 585503
11/02/2017 From: AMERICAN ALLOY STEEL, INC.
P.O.#: C171040
Item: 2 (1 PC) 1/2" X 96" X 240"
TAG: STOCK

Issuing Date : 08/06/2017 **B/L No. :** 479479 **Load No. :** 489100 **Our Order No. :** 149769/2 **Cust. Order No. :** 112684-OK

Vehicle No: LW 62159

Sold To: AMERICAN ALLOY STEEL INC
6230 N HOUSTON ROSSLYN RD
PO BOX 40469
NORTH HOUSTON,TX 77091

Ship To: AMERICAN ALLOY STEEL
6350 N ERIE AVE
C/O SKOL TRACK #21
OWASSO,OK 74055

Specification: 0.5000" x 96.000" x 240.000"
ASTM A516 70/65/60-10(2015)/ASME SA516-70/65/60 PVQ 2013/2015
Normalized Plate NACE MR0175 Annex 2.1.2, MR0103 (2010) Section 2.1.2 Compliant (2015) 13.1.1, 13.1.2)Vacuum Degassed

Marking : 112684-OK

Heat No	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Al(tot)	V	Nb	Ti	N	Ca	B	Sn	Ceq	Pcm
7505075	0.19	1.04	0.007	0.001	0.22	0.24	0.09	0.10	0.02	0.032	0.006	0.002	0.002	0.0071	0.0035	0.0002	0.009	0.41	0.27
7505076	0.19	1.06	0.007	0.000	0.19	0.24	0.10	0.11	0.02	0.027	0.005	0.002	0.001	0.0078	0.0030	0.0001	0.009	0.41	0.27

Plate Serial No	Pieces	Tons	Tensile Test Dir.	Yield (psi)	Tensile (psi)	Elong. % in 2"	Elong. % in 8"	Heat Treat Norm (°F)	Norm Time (min)	Temper (°F)	Temper Time (min)
7505075-07	4	6.53	T	51,900	77,300	39.0		1650	23		
7505076-01	12	19.60	T	52,900	78,000	40.5		1650	23		
7505075-07	4	6.53	T	51,900	77,300	39.0		1650	23		
7505076-01	12	19.60	T	52,900	78,000	40.5		1650	23		

MATERIAL CONFORMS TO
NACE MR0175
BHN 163 TO 159
CERTIFIED BY
AMERICAN ALLOY STEEL
BY J.F DATE 11/2/17

Plate Serial No	Pieces	Tons	Charpy Impacts Dir.	Absorbed Energy (Ft-lbs) (ft-lbs) 1	(ft-lbs) 2	(ft-lbs) 3	(ft-lbs) Ave	Min	Lateral Expansion (in.) (in.) 1	(in.) 2	(in.) 3	(in.) Ave	(in.) Min	Shear (%) (%) 1	(%) 2	(%) 3	(%) Ave	Min	Temp (°F)	Size
7505075-07	4	6.53	H-L	127.3	127.2	118.4	124.3	15											-50	10mm
7505076-01	12	19.60	H-L	95.4	72.5	81.8	83.2	15											-50	10mm

N0343N ½" Carbon plate

Certified a true copy of the original, retained in our file.
AMERICAN ALLOY STEEL, INC.
Reviewed By:
JR 9/29/2017

HOT ROLLED CARBON STEEL PLATE
Piece frequency charpy;

Manufactured to fully killed fine grain practice by Electric Arc Furnace. Welding or weld repair was not performed on this material. Mercury has not been used in the direct manufacturing of this material. Produced as continuous cast discrete plate, unless otherwise noted in Specification. For Mexico shipments:nhc-SalesMX@Nucor.com
Yield by 0.5EUL method unless otherwise specified. Ceq = C+(Mn/6)+((Cr+Mo+V)/5)+((Cu+Ni)/15)
Pcm = C+(Si/30)+(Mn/20)+(Cu/20)+(Ni/60)+(Cr/20)+(Mo/15)+(V/10)+5B
Melted and Manufactured in the USA. ISO 9001:2008 certified (#010940) by SRI Quality System Registrar (#0985-09). PED 97/23/EC 7/2 Annex 1, Para. 4.3 Compliant. DIN 50049 3.1.B/EN 10204 3.1B(2004), DIN/EN 10204 3.1(2005) compliant. For ABS grades only, Quality Assurance certificate 14-MMPQA-723

We hereby certify that the contents of this report are accurate and correct. All test results and operations performed by the material manufacturer are in compliance with the applicable specifications, including customer specifications.

T. A. Depretis, Metallurgist

8/6/2017 11:06:17 AM

RECEIVED
NOV 03 2017
C171040 Stock
PO #_____ JOB #_____

ASME Code Calculations

Section VIII, Div. 1, Appendix 13, Fig 13-2(a), Sketch (1), 2013 Edition

Customer: McClung Energy
Purchase Order Number: 0014949-01
Date: 2/21/2018
ACE Job Number: 1721901-11
Section Name/Serial Number: IC1
Tag:

Header Material: SA-516-70
Code Allowable Stress, **S**: 20000 PSI (137.895 MPa)
Tube Diameter: 0.625 inch (15.88 mm)
Tube Pitch: 1.500 inch (38.100 mm)
C.A., Corrosion Allowance: 0.000 inch (0.0 mm)
P, Design Pressure: 645 PSI (4.4 MPa)
Maximum Design Temperature: 350 deg F (177 deg C)
Minimum Design Temperature: -20 deg F (-29 deg C)
Stress Relief: No
Plug Type: TAPER
Overall Header Width: 5.7500 Inch (146.05 mm)
Overall Header Height: 6.625 inch (168.28 mm)
$\mathbf{t_1}$, Short Side Plate Thickness, Corroded: 0.500 inch (12.70 mm)
$\mathbf{t_2}$, Long Side Plate Thickness, Corroded: 0.875 inch (22.23 mm)
$\mathbf{D_p}$, Plug Thread Diameter: 0.768 inch (19.52 mm)
Hydrostatic Test Pressure: 839 PSI (5.8 MPa)
h, Long Inside Dimension, Corroded: 5.6250 inch (142.88 mm)
H, Short Inside Dimension, Corroded: 4.0000 inch (101.60 mm)

Calculated Variables

$e_m = e_b = \frac{Tube\ Pitch - Dp}{Tube\ Pitch} = \frac{(1.500-0.7684)}{1.500} = 0.48773$ $\alpha = H/h = 4.0000/5.6250 = 0.71111$

$I_1 = \frac{(t_1)^3}{12} = \frac{(0.500)^3}{12} = 0.0104167$ $I_2 = \frac{(t_2)^3}{12} = \frac{(0.875)^3}{12} = 0.0558268$ $K = \alpha\frac{(I_2)}{(I_1)} = 0.71111\frac{(0.0558268)}{(0.0104167)} = 3.81111$

$1 + \alpha^2 K = 1 + 0.71111^2 3.81111 = 2.92720$ $1 + K = 1 + 3.81111 = 4.81111$

$c_1 = 0.5 \times t_1 = 0.5 \times 0.500 = 0.25000$ $c_2 = 0.5 \times t_2 = 0.5 \times 0.875 = 0.43750$

Membrane Stress (Not to Exceed 20000 PSI)

Short Side Plates: $S_m = \frac{Ph}{2t_1 * em} = \frac{645*5.6250}{2*0.500*1.00000} = 3628.1\ PSI, 25.015\ MPa$ ❶

Long Side Plates: $S_m = \frac{PH}{2t_2 * em} = \frac{645*4.0000}{2*0.875*0.48773} = 3022.7\ PSI, 20.841\ MPa$ ❷

Bending Stress

Short Side Plates:

$(S_b)_N = \pm \frac{P*c_1}{12I_1*e_b}\left[1.5H^2 - h^2\frac{1+\alpha^2K}{1+K}\right] = \pm \frac{645*0.25000}{12*0.0104167*1.00000}\left[1.5*4.0000^2 - 5.6250^2 * \frac{1+0.71111^2*3.81111}{1+3.81111}\right] = 6126.3\ PSI, 42.239\ MPa$ ❸

$(S_b)_Q = \pm \frac{P*h^2*c_1}{12*I_1}\left[\frac{1+\alpha^2*K}{1+K}\right] = \pm \frac{645*5.6250^2*0.25000}{12*0.0104167}\left[\frac{1+0.71111^2*3.81111}{1+3.81111}\right] = \pm\ 24833.7\ PSI, 171.222\ MPa$ ❹

Long Side Plates:

$(S_t)_M = \pm \frac{P*h^2*c_2}{12I_2*e_b}\left[1.5 - \frac{1+\alpha^2K}{1+K}\right] = \pm \frac{645*5.6250^2*0.43750}{12*0.0558268*0.48773}\left[1.5 - \frac{1+0.71111^2*3.81111}{1+3.81111}\right] = \pm\ 24363.2\ PSI, 167.978\ MPa$ ❺

$(S_t)_Q = \pm \frac{P*h^2*c_2}{12I_2}\left[\frac{1+\alpha^2K}{1+K}\right] = \pm \frac{645*5.6250^2*0.43750}{12*0.0558268}\left[\frac{1+0.71111^2*3.81111}{1+3.81111}\right] = \pm\ 8109.0\ PSI, 55.909\ MPa$ ❻

Combined Stress (Not to Exceed 30000 PSI)

Short Side Plates:

$(S_T)_N$ = ❶ + ❸ = 3628.1 PSI, 25.015 MPa + 6126.3 PSI, 42.239 MPa = 9754.4 PSI, 67.254 MPa ❼

$(S_T)_Q$ = ❶ + ❹ = 3628.1 PSI, 25.015 MPa + 24833.7 PSI, 171.222 MPa = 28461.8 PSI, 196.237 MPa ❽

Long Side Plates:

$(S_T)_M$ = ❷ + ❺ = 3022.7 PSI, 20.841 MPa + 24363.2 PSI, 167.978 MPa = 27385.9 PSI, 188.819 MPa ❾

$(S_T)_Q$ = ❷ + ❻ = 3022.7 PSI, 20.841 MPa + 8109.0 PSI, 55.909 MPa = 11132 PSI, 76.750 MPa ❿

End Plate Thickness (Per UG-34)

Where T_M = Minimum Thickness

$$T_M = C.A. + H * \sqrt{\left[\left(3.4 - 2.4 * \frac{H}{h}\right) * \left(\frac{0.2 * P}{S}\right)\right]}$$

$T_M =$ Error! Reference source not found. +Error! Reference source not found.$* \sqrt{\left[\left(3.4 - 2.4 * \frac{4.0000}{5.6250}\right) * \left(\frac{0.2 * 645}{20000}\right)\right]}$

= 0.418 In, 10.618 mm

End Plate Thickness Selected by Program: 0.500 In, 12.700 mm

Pipe and Tube Stresses

Where T_E = Effective Thickness
T_A = Actual Thickness
D_0 = Pipe or Tube Outer Diameter
R_0 = Pipe or Tube Outer Radius
T_M = Minimum Thickness
S = Stress

Nozzle 1 (2.375 inch O.D. X 0.218 in Thick Inlet Pipe, SA-106-GR B):
Allowable Stress: Not to Exceed 17100.0 PSI, 117.905 MPa

$T_E = (T_A \times 0.875) - C.A. = (0.2180 \times 0.875) - 0.000 = 0.1907$ in, 4.8450 mm

$R_0 = D_0/2 = 2.3750/2 = 1.1875$

$$S = P\left(\frac{R_0}{T_E} - 0.4\right) = 645\left(\frac{1.1875}{0.1907} - 0.4\right) = 3757.400\ PSI\ \ 25.907\ MPa$$

Nozzle 2 (2.375 inch O.D. X 0.218 in Thick Outlet Pipe, SA-106-GR B):
Allowable Stress: Not to Exceed 17100.0 PSI, 117.905 MPa

$T_E = (T_A \times 0.875) - C.A. = (0.2180 \times 0.875) - 0.000 = 0.1907$ in, 4.8450 mm

$R_0 = D_0/2 = 2.3750/2 = 1.1875$

$$S = P\left(\frac{R_0}{T_E} - 0.4\right) = 645\left(\frac{1.1875}{0.1907} - 0.4\right) = 3757.400\ PSI\ \ 25.907\ MPa$$

Nozzle 3 (Not applicable, Nozzle 3 does not exist for this section):
Allowable Stress: Not applicable

$T_E = (T_A \times 0.875) - C.A. = (\text{Not applicable} \times 0.875) - 0.000 = \text{Not applicable}$

$R_0 = D_0/2 = \text{Not applicable}/2 = \text{Not applicable}$

$$S = P\left(\frac{R_0}{T_E} - 0.4\right) = Not\ applicable\left(\frac{Not\ applicable}{Not\ applicable} - 0.4\right) =$$

Tubes (SA214(WLD)):
Tube Allowable Stress: 11400 PSI, 78.6 Mpa

$T_M = \frac{P*0.5*D_O}{S+0.4*P} = \frac{645*0.5*0.625}{11400+0.4*645}$ = 0.017 In, 0.439 mm

Tube Wall Thickness Selected by Program: 0.060 In, 1.524 mm

Calculations Generated By: Name

ASME Code Calculations

Section VIII, Div. 1, Appendix 13, Fig 13-2(a), Sketch (1), 2013 Edition

Customer: McClung Energy
Purchase Order Number: 0014949-01
Date: 2/21/2018
ACE Job Number: 1721901-11
Section Name/Serial Number: IC2
Tag:

Header Material: SA-516-70 NORM
Code Allowable Stress, **S**: 20000 PSI (137.895 MPa)
Tube Diameter: 0.625 inch (15.88 mm)
Tube Pitch: 1.500 inch (38.100 mm)
C.A., Corrosion Allowance: 0.000 inch (0.0 mm)
P, Design Pressure: 1287 PSI (8.9 MPa)
Maximum Design Temperature: 350 deg F (177 deg C)
Minimum Design Temperature: -20 deg F (-29 deg C)
Stress Relief: No
Plug Type: TAPER
Overall Header Width: 5.2500 Inch (133.35 mm)
Overall Header Height: 6.750 inch (171.45 mm)
$\mathbf{t_1}$, Short Side Plate Thickness, Corroded: 0.625 inch (15.88 mm)
$\mathbf{t_2}$, Long Side Plate Thickness, Corroded: 1.625 inch (41.28 mm)
$\mathbf{D_p}$, Plug Thread Diameter: 0.768 inch (19.52 mm)
Hydrostatic Test Pressure: 1673 PSI (11.5 MPa)
h, Long Inside Dimension, Corroded: 5.5000 inch (139.70 mm)
H, Short Inside Dimension, Corroded: 2.0000 inch (50.80 mm)

Calculated Variables

$e_m = e_b = \frac{Tube\ Pitch - Dp}{Tube\ Pitch} = \frac{(1.500-0.7684)}{1.500} = 0.48773$ $\alpha = H/h = 2.0000/5.5000 = 0.36364$

$I_1 = \frac{(t_1)^3}{12} = \frac{(0.625)^3}{12} = 0.0203451$ $I_2 = \frac{(t_2)^3}{12} = \frac{(1.625)^3}{12} = 0.3575846$ $K = \alpha \frac{(I_2)}{(I_1)} = 0.36364 \frac{(0.3575846)}{(0.0203451)} = 6.39127$

$1 + \alpha^2 K = 1 + 0.36364^2 6.39127 = 1.84513$ $1 + K = 1 + 6.39127 = 7.39127$

$c_1 = 0.5 \times t_1 = 0.5 \times 0.625 = 0.31250$ $c_2 = 0.5 \times t_2 = 0.5 \times 1.625 = 0.81250$

Membrane Stress (Not to Exceed 20000 PSI)

Short Side Plates: $S_m = \frac{Ph}{2t_1 * em} = \frac{1287*5.5000}{2*0.625*1.00000} = 7920.0\ PSI, 54.606\ MPa$ ❶

Long Side Plates: $S_m = \frac{PH}{2t_2 * em} = \frac{1287*2.0000}{2*1.625*0.48773} = 2271.1\ PSI, 15.659\ MPa$ ❷

Bending Stress

Short Side Plates:

$(S_b)_N = \pm \frac{P*c_1}{12I_1*e_b}\left[1.5H^2 - h^2\frac{1+\alpha^2K}{1+K}\right] = \pm \frac{1287*0.31250}{12*0.0203451*1.00000}\left[1.5*2.0000^2 - 5.5000^2 * \frac{1+0.36364^2*6.39127}{1+6.39127}\right] =$
$3574.6\ PSI, 24.646\ MPa$ ❸

$(S_b)_Q = \pm \frac{P*h^2*c_1}{12*I_1}\left[\frac{1+\alpha^2*K}{1+K}\right] = \pm \frac{1287*5.5000^2*0.31250}{12*0.0203451}\left[\frac{1+0.36364^2*6.39127}{1+6.39127}\right] = \pm\ 17398.6\ PSI, 119.959\ MPa$ ❹

Long Side Plates:

$(S_t)_M = \pm \frac{P*h^2*c_2}{12I_2*e_b}\left[1.5 - \frac{1+\alpha^2K}{1+K}\right] = \pm \frac{1287*5.5000^2*0.81250}{12*0.3575846*0.48773}\left[1.5 - \frac{1+0.36364^2*6.39127}{1+6.39127}\right] = \pm\ 26431.1\ PSI, 182.236\ MPa$
❺

$(S_t)_Q = \pm \frac{P*h^2*c_2}{12I_2}\left[\frac{1+\alpha^2K}{1+K}\right] = \pm \frac{1287*5.5000^2*0.81250}{12*0.3575846}\left[\frac{1+0.36364^2*6.39127}{1+6.39127}\right] = \pm\ 2573.8\ PSI, 17.745\ MPa$ ❻

Combined Stress (Not to Exceed 30000 PSI)

Short Side Plates:

$(S_T)_N$ = ❶ + ❸ = 7920.0 PSI, 54.606 MPa + 3574.6 PSI, 24.646 MPa = 11494.6 PSI, 79.253 MPa ❼

$(S_T)_Q$ = ❶ + ❹ = 7920.0 PSI, 54.606 MPa + 17398.6 PSI, 119.959 MPa = 25318.6 PSI, 174.566 MPa ❽

Long Side Plates:

$(S_T)_M$ = ❷ + ❺ = 2271.1 PSI, 15.659 MPa + 26431.1 PSI, 182.236 MPa = 28702.2 PSI, 197.895 MPa ❾

$(S_T)_Q$ = ❷ + ❻ = 2271.1 PSI, 15.659 MPa + 2573.8 PSI, 17.745 MPa = 4845 PSI, 33.404 MPa ❿

End Plate Thickness (Per UG-34)

Where T_M = Minimum Thickness

$$T_M = C.A. + H * \sqrt{\left[\left(3.4 - 2.4 * \frac{H}{h}\right) * \left(\frac{0.2 * P}{S}\right)\right]}$$

$T_M =$ Error! Reference source not found. +Error! Reference source not found.$* \sqrt{\left[\left(3.4 - 2.4 * \frac{2.0000}{5.5000}\right) * \left(\frac{0.2 * 1287}{20000}\right)\right]}$

= 0.427 In, 10.835 mm

End Plate Thickness Selected by Program: 0.625 In, 15.875 mm

Pipe and Tube Stresses

Where T_E = Effective Thickness
T_A = Actual Thickness
D_0 = Pipe or Tube Outer Diameter
R_0 = Pipe or Tube Outer Radius
T_M = Minimum Thickness
S = Stress

Nozzle 1 (2.375 inch O.D. X 0.218 in Thick Inlet Pipe, SA-106-GR B):
Allowable Stress: Not to Exceed 17100.0 PSI, 117.905 MPa

$T_E = (T_A \times 0.875) - C.A. = (0.2180 \times 0.875) - 0.000 = 0.1907$ in, 4.8450 mm

$R_0 = D_0/2 = 2.3750/2 = 1.1875$

$$S = P\left(\frac{R_0}{T_E} - 0.4\right) = 1287\left(\frac{1.1875}{0.1907} - 0.4\right) = 7497.323\ PSI\ \ 51.694\ MPa$$

Nozzle 2 (2.375 inch O.D. X 0.218 in Thick Outlet Pipe, SA-106-GR B):
Allowable Stress: Not to Exceed 17100.0 PSI, 117.905 MPa

$T_E = (T_A \times 0.875) - C.A. = (0.2180 \times 0.875) - 0.000 = 0.1907$ in, 4.8450 mm

$R_0 = D_0/2 = 2.3750/2 = 1.1875$

$$S = P\left(\frac{R_0}{T_E} - 0.4\right) = 1287\left(\frac{1.1875}{0.1907} - 0.4\right) = 7497.323\ PSI\ \ 51.694\ MPa$$

Nozzle 3 (Not applicable, Nozzle 3 does not exist for this section):
Allowable Stress: Not applicable

$T_E = (T_A \times 0.875) - C.A. = (\text{Not applicable} \times 0.875) - 0.000 = \text{Not applicable}$

$R_0 = D_0/2 = \text{Not applicable}/2 = \text{Not applicable}$

$$S = P\left(\frac{R_0}{T_E} - 0.4\right) = Not\ applicable\left(\frac{Not\ applicable}{Not\ applicable} - 0.4\right) =$$

Tubes (SA214(WLD)):
Tube Allowable Stress: 11400 PSI, 78.6 Mpa

$T_M = \frac{P*0.5*D_O}{S+0.4*P} = \frac{1287*0.5*0.625}{11400+0.4*1287}$ = 0.034 In, 0.857 mm

Tube Wall Thickness Selected by Program: 0.060 In, 1.524 mm

Calculations Generated By: Name

ASME Code Calculations

Section VIII, Div. 1, Appendix 13, Fig 13-2(a), Sketch (1), 2013 Edition

Customer: McClung Energy
Purchase Order Number: 0014949-01
Date: 2/21/2018
ACE Job Number: 1721901-11
Section Name/Serial Number: AC
Tag:

Header Material: SA-516-70 NORM
Code Allowable Stress, **S**: 20000 PSI (137.895 MPa)
Tube Diameter: 0.625 inch (15.88 mm)
Tube Pitch: 1.500 inch (38.100 mm)
C.A., Corrosion Allowance: 0.000 inch (0.0 mm)
P, Design Pressure: 1800 PSI (12.4 MPa)
Maximum Design Temperature: 350 deg F (177 deg C)
Minimum Design Temperature: -20 deg F (-29 deg C)
Stress Relief: No
Plug Type: TAPER
Overall Header Width: 5.2500 Inch (133.35 mm)
Overall Header Height: 6.750 inch (171.45 mm)
$\mathbf{t_1}$, Short Side Plate Thickness, Corroded: 0.625 inch (15.88 mm)
$\mathbf{t_2}$, Long Side Plate Thickness, Corroded: 1.625 inch (41.28 mm)
$\mathbf{D_p}$, Plug Thread Diameter: 0.768 inch (19.52 mm)
Hydrostatic Test Pressure: 2340 PSI (16.1 MPa)
h, Long Inside Dimension, Corroded: 5.2500 inch (133.35 mm)
H, Short Inside Dimension, Corroded: 2.0000 inch (50.80 mm)

Calculated Variables

$e_m = e_b = \frac{Tube\ Pitch - Dp}{Tube\ Pitch} = \frac{(1.500 - 0.7684)}{1.500} = 0.48773$ $\alpha = H/h = 2.0000/5.2500 = 0.76190$

$I_1 = \frac{(t_1)^3}{12} = \frac{(0.625)^3}{12} = 0.0558268$ $I_2 = \frac{(t_2)^3}{12} = \frac{(1.625)^3}{12} = 0.2166341$ $K = \alpha \frac{(I_2)}{(I_1)} = 0.76190 \frac{(0.2166341)}{(0.0558268)} = 2.95655$

$1 + \alpha^2 K = 1 + 0.76190^2 2.95655 = 2.71627$ $1 + K = 1 + 2.95655 = 3.95655$

$c_1 = 0.5 \times t_1 = 0.5 \times 0.625 = 0.43750$ $c_2 = 0.5 \times t_2 = 0.5 \times 1.625 = 0.68750$

Membrane Stress (Not to Exceed 20000 PSI)

Short Side Plates: $S_m = \frac{Ph}{2t_1 * em} = \frac{1800*5.2500}{2*0.625*1.00000} = 5400.0\ PSI, 37.232\ MPa$ ❶

Long Side Plates: $S_m = \frac{PH}{2t_2 * em} = \frac{1800*2.0000}{2*1.625*0.48773} = 5368.1\ PSI, 37.011\ MPa$ ❷

Bending Stress

Short Side Plates:

$(S_b)_N = \pm \frac{P*c_1}{12I_1*e_b}\left[1.5H^2 - h^2\frac{1+\alpha^2K}{1+K}\right] = \pm \frac{1800*0.43750}{12*0.0558268*1.00000}\left[1.5*2.0000^2 - 5.2500^2 * \frac{1+0.76190^2*2.95655}{1+2.95655}\right] = 5968.8\ PSI, 41.153\ MPa$ ❸

$(S_b)_Q = \pm \frac{P*h^2*c_1}{12*I_1}\left[\frac{1+\alpha^2*K}{1+K}\right] = \pm \frac{1800*5.2500^2*0.43750}{12*0.0558268}\left[\frac{1+0.76190^2*2.95655}{1+2.95655}\right] = \pm\ 22243.4\ PSI, 153.363\ MPa$ ❹

Long Side Plates:

$(S_t)_M = \pm \frac{P*h^2*c_2}{12I_2*e_b}\left[1.5 - \frac{1+\alpha^2K}{1+K}\right] = \pm \frac{1800*5.2500^2*0.68750}{12*0.2166341*0.48773}\left[1.5 - \frac{1+0.76190^2*2.95655}{1+2.95655}\right] = \pm\ 21883.5\ PSI, 150.881\ MPa$ ❺

$(S_t)_Q = \pm \frac{P*h^2*c_2}{12I_2}\left[\frac{1+\alpha^2K}{1+K}\right] = \pm \frac{1800*5.2500^2*0.68750}{12*0.2166341}\left[\frac{1+0.76190^2*2.95655}{1+2.95655}\right] = \pm\ 9007.7\ PSI, 62.106\ MPa$ ❻

Combined Stress (Not to Exceed 30000 PSI)

Short Side Plates:

$(S_T)_N$ = ❶ + ❸ = 5400.0 PSI, 37.232 MPa + 5968.8 PSI, 41.153 MPa = 11368.8 PSI, 78.385 MPa ❼

$(S_T)_Q$ = ❶ + ❹ = 5400.0 PSI, 37.232 MPa + 22243.4 PSI, 153.363 MPa = 27643.4 PSI, 190.595 MPa ❽

Long Side Plates:

$(S_T)_M$ = ❷ + ❺ = 5368.1 PSI, 37.011 MPa + 21883.5 PSI, 150.881 MPa = 27251.6 PSI, 187.893 MPa ❾

$(S_T)_Q$ = ❷ + ❻ = 5368.1 PSI, 37.011 MPa + 9007.7 PSI, 62.106 MPa = 14376 PSI, 99.117 MPa ❿

End Plate Thickness (Per UG-34)

Where T_M = Minimum Thickness

$$T_M = C.A. + H * \sqrt{\left[\left(3.4 - 2.4 * \frac{H}{h}\right) * \left(\frac{0.2 * P}{S}\right)\right]}$$

$T_M =$ Error! Reference source not found. +Error! Reference source not found.$* \sqrt{\left[\left(3.4 - 2.4 * \frac{2.0000}{5.2500}\right) * \left(\frac{0.2 * 1800}{20000}\right)\right]}$

= 0.673 In, 17.087 mm

End Plate Thickness Selected by Program: 0.875 In, 22.225 mm

Pipe and Tube Stresses

Where T_E = Effective Thickness
T_A = Actual Thickness
D_0 = Pipe or Tube Outer Diameter
R_0 = Pipe or Tube Outer Radius
T_M = Minimum Thickness
S = Stress

Nozzle 1 (1.900 inch O.D. X 0.200 in Thick Inlet Pipe, SA-106-GR B):
Allowable Stress: Not to Exceed 17100.0 PSI, 117.905 MPa

$T_E = (T_A \times 0.875) - C.A. = (0.2000 \times 0.875) - 0.000 = 0.1750$ in, 4.4450 mm

$R_0 = D_0/2 = 1.9000/2 = 0.9500$

$$S = P\left(\frac{R_0}{T_E} - 0.4\right) = 1800\left(\frac{0.9500}{0.1750} - 0.4\right) = 9051.429\ PSI\ \ 62.410\ MPa$$

Nozzle 2 (2.375 inch O.D. X 0.218 in Thick Outlet Pipe, SA-106-GR B):
Allowable Stress: Not to Exceed 17100.0 PSI, 117.905 MPa

$T_E = (T_A \times 0.875) - C.A. = (0.2180 \times 0.875) - 0.000 = 0.1907$ in, 4.8450 mm

$R_0 = D_0/2 = 2.3750/2 = 1.1875$

$$S = P\left(\frac{R_0}{T_E} - 0.4\right) = 1800\left(\frac{1.1875}{0.1907} - 0.4\right) = 10485.767\ PSI\ \ 72.299\ MPa$$

Nozzle 3 (Not applicable, Nozzle 3 does not exist for this section):
Allowable Stress: Not applicable

T_E = (T_A x 0.875) – C.A. = (Not applicable x 0.875) – 0.000 = Not applicable

R_0 = D_0/2 = Not applicable/2 = Not applicable

$$S = P\left(\frac{R_0}{T_E} - 0.4\right) = Not\ applicable\left(\frac{Not\ applicable}{Not\ applicable} - 0.4\right) =$$

Tubes (SA214(WLD)):
Tube Allowable Stress: 11400 PSI, 78.6 Mpa

$T_M = \frac{P*0.5*D_O}{S+0.4*P} = \frac{1800*0.5*0.625}{11400+0.4*1800}$ = 0.046 In, 1.179 mm

Tube Wall Thickness Selected by Program: 0.060 In, 1.524 mm

Calculations Generated By: Name

MULTI-WING AMERICA, INC.
ISO 9001-2000 A Crowley Company

Multi-Wing Z Series Fans
Blade Pitch Angle Setting Instructions

Before You Begin:

To maintain balance of fan:

- Mark the hub castings across a joint, so the fan hub can be reassembled in the same orientation.
- Mark the location of any balancing weight. Balancing weight will be on the outer bolt circle, in the form of washers, and/or longer bolts, or an additional balancing nut.
- Number the blades and blade sockets, so that they are replaced into their original position.

If possible, note the location of the pitch setting pin in the blade socket when disassembling the fan, and whether pin is located in the Hub or Retainer half of the fan (see step 7 for detailed definition).

Step 1 – Determine Blade Type: "1Z", "2Z", "4Z", "5Z", or "6Z"

If the blade has a sickle shape, then look for 1Z or 2Z molded on the blade.

If the blade is wider at the tip than at the base near the hub, then you have a 6Z.

Otherwise, look for 4Z or 5Z markings on blade which are in one of two places:
Look on cone section at base of blade (visible when fan is assembled), or
Look inside the bottom of the socket (blade must be removed from hub).
Alternatively, measure the width of the blade at the widest portion at base of blade:
4Z blade is approximately 4-1/2 inches, 5Z blade is approximately 5-1/4 inches.

Step 2 – Determine Rotation Code: "L" or "R"

R rotation rotates clockwise facing air discharge, L rotation is counterclockwise facing air discharge.

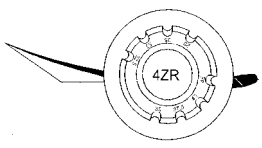
The 1Z and 2Z blade profiles have an arrow showing rotation molded into the blade on inlet side.

The 6Z is universal and can be used as an R or L rotation, depending on how pitch angle is set.

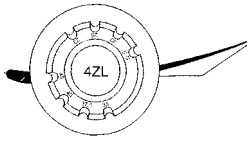
For 4Z and 5Z blades, the rotation code is molded into the blade, either on the cone section at base of blade, or inside bottom of the socket.

Examples of rotation for 4Z blades as viewed from end of socket are below, and 5Z is similar.

R, or clockwise



L, or counterclockwise



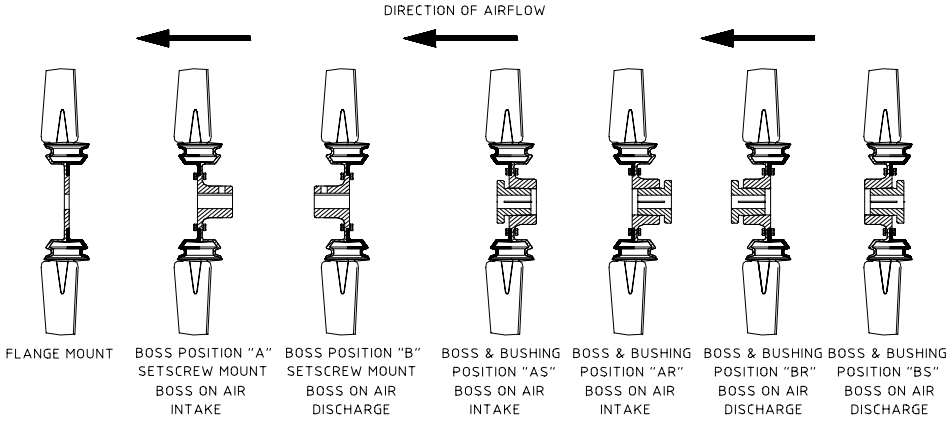
P.O. Box 425, 15030 Berkshire Industrial Parkway, Burton, Ohio 44021
Phone 440-834-9400 Fax 440-834-0449 www.mw-america.com

Step 3 – Determine Boss location code: "A" or "B"

The boss is the center section of the hub through which the fan is mounted to the shaft, and typically contains either setscrews or a center-tapered hole where the bushing inserts.

Select boss location A or B:
A is the boss on air inlet, including A, AR, and AS configurations.
B is the boss on air discharge, including B, BR, and BS.
See examples in drawing below.

For flange mounted (engine) fans, use boss location A for blower fans, and boss location B for suction fans.



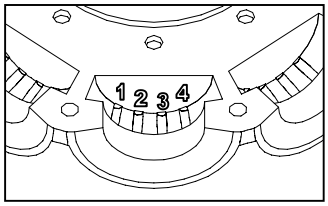
Step 4 – Find Blade Pitch Angle: 20, 25, 27.5, 30, 32.5, 35, 37.5, 40, 45, or 50

The blade pitch angle can be found several ways:

First, by knowledge of the Multi-Wing fan part number.
The pitch angle precedes the blade material code in the part number. For example, the pitch angle is 30 degrees in this part number: 36/9-9/30/PPG/5ZR/ SH 1-3/8 /AS

Second, by careful disassembly with this method:

- Disassemble fan on flat surface, and note in which groove the pin is located. See number code in picture to the right.
- Using pictures in step 7 on next page, determine if the pin was in the hub (HUB) or retainer side (RET) of fan.
- Using table in step 6 below, find the possible blade pitch.
- Using table in step 5 below, select your blade angle based on whether your pin was in the HUB or RET.



Third, by calling a sales engineer at Multi-Wing America for assistance in selecting a blade pitch angle for your application.

Step 5 – Determine Hub/Retainer Code: "HUB" or "RET"

Find "HUB" or "RET" in chart below:

Type	Rotation	Boss Pos.	Blade Pitch Angle									
			20°	25°	27.5°	30°	32.5°	35°	37.5°	40°	45°	50°
1Z,2Z,4Z	R or L	A	RET	RET	-	RET	RET	HUB	HUB	HUB	HUB	-
1Z,2Z,4Z	R or L	B	HUB	HUB	-	HUB	HUB	RET	RET	RET	RET	-
5Z	R or L	A	-	RET	-	RET	RET	RET	HUB	HUB	HUB	HUB
5Z	R or L	B	-	HUB	-	HUB	HUB	HUB	RET	RET	RET	RET
6Z	R	A	RET	RET	HUB	RET	HUB	RET	-	-	-	-
6Z	R	B	HUB	HUB	RET	HUB	RET	HUB	-	-	-	-
6Z	L	A	HUB	HUB	RET	HUB	RET	HUB	-	-	-	-
6Z	L	B	RET	RET	HUB	RET	HUB	RET	-	-	-	-

Step 6 – Determine Groove Number: 1 or 2 or 3 or 4

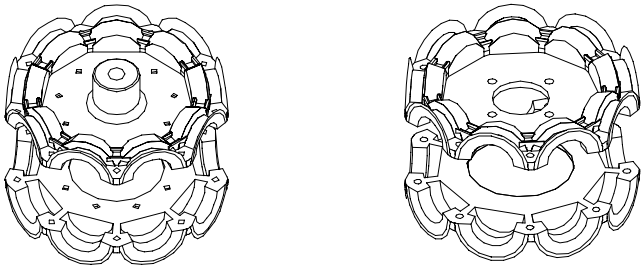
Find the groove number in chart below:

Type	Rotation	Blade Pitch Angle									
		20°	25°	27.5°	30°	32.5°	35°	37.5°	40°	45°	50°
1Z,2Z,4Z	R	4	3	-	2	1	4	3	2	1	-
1Z,2Z,4Z	L	1	2	-	3	4	1	2	3	4	-
5Z	R	-	4	-	3	2	1	4	3	2	1
5Z	L	-	1	-	2	3	4	1	2	3	4
6Z	R	1	2	1	3	2	4	-	-	-	-
6Z	L	1	2	4	3	3	4	-	-	-	-

Step 7 – Final Assembly

Definition of HUB and RET for purposes of these instructions:

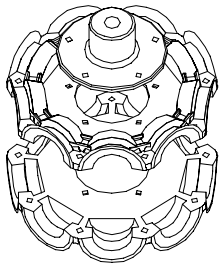
For 2-piece hubset like below:



Top half is the HUB, and bottom half is the RET or retainer ring.

Step 7 – Final Assembly continued

For 3-piece hubset as below:



Top two pieces together are considered the HUB, and bottom piece is considered the RET or retainer ring.

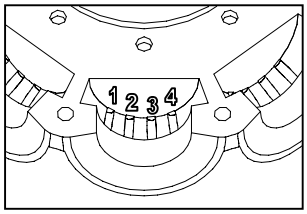
Using the HUB or RET code found in Step 5:

If code is HUB, place the hub down on work surface first (one or two pieces, depending on above).
If code is RET, place one retainer ring only down on the work surface first.

A weighted coffee can could be used to elevate the fan from the work surface.

Using the Groove Number found in Step 6:

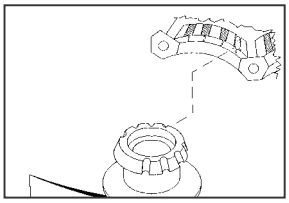
Using picture to right, place the locking pin in the groove number that you found in Step 6 above.



Finally, Insert Blades:

- Place the blade over the pin in the hub/retainer blade socket, so that the pin also fits into the appropriate pitch angle groove in the blade. See example picture to the right.

  For 6Z fans, use the pitch angle groove in the blade marked with your rotation (R or L) and pitch angle. Example: L35 is “L” rotation and 35-degree pitch angle.



- Repeat for all blades.
- Assemble hubset together, aligning the match marks you made.
- Replace any balancing weight to its original position.
- To finish, tighten the bolts in a cross pattern to 5 to 6 foot-pounds of torque.

INSTRUCTIONS FOR BLADE PITCH ADJUSTMENT
FOR THE LARGE SERIES MULTI-WING W BLADES

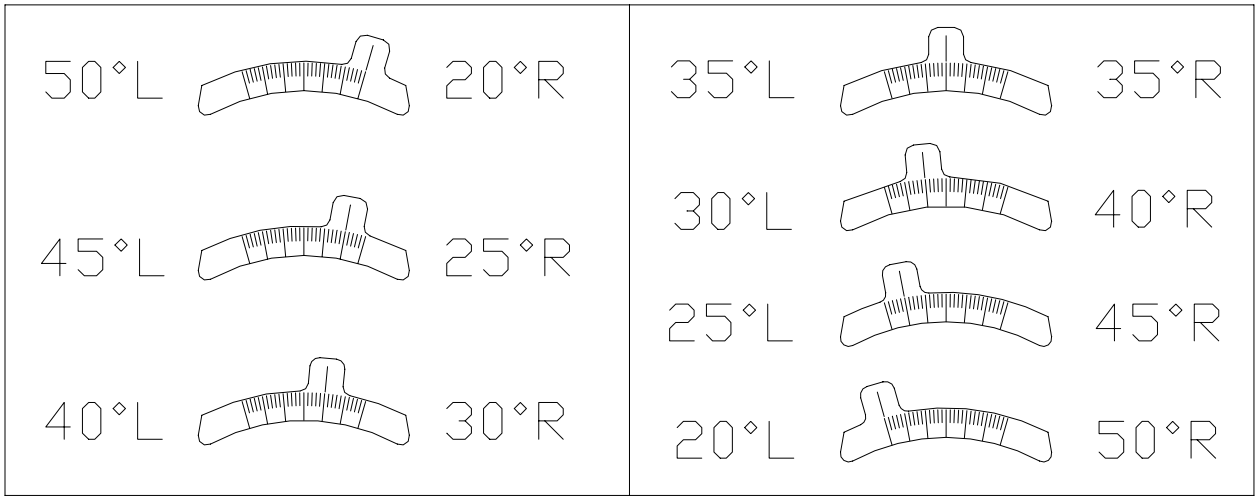
1) NOTE ORIGINAL POSITION OF RETAINING PLATES, CENTER BOSS AND ALL HARDWARE INCLUDING ADDITIONAL HARDWARE USED FOR BALANCING

2) REMOVE **ALL** THE BOLTS AND NUTS.

3) DETERMINE BLADE ROTATION – ON THE CONCAVE SIDE OF THE BLADE IS A BLADE MARKING SHOWING 6WR, 6WL, 7WL, 7WR, OR 9WR. THE "L" AND "R" DENOTE THE ROTATION OF THE BLADE.

4) REPLACE THE PITCH INSERT IN THE BLADE ROOT WITH AN INSERT OF THE DESIRED PITCH.

PITCH IS DETERMINED BY COUNTING DIAL MARKS ON THE INSERT FROM THE SIDE OF APPROPRIATE BLADE ROTATION FOUND IN STEP 3. EACH LARGE MARK REPRESENTS 5 DEGREES. THE ENDS OF THE INSERT ARE 20 AND 50 DEGREES ACCORDINGLY.



5) REPLACE BLADES TO THEIR ORIGINAL LOCATION.

6) REPLACE ALL NUTS, BOLTS, AND WASHERS ON THE FAN HUB.

7) REPLACE RETAINING PLATES AND CENTER BOSS TO ORIGINAL LOCATION.

7) TIGHTEN NUTS AND BOLTS TO:
14 FOOT POUNDS OF TORQUE

(REV. 9/7/05)

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Quality System
Quality Endorsed Company
ISO 9001 QEC-15013
SAI Global

D-3153 Pneumatic Actuator

Product Bulletin

D-3153-xxxx Series

Code No. LIT-2681054P
Issued April 28, 2010
Supersedes May 1, 1996

The D-3153 Pneumatic Actuator is a multipurpose positioning device used primarily for operating ventilating dampers in response to the output signals of a pneumatic controller or electro-pneumatic transducer.

The D-3153 Pneumatic Actuator is used with dampers up to a maximum area of 16 ft^2 (1.5 m^2) for proportional volume control, and 25 ft^2 (2.3 m^2) for 2-position actuation (provided that the torque requirements are compatible with the specific application).

The D-3153 Pneumatic Actuator component is recognized by Underwriters Laboratories Inc.® (UL) for use on UL classified 555/555S smoke and combination fire/smoke dampers which have been tested and approved to a degradation temperature of 250°F (121°C).

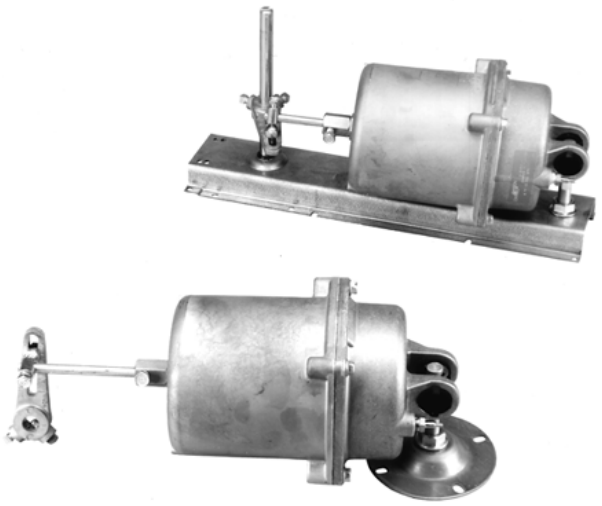

Figure 1: D-3153 Pneumatic Actuator

Table 1: Features and Benefits

Features	Benefits
All-aluminum Housing	Creates a lightweight, non-combustible actuator
Telescoping Linkage	Provides fast, flexible installation
Long Life and Reliable Design	Places over a million actuators now in service
2-way Swivel Head	Ensures full power delivery
Agency Recognition	Provides a UL recognized component for fire and smoke applications to 250°F (121°C)

Application

When used with proportional control, the damper size is limited to 16 ft^2 (1.5 m^2) maximum. As a 2-position control, damper size is limited to 25 ft^2 (2.3 m^2).

Three nominal spring ranges are available:

- 3 to 7 psi (21 to 49 kPa), D-3153-7
- 5 to 10 psi (35 to 70 kPa), D-3153-3 and -6
- 8 to 13 psi (56 to 91 kPa), D-3153-1, -2, -4, -5, and -18

The control air pressure for normal Heating, Ventilating, and Air Conditioning (HVAC) operation is 0-20 psig (0-138 kPa). The minimum control pressure for safety damper functions is 20 psig (138 kPa) with the maximum pressure of 30 psig (207 kPa). When used for both proportional and safety applications, provide a separate air signal to override normal HVAC operation and cause safety damper functions.

The D-3153 Pneumatic Actuator incorporates several internal and external features that add functional flexibility. A 2-way swivel connection on the actuator cylinder head provides non-binding movement.

Johnson Controls

All actuators have a telescoping piston rod for easy linkage of the damper for attachment points up to 8-3/4 in. (222 mm) away from the face of the actuator. A swivel ball joint and slotted crank arm connector are furnished on all actuators for optional methods of linkage to the damper.

The UL recognized component D-3153 Pneumatic Actuators, with universal and auxiliary mounting brackets, are specifically designed for use with Johnson Controls® safety dampers up to 250°F (121°C).

Operation

Air pressure from a pneumatic controller is applied to the diaphragm of the actuator, which moves the piston against the forces of the internal spring and the load. The external load force shifts the operating range from the nominal spring range. The piston moves to a position where the applied force and the spring, plus external forces, are in equilibrium. However, with a pilot positioner added, the piston moves to a position proportional to the control signal regardless of the load.

Installation

Two standard mounting packages are available with the D-3153 Pneumatic Actuator. The models with universal mounting bracket assemblies provide all of the parts and instructions required for applying the actuator to Johnson Controls D-1300 damper applications: duct (wall) mounting or frame mounting, either normally open or normally closed.

The auxiliary mounting bracket assembly facilitates applying the D-3153 Pneumatic Actuator to allied equipment manufacturer's products, and non Johnson Controls installations for actuator conversions. These assemblies are furnished with a crank arm linkage and pedestal style bracket. Two positions are provided on the pivot post for attaching the actuator to the mounting bracket so that force can be more directly applied to linkage points that are neither perpendicular nor parallel to the actuator mounting plane.

A stop screw kit is available for special applications to limit the power stroke of the actuator when required. A 4 ft (122 cm) linkage rod is also available for special applications to reach extended linkage when required.

Where precision sequential operation is desired, or additional positioning power is necessary, use a D-9502 positioner. Up to four more D-3153 Pneumatic Actuators may be slaved from one pilot for coupled dampers. A D-9502 kit is also available to enable 2-stage actuator control for providing minimum outdoor air during occupation (refer to the *D-9502 Pneumatic Damper Actuator Positioner Product Bulletin [LIT-1628399P]*).

Refer to the *D-3153 with Universal Mounting Bracket Installation Bulletin (Part No. 34-188-18)* and the *D-3153 with Auxiliary Mounting Bracket Installation Bulletin (Part No. 34-154-19)* for more details.

Repair Information

Do not make field repairs. If the D-3153 Pneumatic Actuator fails to operate within its specifications, replace the unit. For a replacement actuator, contact the nearest Johnson Controls representative.

Table 2: Force Values at 20 psig (140 kPa) Supply

Spring Range, psig (kPa)	Stroke	Force, lb (Newton)	Torque Output for 90° Rotation
8 to 13	Power	105 (467)	158 in·lb (18 N·m)
(56 to 91)	Return	120 (534)	180 in·lb (20 N·m)
5 to 10	Power	150 (667)	225 in·lb (25 N·m)
(35 to 70)	Return	75 (334)	113 in·lb (13 N·m)
3 to 7	Power	195 (867)	293 in·lb (33 N·m)
(21 to 49)	Return	45 (200)	68 in·lb (8 N·m)

Dimensions

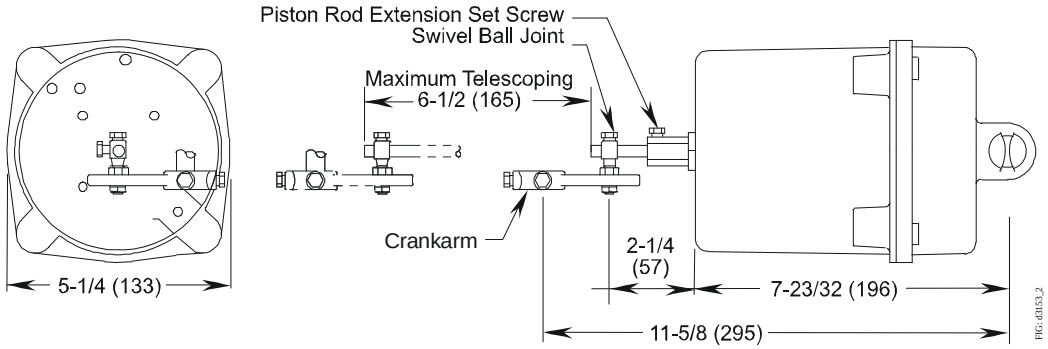

Figure 2: D-3153 Pneumatic Actuator Dimensions, in. (mm)

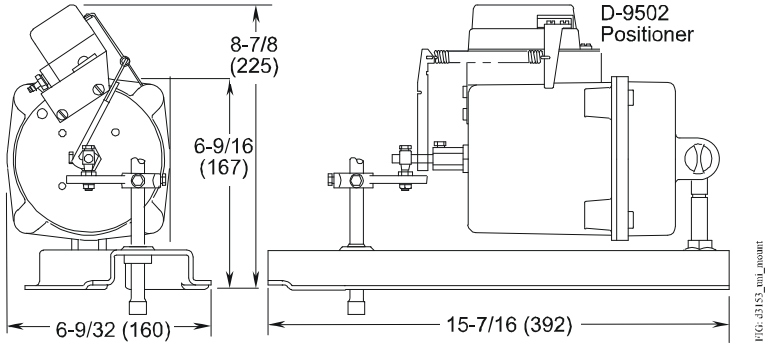

Figure 3: D-3153 Pneumatic Actuator with Universal Mounting Bracket Dimensions, in. (mm)

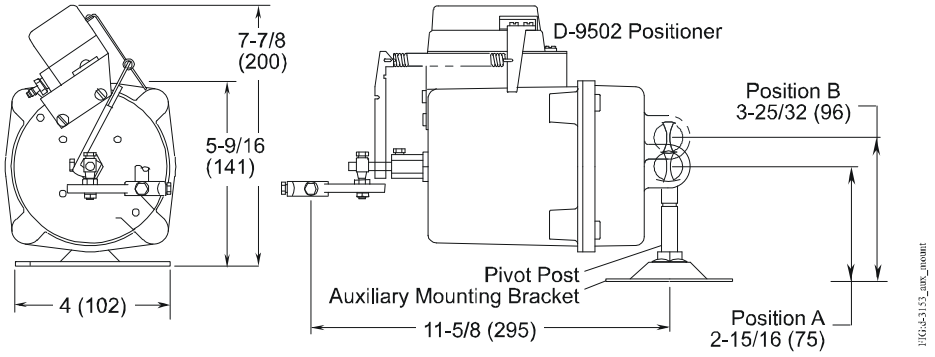

Figure 4: D-3153 Pneumatic Actuator with Auxiliary Mounting Bracket Dimensions, in. (mm)

Table 3: Ordering Information

Nominal Spring Range, psig (kPa)	With Universal Mounting Bracket	With Auxiliary Mounting Bracket	Body Only
8 to 13 (56 to 91)	D-3153-2	D-3153-5	D-3153-6003
8 to 13 (56 to 91) with D-9502	D-3153-1	D-3153-4	–
0 to 3 (0 to 21) and 9 to 13 (63 to 91) with 2-stage Pilot	–	D-3153-18	–
5 to 10 (35 to 70)	D-3153-3	D-3153-6	D-3153-6002
3 to 7 (21 to 49)	–	D-3153-7	D-3153-6001

Table 4: Accessories (Order Separately)

Description	Shipping Weight, lb (kg)	Code Number
Rubber Boot Kit	0.2 (0.09)	D-3073-100
Ball Joint, weather resistant	0.3 (0.11)	D-3073-604
Blade Arm Kit	1.0 (0.45)	D-9999-100
Crank Arm, 1/2 in. adjustable to 2-3/4 in. radius	0.5 (0.23)	D-3153-101
Crank Arm, 3/8 in. adjustable to 2-3/4 in. radius	0.5 (0.23)	D-3153-108
Crank Arm, 7/16 in. adjustable to 2-3/4 in. radius	0.5 (0.23)	D-3153-109
Linkage Rod, 4 ft (122 cm)	2.0 (0.91)	D-3153-102
Linkage Rod, replacement	1.0 (0.45)	D-3153-103
Stop Screw Kit, 1/4 – 24 x 3 in.	0.5 (0.23)	D-3153-104
Proportional Pilot Positioner Kit[1]	2.0 (0.91)	D-9502-8
Ball Joint	0.5 (0.23)	D-9999-104
Pivot Post, 5 per kit	0.5 (0.23)	D-3153-110
E-rings for Pivot Post, 10 per kit	0.5 (0.23)	D-3153-111
Mounting Nuts for Pivot Post, 10 per kit	0.5 (0.23)	D-3153-112
Universal Mounting Bracket	3.5 (1.13)	D-3153-105
Auxiliary Mounting Bracket	1.0 (0.45)	D-3153-106
2-stage Positioner Kit[1]	2.0 (0.91)	D-9502-9

1. Positioner kit includes positioner, mounting plate, spring, and mounting hardware.

Technical Specifications

D-3153 Pneumatic Actuator

Product	D-3153 Pneumatic Actuators
Stroke	3 in. (76 mm)
Control Air Pressure	0-20 psig (0-138 kPa) for HVAC 20 psig (138 kPa) minimum for safety damper functions 30 psig (207 kPa) maximum without pilot
Air Connections	1/8 in. NPT straight barbed fitting for 5/32 in. or 1/4 in. O.D. polytubing (furnished) compression fitting for 1/4 in. O.D. copper tubing (optional)
Ambient Operating Conditions	-20 to 150°F (-29 to 66°C)
Effective Diaphragm Area	15 $in.^2$ (97 cm^2)
Materials	Body: Die-cast Aluminum; Diaphragm: Synthetic elastomer
Dimensions (H x W x D)	See Figure 2, Figure 3, and Figure 4
Shipping Weight, lb (Kg)	**D-3153-1** 11.5 (5.2) **D-3153-3** 10.0 (4.5) **D-3153-5** 8.5 (3.9) **D-3153-7** 8.5 (3.9) **D-3153-2** 10.0 (4.5) **D-3153-4** 10.5 (4.8) **D-3153-6** 8.5 (3.9) **D-3153-18** 10.5 (4.8)
Compliance	UL recognized component to 250°F (121°C) with compression fitting for copper tubing, File No. R15581, D-3153-42 and D-3153-43 ULC Listed

For application at conditions beyond these specifications, consult the local Johnson Controls office. Johnson Controls, Inc. shall not be liable for damages resulting from misapplication or misuse of its products.

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507 E. Michigan Street, Milwaukee, WI 53202

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Rex®

Bearing Replacement and Maintenance Instructions

(See other side for Installation Instructions)

DISASSEMBLY —

1. Remove set collars.
2. Remove seals.
3. Remove MICRO-LOCK screw and key. (Do not lose nylon washer).
4. Remove threaded cover by turning counter clockwise.
5. Place housing cover side down on arbor press with spacer blocks under housing.
6. Place a soft metal bar or wood block on face of inner ring and press bottom outer ring and inner ring assembly from housing.
7. To remove the back outer ring, large bore bearings from 4 7/16" thru 7" have drive pin holes. The back outer ring of smaller bore size units may be removed with a bearing puller or hammer and drift.

REASSEMBLY —

1. Place housing cover side up on arbor press with spacer blocks under housing.
2. Press in back outer ring and seat against housing shoulder.
3. Insert inner ring assembly and rotate to seat rollers against back outer ring.
4. Press in front outer ring.
5. Install threaded cover, turning clockwise until inner ring resists rotation or misalignment.
6. Back off threaded cover one quarter turn — align cover slot with the nearest counter bored hole in housing. See ADJUSTMENT TABLE.
7. Install MICRO-LOCK key with nylon washer under head of screw.
8. **Using a soft drift or block, rap face of inner ring on side opposite threaded cover to seat front outer ring. Inner ring assembly should rotate freely.**
9. Install seals. **Z-Seal**-Place centering spring in seal groove with fingers facing up. Place U-shaped element on fingers. Place centering ring on element with projection on face up. Install snap ring so that projection on centering ring is between ends of snap ring. **K-Seal**-Place seal into seal groove with anti-rotation boss sticking up. Install snap ring so that the raised boss is between the snap ring ends. **M-Seal**-Place seal into seal groove with spring facing out. No snap ring is required with **M-Seal**.
10. Install collars.
11. Lubricate bearing with amount of grease shown in LUBRICATION TABLE. Rotate inner ring assembly during lubrication to assure distribution of grease in bearing.

LUBRICATION INSTRUCTIONS

GENERAL INFORMATION AND SELECTION

This information is to aid in the proper lubrication of Rex® bearings for the majority of applications. Standard bearings come prelubricated from the factory with Mobil Mobilith AW2 grease. Mobilith AW2 is an N.L.G.I. Grade 2, EP (extreme pressure) grease with a lithium complex thickener. It can be used for high loads, and in some cases at temperatures as low as –40°F or as high as +350°F. For high speeds, other special service conditions, or for inquiries on other acceptable greases, please consult your local Rexnord representative or the Rex® Bearing Engineering Department. When rebuilding Rex® bearings for use in average operating conditions, the bearing should be lubricated with the amount of grease by weight as shown in the LUBRICATION TABLE.

RELUBRICATION

Bearings should be relubricated at regular intervals. The frequency and amount of lubricant will be determined by the type of service. General guidelines for relubrication frequency and amount are based upon the average application conditions. See LUBRICATION TABLE.

At high temperature, greases tend to degrade more rapidly and thus require fresh grease more frequently. In general, small amounts of grease added frequently provide better lubrication. Most greases will eventually harden, causing relubrication to become less effective. When this occurs, the bearing should be disassembled, cleaned, and lubricated per LUBRICATION TABLE. When equipment will not be in operation for some time, grease should be added to provide corrosion protection. This is particularly important for equipment exposed to severe weather.

AUTOMATIC LUBRICATION SYSTEMS

A variety of automatic relubrication systems are available for use with roller bearings. Key considerations are:

1. NLGI grade of grease used, consistent with system layout.
2. An amount/frequency combination necessary to replenish the grease.

MIXING OF GREASES

Mixing of any two greases should be checked with the lubricant manufacturer. If the grease bases are different they should not be mixed.

OIL LUBRICATION

Rex housing designs do not include oil sumps, thus are not readily used with static oil lubrication. However, they can be adapted to re-circulating oil systems provided an adequate drain size and proper seals are incorporated.

LUBRICATION TABLE

SHAFT SIZE – (INCHES)			GREASE WT. REQUIRED (OZ.)		RECOMMENDED NUMBER OF MONTHS BETWEEN RELUBRICATION* (BASED ON 40 HR. WK.)					
					RPM					
Single Collar Series 2000 Series 3000	Double Set Collar Heavy Duty Series 5000	Adapter Series 9000	To Lubricate Rebuilt Units	To Relubricate Units	100	300	500	1000	1750	3000
3/4 - 1 1 1/8 - 1 1/4 1 7/16 - 1 1/2	.... 1 7/16	....	0.4 0.5 0.6	0.1 0.1 0.1	12	8	5	2	1	1/2
1 11/16 - 1 3/4 1 15/16 - 2 2 3/16 - 2 1/4 2 3/8 - 2 1/2 2 11/16 - 3	1 1/2 - 1 11/16 1 15/16 2 - 2 3/16 2 7/16 2 1/2 - 2 15/16	.... 1 15/16 - 2 2 3/16 2 7/16 - 2 1/2	0.8 0.9 1.1 1.5 2.8	0.2 0.2 0.2 0.3 0.5	8	5	3	1	1/2	...
3 3/16 - 3 1/2 3 11/16 - 4	3 3/16 - 3 7/16 3 11/16 - 4 4 3/16 - 4 1/2	2 11/16 - 3 3 3/16 - 3 7/16 3 11/16 - 4	3.7 6.9 8.4	0.6 1.1 1.5	6	4	2	1	1/2	...
....	4 15/16 - 5 5 7/16 5 15/16 - 6 6 7/16 - 7	4 3/16 - 4 7/16 4 15/16 - 5 5 3/16 - 5 7/16 5 15/16 - 6 7/16	14.3 22.1 25.3 33.0	2.5 4.0 4.5 6.0	4	2	1	1/2	...	...

ADJUSTMENT TABLE (AXIAL CLEARANCE)

SHAFT SIZE INCHES (SERIES)			FACTORY SETTING (AVG. SPEEDS)	RECOMMENDED THREADED COVER ADJUSTMENT FOR HIGH SPEEDS		
2000 3000 Series	5000 Series	9000 Series	Axial Clearance (Inches)	Speeds Over	Axial Clearance (Inches)	Inches Per 1/12 Turn
3/4 thru 1 1/2	1 7/16	....	.007-.012	2000 RPM	.012-.017	.005
1 11/16 thru 2	1 1/2 thru 1 15/16	....	.007-.012	1500 RPM	.012-.017	.005
2 3/16 thru 3	2 thru 2 15/16	1 15/16 thru 2 1/2	.010-.017	1250 RPM	.017-.024	.007
3 3/16 thru 4	3 3/16 thru 4	2 11/16 thru 3 7/16	.010-.017	1000 RPM	.017-.024	.007
....	4 3/16 thru 5	3 11/16 thru 4 7/16	.010-.020	750 RPM	.020-.030	.010
....	5 7/16 thru 7	4 15/16 thru 6 7/16	.015-.025	500 RPM	.025-.035	.010

* Relubrication amounts and frequencies shown in the table are based on standard clearances, moderate loads, etc., which yield housing temperatures of 150° F or less. Lubrication practices indicate that the relubrication frequency should be doubled for every 20° F above that level.

Rexnord

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105-99501-07

Rex®

Installation Instructions

Mounted Roller Bearings

(See other side for Bearing Kit Replacement and Maintenance Instructions)

BEARING MOUNTING PROCEDURE

SET COLLAR — FIXED UNITS ONLY

1. Position bearings on the shaft, applying all driving pressure to the face of the inner ring.
2. Align the bearing housing to its mounting base by measuring from the face of the inner ring to the face of the threaded cover.
   Where shimming is required — use full shims across housing base — not just at bolt holes.
3. Bolt housing securely to mounting base.
4. Tighten the set collar set screws on bearing closest to drive (or most important to axial location of shaft) to the shaft. Proper tightening torque can be found in SET SCREW TORQUE TABLE. **The remaining bearings should not be secured to the shaft at this time.** Alternate torquing of the screws to prevent unequal loading. If an Allen wrench is used as a torque wrench, place length of pipe over the long end and pull until wrench begins to twist.
5. Rotate shaft under power to permit the remaining bearings to seek their natural running position on the shaft.
6. Shut off the power and torque down set screws in remaining bearings using procedure in Step 4.

SET COLLAR — EXPANSION UNITS ONLY

1. Center cartridge in outer housing. If maximum expansion capability is required, place cartridge in extreme position of housing to permit full movement of cartridge in direction of expansion.
2. The remainder of the installation procedure is the same as Fixed Units, follow Steps 2, 3 and 4.

ADAPTER UNITS

1. A. Free tapered split sleeve in bore of bearing by backing off locknut and rapping face of locknut.
   B. Position bearing on shaft with fixed bearing closest to drive (or most important to axial location of shaft).
2. Position and loosely bolt housing to mounting base.
3. Secure fixed bearing to shaft by tightening locknut until sleeve grips shaft. Turn a 1/2 turn more and bend one of the lockwasher tangs into one of the slots on the outside diameter of locknut.
4. Align each bearing housing as accurately as possible to its mounting base or frame by measuring from the face of the inner ring to the face of the threaded cover.
5. Operate bearing under full load for several days to permit seating of bearing and sleeve on the shaft. Then shut down the system and retighten locknuts on all bearings.

ADAPTER UNITS — EXPANSION UNITS ONLY

1. Center Cartridge in outer housing. If maximum expansion capability is required, place cartridge in extreme position in housing to permit full movement of cartridge in direction of expansion.
2. The remainder of the installation procedure is the same as Fixed Units, follow Steps 2,3,4, and 5 above.

DUPLEX UNITS

When mounting Duplex Units, place end plate (bolted cover with pilot) into bore of housing. Press first outer ring until it seats against this pilot, then insert inner ring assembly and turn to free rollers. Press in second outer ring, turn inner ring assembly so rollers are free, then seat second outer ring. Using shims as a feeler, determine exact amount required to fill space between housing face and bolted cover. See ADJUSTMENT TABLE and add shims to obtain proper bearing clearance. After unit is bolted together, free the bearing by pressing or striking inner ring on the side opposite the shim adjustment.

GENERAL INSTALLATION COMMENTS

1. Shaft Journal areas must be free of burrs, cleaned of fretting corrosion and within the tolerance range shown in the SHAFT TOLERANCE TABLE.
2. Mounted units are prelubricated at the factory with a multi-purpose lithium soap grease. No additional grease is required at time of installation.
3. Position housings for:
   a. accessibility of grease fittings.
   b. if thrust is present — place thrust force against shoulder side of housing, not against threaded cover side.
4. If spacer shims are used for alignment they must cover the entire housing base.
5. Spot drill or mill flats on shaft for increased holding power of set screws or ease of removal.
6. When an eccentric load condition exists, position set screws directly opposite from eccentric weight.
7. Shaft shoulders are recommended to support vertical shafts and high thrust loads. The shoulder diameter should not exceed the outside diameter of the inner ring.
8. When pillow blocks are mounted on an inclined plane or the work force is parallel with the base, either lateral bolts or welded "stop blocks" should be used to prevent shifting.
9. Avoid direct hammer blows to the bearing and it's components by using a soft drift or block.
10. New seals should be used whenever a bearing is rebuilt.

SET SCREW TORQUE TABLE

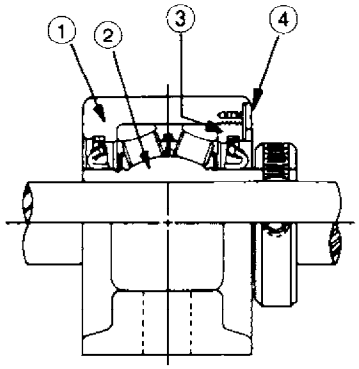
Shaft Size (Inches)		Set Screw Size	Tightening Torque (Inch-Pounds)
Normal Duty 2000 Series	Heavy Duty 5000 Series		
3/4 - 1 1/4	....	5/16	125
1 7/16 - 2	1 7/16 - 1 15/16	3/8	225
2 3/16 - 2 1/4	2 - 2 3/16	7/16	325
2 3/8 - 3 1/2	2 7/16 - 3 7/16	1/2	475
3 11/16 - 4	3 11/16 - 5 7/16	5/8	1150
....	5 15/16 - 7	3/4	1600

For more detailed instructions refer to the latest REXNORD CORP. Catalog.

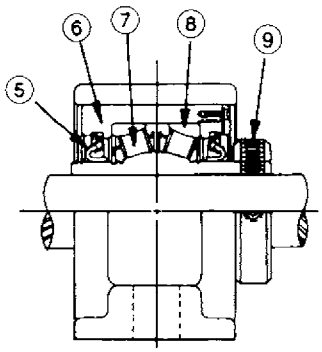
SHAFT TOLERANCE TABLE – INCHES

Nominal Shaft Size	Commercial Shaft Tolerance* (Cold Finished Steel, Low Carbon)	RECOMMENDED SHAFT TOLERANCES		
		Set Collar Mounting	Adapter Mounting	Press Fit Mounting
		Severe Loading or High Speed		
1-2	+.000 - .003	+.000 - .001	+.000 - .003	Consult
2-4	+.000 - .004	+.000 - .001	+.000 - .004	Rexnord
4-6	+.000 - .005	+.000 - .0015	+.000 - .005	
6-8	+.000 - .006	+.000 - .0015	+.000 - .005	

* Commercial shafting tolerances are normally satisfactory for low to moderate loads in slow to moderate speed applications.



FIXED



FLOATING

1. HOUSING
2. INNER RING
3. THREADED COVER
4. MICROLOCK ASSY
5. SEAL
6. CARTRIDGE
7. ROLLER
8. OUTER RING
9. SET COLLAR

Rexnord® 6000 Series Adapter Mounted Spherical Roller Bearing Units with SHŪRLOK® Technology Installation Instructions

Important -- Read Carefully

These instructions are provided to aid in the proper installation, operation, and maintenance of the Rexnord® adapter mounted spherical roller bearing units. They should be carefully read and followed. Failure to do so may result in unsatisfactory service as well as serious personal injury or property damage.

NOTE: IT IS IMPORTANT TO ALIGN THE ADAPTER SLEEVE LOCKING PIN WITH THE INNER RING KEYWAY BEFORE ASSEMBLING THE ADAPTER SLEEVE INTO THE INNER RING IF REMOVED. WHEN INSTALLING TWO FIXED BEARINGS, PLEASE REFER TO PAGE 2.

DO NOT OVERTIGHTEN BEARING OR WARRANTY WILL BE VOID. REFER TO TABLE 2, PAGE 2 FOR TIGHTENING INSTRUCTIONS.

CAUTION: The reliability built into all Rexnord® bearings can be realized in service only when they are correctly selected, properly installed, protected and maintained.

The correct selection of bearings or mounted units requires that the magnitude and nature of all loads, speed, alignment, mounting, operating requirements and maintenance be adequately considered. The selection of materials and design of housings, shafting, fasteners, seals, and accessories as well as provisions for installation and maintenance must follow good engineering principles.

Housings must be selected and installed with regard to the degree and direction of the forces that will occur. Housings should not be used under tension loads except with adequate safety factors. For this reason pillow blocks are best suited to withstand radial loads passing through the base. When heavy loads or shock loads are possible it is most important to mount a unit so that the line of force passes directly into its base so that the unit is directly and substantially supported other than through its mounting bolts. Where the line of force falls outside the base, such as with horizontal or uplift loads on pillow blocks, serious housing and fastener deflection or failure may occur. These conditions may require designs using different materials, fasteners, mounting design, stop bars, etc., together with proper safety factors. When these conditions are unavoidable, the Rexnord® Bearing Division should be consulted.

Please note the following important points:

A. Cleanliness
Keep dirt, water, and metal chips off all parts.

B. Careful Handling
Hammer blows, overheating, or improper use of force can damage precision parts.

C. Adapter Sleeve Tightening
Bearings must be correctly forced up their tapered adapter sleeves. Improperly tightened bearings and adapter assemblies may slip or turn on the shaft. When mounting these bearings on a used or worn shaft, care must be taken to clean up the shaft journal and rebuild, as necessary, to the required tolerances. Never replace bearings on a shaft which is bent or which has been damaged or softened by a torch.

D. Shaft Tolerances
These bearings can be mounted to commercially available shafts with standard undersized tolerances as shown in the following table:

Table 1 - Shaft Diameter Tolerances

Shaft Diameters	Tolerances
1” through 2”	Nominal to -.003”
2 1/16” through 4”	Nominal to -.004”
4 1/16” through 5”	Nominal to -.005”

E. Bolts
Housing mounting bolt tightness is important to prevent the housing from shifting and to adequately support loads.

F. Free Rotation and Alignment
Check for free rotation before machine startup to assure that final alignment is proper.

G. Lubrication
Units must be adequately lubricated. A bearing not properly lubricated can run to destruction and possibly cause damage to other components.

H. Installation in Extreme Temperatures
Use alternative installation instructions as outlined on Page 2, Step 5, if installing bearings in temperatures greater than 120˚F or less than 20˚F. The optical strain sensor may not indicate properly outside of this temperature range.

I. High Speed Applications
If the bearing will run at higher speeds than shown in Table 5, clearance must be adjusted. Refer to the clearance adjustment instructions on page 3.

INSTALLATION

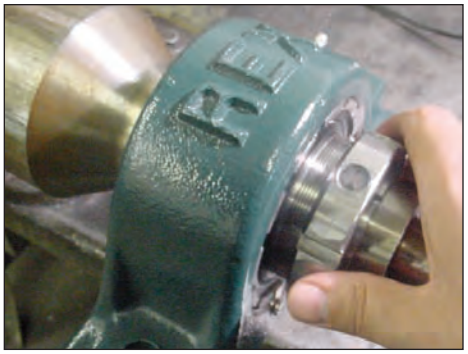
ONE FIXED AND ONE FLOATING UNIT

1. Check Shaft - Shafting must be clean, round, straight, free of burrs and nicks, and of correct size. Do not coat the shaft or adapter bore with a preservative, lubricant, or other substance such as LOCTITE®. Adapter mounted units are normally not detrimental to the shaft surface and the use of any preservative or lubricating medium is not required.

2. Assembly on Shaft - The adapter assembly is shipped inside the bearing. The adapter components do not need to be removed. **If you should happen to remove the adapter sleeve from the bearing during installation, you must align the locking pin mounted in the adapter sleeve with its mating keyway in the inner ring bore as shown in the picture below:**

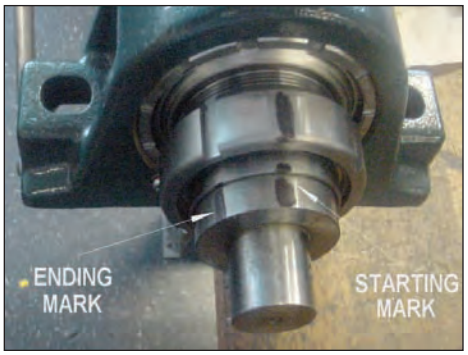
Slide the bearings on the shaft to their intended positions. Back off the setscrews in the locknut so the locknut will turn easily. If the bearings do not slide freely down the shaft, slightly loosen the locknut by hand until the bearing is free to slide down the shaft. Position the bearings on the shaft with the fixed bearing closest to the drive. Align the housings square to the shaft, then tighten the mounting bolts.

3. Tighten the Adapter Assembly of the Fixed Bearing first – Make sure the shaft is locked so as not to rotate. Hand tighten the locknut to take out looseness, then use a hook type spanner wrench to bring the locknut to a snug fit.



If the adapter sleeve begins to slip around the shaft, then retain the sleeve using a second small hook type spanner wrench. Engage the second spanner wrench into the split area of the adapter sleeve. Position the wrench in the opposing direction of the first spanner wrench that is engaged in the locknut. Continue tightening until the adapter sleeve will no longer slip about the shaft.

Now mark the position of the locknut relative to the shaft with a grease pencil or a dark marker at the top of the locknut and shaft. Make sure the mark is legible and marks both the locknut and shaft at the same point.



Begin to tighten the locknut using one of these methods:

1. the special SHŪRLOK® installation tool with a ½ or ¾" drive breaker bar (see below)
2. a soft steel drift pin and a hammer
3. an impact type spanner wrench
4. a chain wrench

Bearing Size	SHŪRLOK® Installation Tool Part Number
115	105-90420-11
203	105-90420-21
206/207	105-90420-31
211/212/215	105-90420-41
303/307	105-90420-51
311/315	105-90420-61
403/407	105-90420-71
415	105-90420-81

Tighten the locknut clockwise about ¾ of a turn. Check the visual indicators for any color change. It is important to check both indicators. If neither indicator shows any color, continue tightening the locknut in $^{1}/_{8}$ turn increments while noting the condition of the visual indicators. The visual indicators are used to confirm the tightness in the mounting.

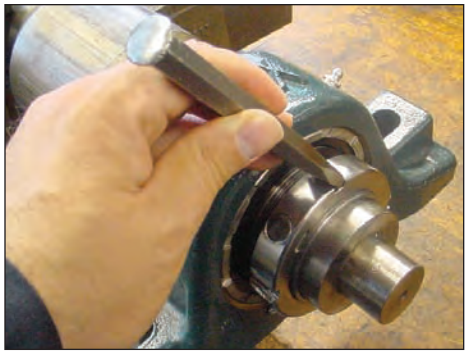


Table 2 - Final Locknut Adjustments

Shaft Size Range - in		Minimum Locknut Adjustment (Turn)	Maximum Locknut Adjustment (Turn)
From	To		
1 15/16	2 15/16	1	1 1/4
3 3/16	4 7/16	1 1/8	1 3/8
4 15/16	_	1	1 1/4

At least one of the visual indicators should show a color change. It is important to note that any of the color patterns shown here or any patterns in between are acceptable. The indication pattern does not need to be centered and may show on one side of the indicator only. Only one of the indicators needs to show color for the bearing to be properly tightened. If both of the indicators are still clear after tightening to the Minimum Locknut Adjustment in Table 2, then continue to tighten in 1/8 turn increments. Discontinue tightening when at least one indicator shows a color change or the Maximum Locknut Adjustment in Table 2 is reached. If the Maximum Locknut Adjustment is reached and neither indicator shows a color change, the unit should be dismounted. Remount the unit using the alternate method of mounting as shown in step 5.

4. Over-Tightening the Adapter Assembly – If the indicator starts to show yellow and/or red indication anywhere on the indicator, the mounting has been over-tightened. As shown in the following picture:

Over tightening can reduce too much bearing internal clearance and cause the bearing to run hot. To rectify this situation, simply impact the locknut in the counter clockwise direction which loosens the adapter assembly. When the adapter assembly becomes completely loose, start the tightening procedure again from step 3.

5. Alternate Mounting Method – If for any reason the visual indicator becomes damaged or no color change was seen in Step 3, this alternate method for mounting the adapter assembly must be used, otherwise skip to step 6.

Start at step 1 INSTALLATION, then hand tighten the locknut to take out looseness. Use a hook type spanner wrench to bring the locknut to a snug fit. If the adapter sleeve begins to slip around the shaft, then retain the sleeve using a second small hook type spanner wrench. Engage the second spanner wrench into the split area of the adapter sleeve. Position the wrench in the opposing direction of the first spanner wrench that is engaged in the locknut. Continue tightening until the adapter sleeve will no longer slip about the shaft.

Mark the position of the locknut relative to the shaft with a grease pencil or a dark marker at the top of the locknut and shaft. Make sure the mark is legible and marks both the locknut and shaft at the same point. Tighten the locknut clockwise until the Maximum Locknut Adjustment is achieved in Table 2. When tightening the locknut, be sure to check the sleeve to make sure it does not turn on the shaft.

6. Secure Locknut – To secure the locknut from coming loose during operation, tighten the two radial setscrews positioned in the locknut to the following recommended seating torque with a hex type torque wrench. If one of the setscrews is lined up with the slot in the adapter sleeve, tighten the locknut clockwise until the setscrew clears the slot in the adapter sleeve. An alternate method for tightening these set screws is to use a hex wrench. Tighten the setscrew until the wrench takes a permanent twisting set.

While tightening the setscrews, the color of the indicator may change, become darker, lighter, or completely clear. This is acceptable as the bearing has already been properly tightened.

Table 3 - Locknut Setscrew Seating Torque

Shaft Size in	Seating Torque in - lbs
1 15/16	87 - 92
2 3/16	
2 3/8 – 2 7/16	
2 11/16 – 2 15/16	165 - 185
3 3/16 – 3 7/16	
3 11/16 – 3 15/16	290 - 325
4 3/16 – 4 7/16	
4 15/16	

7. Tighten the Floating Bearing - Center the floating bearing cartridge in the housing. Tighten the bearing to the shaft following the same procedure for the fixed bearing.

REMOVAL

Back out the locknut setscrews, then loosen the locknut in a counter-clockwise direction until the adapter assembly becomes completely loose. The bearing should slide freely along the shaft.

INSTALLATION

TWO FIXED UNITS

When installing two fixed units on a shaft, special precautions need to be taken.

If you are installing two fixed pillow block units, tighten the mounting bolts of the first unit, then install it as shown in the INSTALLATION section. Install the second bearing as normal, then tighten its mounting bolts last. This ensures that the axial take-up of the adapter is compensated by the clearance in the mounting bolt holes.

If you are installing two fixed flange units, tighten the mounting bolts of the first unit and install as normal. Snug up the mounting bolts on the second unit. Now go through the INSTALLATION procedure to take out the adapter assembly looseness for the second bearing. After reaching a snug fit for the locknut, loosen the mounting bolts enough to allow for housing movement away from the mounting base. Housing movement should equal the required shim stock thickness shown in Table 4.

When using in a cartridge application and your equipment does not have the ability to provide floating capability, consult factory.

Table 4 - Shim Stock Thicknesses

Shaft Size Range – in		Shim Stock in
From	To	
1 15/16	2 3/16	.056
2 3/8	2 7/16	.063
2 11/16	2 15/16	.063
3 3/16	3 7/16	.080
3 11/16	3 15/16	.080
4 3/16	4 7/16	.094
4 15/16	_	.100

Now complete the installation of the second bearing. Once the second bearing has been mounted, place shim stock underneath each bolt pad between the housing base and the structure. Place the shim stock adjacent to each bolt on two sides about the shaft of the bolt to allow for uniform pressure under each bolt pad. Tighten housing mounting bolts to complete the installation.

BEARING UNIT REPLACEMENT

Disassembly

1. Remove adapter sleeve and locknut
2. Remove seals
3. Remove MICROLOCK screw and key. (Do not loose nylon washer)
4. Remove threaded cover by turning counter clockwise
5. Place housing threaded cover side down on arbor press with spacer blocks under housing
6. Place a soft metal bar or wood block on face of inner ring and press bottom outer ring and inner ring assembly from housing
7. To remove the back outer ring, large bore bearings 4 7/16" thru 7" have drive pin holes. The back outer ring of smaller size units may be removed with a bearing puller or hammer and drift.

Reassembly

1. Place housing cover side up on arbor press with spacer blocks under housing.
2. Press in back outer ring and seat against housing shoulder.
3. Insert inner ring assembly and rotate to seat rollers against back outer ring.
4. Press in front outer ring.
5. Install threaded cover, turning clockwise until inner ring resists rotation or misalignment.
6. Back off threaded cover one quarter turn – align cover slot with the nearest counter bored hole in housing. See Table 5 - ADJUSTMENT TABLE.
7. Install microlock key with nylon washer under the head of the screw.
8. Using a soft drift or block, rap face of inner ring on side opposite threaded cover to seat front outer ring. Inner ring assembly should rotate freely.
9. Install seals. Z-Seal – Place centering spring in seal groove with fingers facing up. Place U-shaped element on fingers. Place centering ring on element with projection on face up. Install snap ring so that projection on centering ring is between ends of snap ring. K-Seal – Place seal into the seal groove with anti rotation boss sticking up. Install snap ring so that the raised boss is between the snap ring ends. M-Seal – Place seal into seal groove with spring facing out. No snap ring is required with M-Seal.
10. Mount the bearing to the shaft per standard mounting instructions starting at Step 1, Page 1.
11. Lubricate bearing with amount of grease shown in Table 6 - LUBRICATION TABLE. Rotate inner ring assembly during lubrication to assure distribution of grease in bearing

Table 5 - Adjustment Table (AXIAL AND RADIAL CLEARANCES)

Size Code	SHAFT SIZE (INCHES)	FACTORY ADJUSTMENT (Average Speeds)		RECOMMENDED ADJUSTMENT HIGH SPEEDS			CLEARANCE ADJUSTMENT INCHES PER 1/12 TURN	
	6000 SERIES	STD AXIAL CLEARANCE	STD RADIAL CLEARANCE	SPEED OVER	AXIAL CLEARANCE	RADIAL CLEARANCE	AXIAL	RADIAL
2-4	……	.007-.012	.0022-.0037	2000	.012-.017	.0037-.0053	0.005	0.0016
5-6	1 15/16	.007-.012	.0020-.0034	1500	.012-.017	.0034-.0049	0.005	0.0014
7-9	2 3/16 – 2 15/16	.010-.017	.0026-.0044	1250	.017-.024	.0044-.0062	0.007	0.0018
10-11	3 3/16 – 3 15/16	.010-.017	.0025-.0043	1000	.017-.024	.0043-.0060	0.007	0.0018
12-13	4 3/16 – 4 15/16	.015-.025	.0032-.0054	750	.025-.035	.0054-.0076	0.010	0.0022

LUBRICATION

Rexnord® adapter mounted spherical roller bearing units are prelubricated. No additional lubricant is required for startup. As a precaution, if equipment is to be built and left idle for any period of time prior to actual use, the units should be filled 100% full to provide maximum protection from corrosion, etc. The bearing's inner ring should also be rotated every 6 months.

The specific conditions on an application such as exact hours of operation, temperature, moisture, speed and dirt govern the required lubrication cycle. A proper lubrication cycle can be determined by inspection of the flushed out lubricant during a trial period of operation. Add grease slowly. Use a sufficient volume of grease to purge the bearing seals of old lubricant. It is preferable to rotate bearings during relubrication where good safety practice permits.

Inspection of bearing installations at least every six months is recommended. Any unusual noise or vibration change should be immediately investigated. The suggested relubrication schedule in the following table is a general guide.

Table 6 - Lubrication Table

SHAFT SIZE inches	GREASE WT. REQUIRED (OZ.)		RECOMMENDED NUMBER OF MONTHS BETWEEN RELUBRICATION INTERVALS. (BASED ON 40 HR. WK.)					
			RPM					
	To Lubricate Rebuilt Units	To Relubricate Units	100	300	500	1000	1750	3000
1 15/16	.9	.2	8	5	3	1	1/2	---
2 3/16	1.1	.2						
2 3/8 – 2 7/16	1.5	.3						
2 11/16 – 2 15/16	2.8	.5						
3 3/16 – 3 7/16	3.7	.6	6	4	2	1	1/2	---
3 11/16 – 3 15/16	6.9	1.1						
4 3/16 – 4 7/16	8.4	1.5						
4 15/16	14.3	2.5	4	2	1	1/2	---	---

*Relubrication amounts and frequencies shown in the table are based on standard clearances, moderate loads, etc., which yield housing temperatures of 150° F or less. Lubrication practices indicate that the relubrication frequency should be doubled every 20° F above 150° F. Rexnord® Bearing Division cannot be held responsible for performance of individual batches of grease. Changes in lubricant specifications, performance, and lubricant guarantees are the responsibility of the lubricant manufacturer.

INTERNAL CLEARANCE ADJUSTMENT FOR HIGH SPEEDS

Before adjusting bearing clearance, please contact Rexnord® tech service at 866-REXNORD. To adjust bearing clearance for speeds greater than illustrated in Table 5, the threaded cover must be backed off. Using a grease pencil or marker, draw a line on the housing face at one of the notches on the cover. Using a screwdriver, back off the micro-lok screw and tab that locks the cover. Using a drift pin or screwdriver and hammer, drive the threaded cover in a counter-clockwise rotation until the next closest notch in the cover aligns with the mark on the housing. Check alignment of the micro-lok setscrew and tab to make sure it fits in the notch of the cover. If not, tap the threaded cover to align the notch. Re-tighten the micro-lok setscrew and tab. The bearing now has the increased clearance needed to run at the higher speeds and temperatures.

LIMITED WARRANTY - LIABILITY

A. IT IS EXPRESSLY AGREED THAT THE FOLLOWING WARRANTY IS GIVEN IN LIEU OF ALL OTHER WARRANTIES, WHETHER EXPRESSLY IMPLIED OR STATUTORY, INCLUDING THOSE OF **MERCHANTABILITY** AND FITNESS FOR A PARTICULAR PURPOSE, AND OF ANY OTHER OBLIGATION OR LIABILITY ON OR PART OF ANY KIND OR NATURE WHATSOEVER.

No representative of ours has any authority to waive, alter, vary, or add to the terms hereof without prior approval in writing, to our customer, signed by an officer of our company. It is expressly agreed that the entire warranty given to the customer is embodied in this writing. This writing constitutes the final expression of the parties' agreement with respect to warranties, and that it is a complete and exclusive statement of the terms of the warranty.

We warrant to our customers that all Products manufactured by us will be free from defects in material and workmanship at the time of shipment to our customer for a period of **two (2) years** from the date of shipment. All warranty claims must be submitted to us within ten days of discovery of defects within the warranty period, or shall be deemed waived. As to Products or parts thereof that are proven to have been defective at the time of shipment, and that were not damaged in shipment, the sole and exclusive remedy shall be repair or replacement of the defective parts or repayment of the proportionate purchase price for such Products or parts, at our option. Replacement parts shall be shipped free of charge f.o.b. from our factory.

This warranty shall not apply to any Product which has been subject to misuse; misapplication, neglect (including but not limited to improper maintenance and storage); accident, improper installation, modification (including but not limited to use of unauthorized parts or attachments), adjustment, repair or lubrication. Misuse also includes, without implied limitation, deterioration in the Product or part caused by chemical action, wear caused by the presence of abrasive materials, and improper lubrication. Identifiable items manufactured by others but installed in or affixed to our Products are not warranted by us but, bear only those warranties, express or implied, given by the manufacturer of that item, if any.

Responsibility for system design to insure proper use and application of Rexnord Products within their published specifications and ratings rests solely with customer. This includes without implied limitation analysis of loads created by torsional vibrations within the entire system regardless of how induced.

B. It is expressly agreed that our liability for any damage arising out of or related to this transaction, or the use of our Products, whether in contract or in tort, is limited to the repair or replacement of the Products, or the parts thereof by us, or to a refund of the proportionate purchase price. We will not be liable for any other injury, loss, damage, or expense, whether direct or consequential, including but not limited to loss of use, income, profit, production, or increased cost of operation, or spoilage of or damage to material, arising in connection with the sale, installation, use of, inability to use, or the replacement of, or late delivery of, our Products.

C. It is also expressly agreed that any cause of action for breach of any warranty must be brought within one year from the date of the breach.

Rexnord Industries, LLC
Industrial Bearing Group
2400 Curtiss Street
Downers Grove, IL 60515

Series 200, 300, 3-U200, 3-Y200, 3-W200, U200, Y200, W200, U300 and Y300

Link-Belt® Ball Bearing Units Service Instructions B-BBU-22

IMPORTANT — Read Carefully

These instructions are provided to aid in the proper installation, operation and maintenance of Link-Belt Series 200, 300, 3-U200, 3-Y200, 3-W200, U200, Y200, W200, U300 and Y300 ball bearing units. They should be carefully read and followed. Failure to do so may result in unsatisfactory service as well as serious personal injury or property damage.

U200 series ball bearing units up to and including 2 7/16 inch shaft size are secured to the shaft with two setscrews threaded into the inner ring. Larger size U200 series and all U300 series units are equipped with spring locking collars having two setscrews. All W200, Y200, and Y300 series ball bearing units feature eccentric locking collars with one setscrew.

CAUTION

The reliability built in all Link-Belt bearings can be realized in service only when they are correctly selected, properly installed, protected and maintained.

The correct selection of bearings or mounted units requires that the magnitude and nature of all loads, speeds, alignment, mounting, operating requirements and maintenance be adequately considered. The selection of materials for and design of housings, shafting, fasteners, seals and accessories as well as provisions for installation and maintenance must follow good engineering principles.

When axial (thrust) loads are present, shaft collars or other means may be required to transmit the thrust from the shaft to the inner ring and prevent the bearing from slipping axially on the shaft.

Housings must be selected and installed with regard to the degree and direction of the forces that will occur. Housings should not be used under tension loads except with adequate safety factors. For this reason pillow blocks are best suited to withstand radial loads passing through the base. When heavy loads or shock loads are possible, it is most important to mount a unit so that the line of force passes directly into its base, or so that the unit is directly and substantially supported other than through its mounting bolts. Where the line of force falls outside the base, such as with horizontal or uplift loads on pillow blocks, serious housing and fastener deflection or failure may occur. These conditions may require designs using different materials, fasteners, mounting design, stop bars, etc., together with proper safety factors. When these conditions are unavoidable, Link-Belt Bearing Division should be consulted.

The following points of installation and operation are very important:

A. Cleanliness — Keep dirt, water, and metal chips off all parts.

B. Careful Handling — Hammer blows or improper use of force can damage precision parts.

C. Shaft Fits — Bearings should have proper fits on the shafts to minimize fret wear. See installation instructions for shaft tolerances. When mounting bearings on a used or worn shaft, care must be taken to clean up the shaft journal and rebuild, as necessary, to the required tolerances. Never replace bearings on a shaft which is bent or which has been damaged or softened by a torch.

D. Bolts — Housing mounting bolt tightness is important to prevent the housing from shifting, and to adequately support loads.

E. Collars and Setscrews — Eccentric cam locking collars must be securely tightened in the direction of shaft rotation with the setscrew locked, and setscrews in spring locking collars or in setscrew mounted bearings must be properly torqued to prevent the shaft from slipping in the inner ring and to prevent loosening during operation.

F. Free Rotation and Alignment — Check for free rotation before machine start-up to assure that final alignment is proper. Although bearings are alignable in housings, they will not "self-align" in many cases and destructive moment loads may be imposed if initial installation alignment is not provided.

G. Lubrication — Units designed for relubrication must be adequately lubricated. A bearing not properly lubricated can run to destruction and possibly cause damage to other components. Add grease slowly. Rapid application may blow the seals and allow the grease to escape.

H. Temperature — Certain components of these units are made from materials which have temperature limits. Unless units are specifically made for high temperature applications, operating temperatures must not exceed 225°F for units with E, E2, N, U, or housing felt seals, or 275°F for units with H seals.

INSTALLATION

1. **Check Shaft** — Shafting must be clean, round, straight, free of burrs and nicks and of correct size.

   For most operating conditions with low to moderate loads and speeds, the following shaft tolerances are recommended:

Shaft Diameter	Recommended Tolerance
1/2" thru 2"	Nominal to minus .0005"
2 1/16" thru 4"	Nominal to minus .0010"

   Satisfactory performance may be obtained with increased shaft tolerances under some less severe conditions. Very difficult applications may require a light interference fit of the bearing on the shaft. Consult Link-Belt Bearing Division for recommendations.

2. **Shaft Preparation** — When frequent removal of bearings is anticipated, file flats on the shaft approximately 1/16" deep under the setscrew locations. This provides for easy removal, as bearings will clear the burrs caused by correctly tightened setscrews.

3. **Lubricate Shaft & Bearing Bore** — Coat the shaft and bearing bore with grease or oil to facilitate assembly.

4. **Assemble on Shaft** — If it is necessary to tap or press units on the shaft, use a hardwood block, soft steel bar or tube against the end of the inner ring. DO NOT strike or exert pressure on housing or seals.
   Setscrew Mounted Units — Back out all setscrews to clear the shaft and slide the units into position on the shaft.
   Spring Locking Collar Units — Back out all collar setscrews to clear the shaft and slide the units into position on the shaft.
   Eccentric Cam Locking Collar Units — Slide each unit into position on the shaft with the cam locking collar positioned for engagement with the inner ring cam.

5. **Preliminary Unit Location** — With both bearing units on the shaft, preliminarily locate the shaft in position. Lightly bolt the units to the mounting structure. SAE Grade 5 mounting bolts can be used. Bridge over housing mounting bolt slots with heavy flat washers. The use of heavy spring lockwashers under bolt heads and nuts is good practice to prevent loosening.

6. **Final Positioning** — Establish the final shaft position. Align the bearing units by hand, if required, or use a shaft or a rubber mallet. Securely bolt both

TABLE 1 — Inner Ring and Collar Setscrew Tightening Torque

Shaft Size (in.)	Seating Torque (in-lbs.) W200	Y200	U200	U300	Y300
1/2 to 11/16	87 - 92	87 - 92	33 - 40	33 - 40	
3/4	87 - 92	87 - 92	87 - 92	33 - 40	
13/16 to 1	87 - 92	87 - 92	87 - 92	87 - 92	
1-1/16 to 1-3/16	165-185	165-185	87 - 92	165-185	290-325
1-1/4 to 1-7/16	290-325	290-325	165-185	165-185	290-325
1-1/2 to 1-9/16	290-325	290-325	165-185	165-185	
1-5/8 to 1-3/4	290-325	290-325	165-185	290-325	430-460
1-13/16 to 1-15/16	290-325	290-325	290-325	290-325	620-680
2 to 2-3/16		430-460	290-325	430-460	620-680
2-1/4 to 2-7/16		430-460	290-325	430-460	620-680
2-1/2 to 2-11/16			430-460	620-680	1225-1350
2-3/4 to 2-15/16			620-680	620-680	2125-2350
3 to 3-1/2			620-680	1225-1350	
3-9/16 to 3-3/4			1225-1350	1225-1350	
3-13/16 to 4			1225-1350	2125-2350	

Note: Satisfactory tightness may be obtained by using a standard hex wrench (50-52 Minimum RHN C) and tightening until a slight permanent twist is obtained in wrench for each setscrew.

units to the mounting structure by correctly torquing the bolts.

7. **Locking The Bearings** — Before the collars or setscrews are tightened, it should be possible to axially move the shaft by hand thru the bearings bores. If this cannot be done, repeat step 6. When satisfied, lock one bearing to the shaft. If one unit is an expansion type, lock the fixed bearing first.

   Setscrew Mounted And Spring Locking Collar Units - Tighten both setscrews to the seating torque values in table 1, or, using a good quality individual hex wrench, tighten each setscrew until a slight permanent twist is attained in the shank of the wrench.

   Eccentric Cam Locking Collar Units - Engage the collar on the inner ring cam. Rotate the collar in the direction of shaft rotation until it becomes tight using a hammer and a drift pin, continue tightening until solid. Tighten the setscrew.

   Rotate the shaft a few revolutions to center the bearings. Locate expansion units in the center of their axial movement. Tighten the setscrews or collars on the remaining unit using the same method.

8. **Tabbed End Closure Installation - For YG300 & UG300 only** — Insert the end closure tabs into the housing loading slots. Tap on the end closure face by hand or with a rubber mallet until the end closure seats against the housing. Fill the gap between the end closure outer diameter and housing bore with a bead of silicone sealant/ adhesive.

9. **Check for Noise, Freedom of Rotation Or Vibration** — Any condition of strain, irregular rotational torque, abnormal sound or vibration should be investigated. Look for improper alignment, out-of-balance, bent shaft, distorted or weak supports, broken welds, etc. Installation should be rechecked and corrected as required.

The use of stop bars welded to the support at each end of units leaving about 1/32" space after units are securely fastened. These bars assure proper location of the units and prevent shifting when loads are applied.

LUBRICATION

Units are prelubricated. With relubricatable designs no additional lubricant is required for startup. As a precaution, if equipment is to be built and left idle for any period of time prior to actual use relubricatable bearings should be filled 100% full to provide maximum protection from corrosion, etc. The suggested relubrication schedule under Table 2 is a general guide.

The specific conditions on an application such as exact hours of operation, temperature, moisture, speed and dirt govern the required lubrication cycle. This can be determined by inspection of the flushed out lubricant during a trial period of operation. Add grease slowly. Use a sufficient volume of grease to purge the bearing seals of old lubricant. It is preferable to rotate bearings during relubrication where good safety practice permits. Inspection of bearing installations at least every six months is recommended. Any unusual noise or vibration change should be immediately investigated.

TABLE 2 — Grease Lubrication

OPERATING ENVIRONMENT		Bearing Operating Temperature	Greasing Interval (1)	Use Grease Equivalent to these (2)
Dirt Exposure	Moisture Exposure			
Slight	None	32°F to 120°F	6 months	High quality NLGI No. 2 multi-purpose ball bearing greases are generally satisfactory. Consultation with a reputable lubricant supplier is recommended.
		120° to 160°F	2-4 months	
		160°F to 200°F	1-2 months	
Moderate to Heavy		32°F to 160°F	1-4 weeks	
		160°F to 200°F	1 week	
Slight to Heavy	Direct water splash or exposure to outdoor environment	32°F to 200°F	Daily to 1 week or as determined by inspection of installation	Mobil Oil Corp., Mobilith AW 2 Shell Oil Co., Alvania EP 2 Texaco Inc., Premium RB 2
Slight	None	-60°F to 32°F	Determined by inspection of installation	Shell Oil Co., Aeroshell 7A Mobil Oil Corp., Mobiltemp SHC 32
		above 200°F		Special lubrication and seals may be required.

(1) Frequency of regreasing will vary, depending on the hours of operation, temperature and surrounding conditions.
(2) Do not use dibasic ester type lubricants without consulting Link-Belt Bearing Division, which can provide assistance in selection of lubricants given knowledge of operating conditions.
Link-Belt Bearing Division cannot be held responsible for performance of individual batches of grease. Changes in lubricant specifications, performance, and lubricant guarantees are the responsibility of the lubricant manufacturer.

LIMITED WARRANTY — LIABILITY

A. IT IS EXPRESSLY AGREED THAT THE FOLLOWING WARRANTY IS GIVEN IN LIEU OF ALL OTHER WARRANTIES, WHETHER EXPRESS, IMPLIED OR STATUTORY, INCLUDING THOSE OF **MERCHANTABILITY** AND FITNESS FOR A PARTICULAR PURPOSE, AND OF ANY OTHER OBLIGATION OR LIABILITY ON OUR PART OF ANY KIND OR NATURE WHATSOEVER.

No representative of ours has any authority to waive, alter, vary or add to the terms hereof without prior approval in writing, to our customer, signed by an officer of our company. It is expressly agreed that the entire warranty given to the customer is embodied in this writing; that this writing constitutes the final expression of the parties' agreement with respect to warranties; and that it is complete and exclusive statement of the terms of the warranty.

We warrant to our customers that all Products manufactured by us will be free from defects in material and workmanship at the time of shipment to our customer for a period of one (1) year from the date of shipment. All warranty claims must be submitted to us within ten days of discovery of defects within the warranty period, or shall be deemed waived. As to Products or parts thereof that are proven to have been defective at the time of shipment, and that were not damaged in shipment, the sole and exclusive remedy shall be repair or replacement of the defective parts or repayment of the proportionate purchase price for such Products or parts, at our option. Replacement parts shall be shipped free of charge f.o.b. our factory.

This warranty shall not apply to any Product which has been subject to misuse; misapplication, neglect (including but not limited to improper maintenance and storage); accident; improper installation, modification (including but not limited to use of unauthorized parts or attachments), adjustment, repair or lubrication. Misuse also includes, without implied limitation, deterioration in the Product or part caused by chemical action, wear caused by the presence of abrasive materials, and improper lubrication. Identifiable items manufactured by others but installed in or affixed to our Products are not warranted by us but, bear only those warranties, express or implied, given by the manufacturer of that item, if any.

Responsibility for system design to insure proper use and application of Link-Belt Products within their published specifications and ratings rests solely with customer. This includes without implied limitation analysis of loads created by torsional vibrations within the entire system regardless of how induced.

B. It is expressly agreed that our liability for any damages arising out of or related to this transaction, or the use of our Products, whether in contract or in tort, is limited to the repair or replacement of the Products, or the parts thereof by us, or to a refund of the proportionate purchase price. We will not be liable for any other injury, loss, damage or expense, whether direct or consequential, including but not limited to loss of use, income, profit, production, or increased cost of operation, or spoilage of or damage to material, arising in connection with the sale, installation, use of, inability to use, or the replacement of, or late delivery of, our Products.

C. It is also expressly agreed that any cause of action for breach of any warranty must be brought within one year from the date of the breach.

Link-Belt Bearing Division
Rexnord Corporation
7601 Rockville Road, Box 85, Indianapolis, Indiana 46206

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Stock Carrying Distributors and Representatives Throughout the World

Link-Belt®

Fan and Blower Bearing

Ball Bearing Unit

Rexnord proudly introduces a newly designed bearing, utilizing a high-speed design and characteristics essential for the air handling industry.

The Link-Belt Fan and Blower bearing is a standard duty bearing that is powder coated cast iron, to handle the harshest environments.

Accurate alignment of the double ball bearing design, along with super-finished raceways allows for high-speed operation.

Link-Belt's Centrik-Lok CL design features eight gripping tabs to solve the toughest shaft mounting problems. Its unique split collar design utilizes a high-strength socket head cap screw for secure and easy installation. The locking collar yields superior axial holding force. This innovative design provides 20% greater gripping force than the next best competitor.

Key Industries
Air Handling

Housing
- 4-bolt pillow block
- 2 bearings – one housing secured with snap rings
- Perfect alignment
- Bolt-in-place

Shaft Sizes
- 15/16" - 2 7/16"

Accommodates Commercial Grade Shafting
- 1/2" – 2" nominal to -.003"
- 2 1/8" – 2 7/16" nominal to -.004"

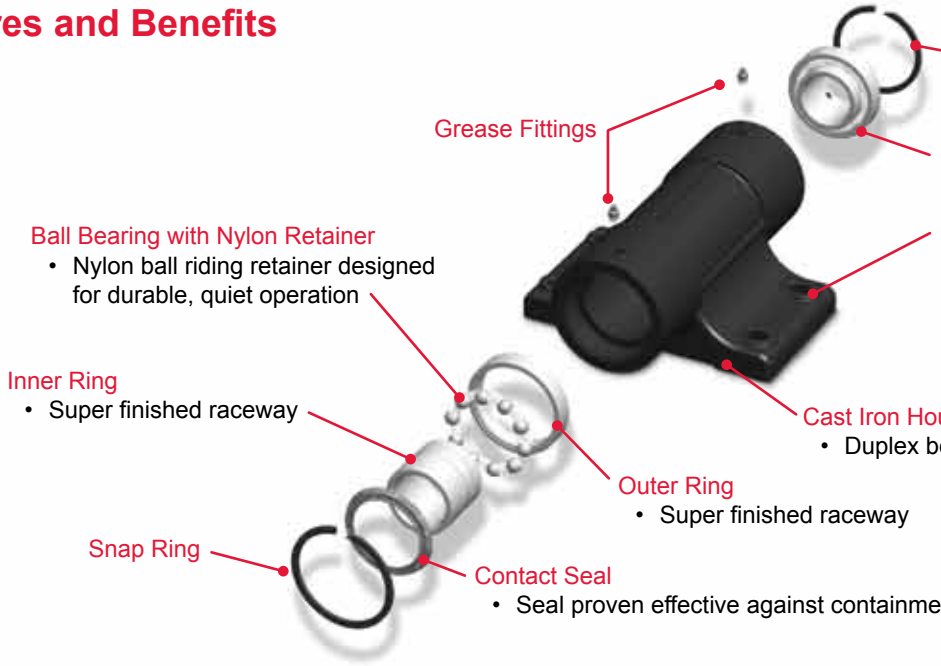
Mounting Type
- Centrik-Lok
- Set-screw
- Eccentric Cam Locking Collar

General Bearing Information
- Races – precision-ground and super-finished
- Housings – powder-coated cast iron
- Grease – multi-purpose lithium complex
- Centrik-Lok CL: Black Oxide – corrosion resistance
- Standard seal – single lip contact with flingers (N)
- Optional seals available
- H – Labyrinth clearance seal
- E3 – Triple-lip seal

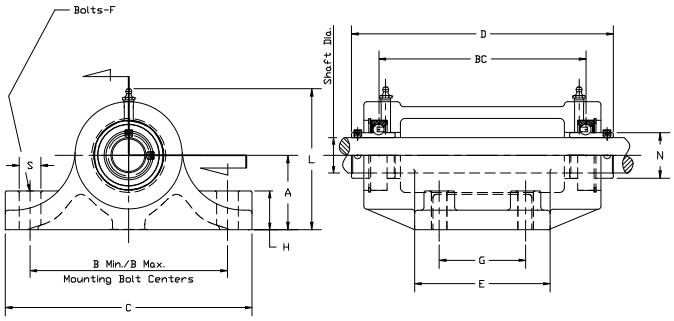
Centrik-Lok Unit

REXNORD

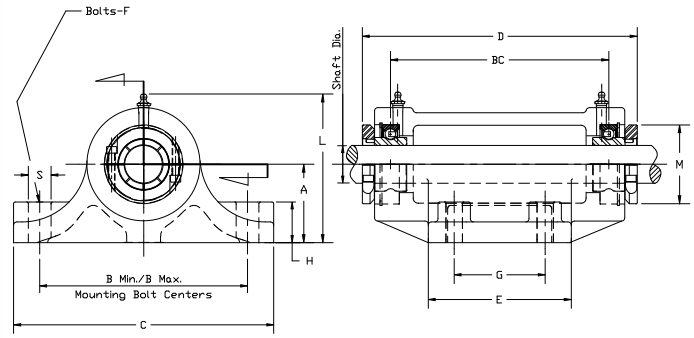
Features and Benefits



Set-Screw



Centrik-Lok CL



Set-Screw Dimensions

Shaft Diameter	Part Number	A	Bmin	Bmax	BC	C	D	E	F	G	H	L	N	S	Wt. (lbs)	Insert Bearing Number	Dodge Equivalent	Fafnir DRNR
15/16	PPU215N	2 1/2	6 1/16	6 7/16	6 17/64	7 3/4	7 7/8	4 1/4	3/8	2 3/4	7/8	4 5/8	1.313	5/8	16	UB215XN	F&B-CC-015	1015KR
1-3/16	PPU219N	2 1/2	6 1/16	6 7/16	6 3/32	7 3/4	8	4 1/4	3/8	2 3/4	7/8	4 5/8	1.587	5/8	16	UB219XN	F&B-CC-103	1103KR
1-7/16	PPU223N	3	7 3/4	8 1/4	8 21/32	10	10 7/8	5 1/2	1/2	3 1/2	1	5 11/16	1.847	7/8	36	UB223XN	F&B-CC-107	1107KR
1-11/16	PPU227N	3	7 3/4	8 1/4	8 33/64	10	11	5 1/2	1/2	3 1/2	1	5 11/16	2.281	7/8	36	UB227XN	F&B-CC-111	1111KR
1-15/16	PPU231N	3 1/2	9 1/8	9 7/8	11 11/32	12	13 7/8	7	5/8	4 1/2	1 1/4	6 25/64	2.475	1 1/8	60	UB231XN	F&B-CC-115	1115KR
2-3/16	PPU235N	3 1/2	9 1/8	9 7/8	11 11/32	12	14 5/32	7	5/8	4 1/2	1 1/4	6 25/64	2.749	1 1/8	56	UB235XN	F&B-CC-203	1203KR
2-7/16	PPU239N	3 1/2	9 1/8	9 7/8	11 3/8	12	14 1/2	7	5/8	4 1/2	1 1/4	6 19/32	3.012	1 1/8	65	UB239XN	F&B-CC-207	NA

Centrik-Lok CL Dimensions

Shaft Diameter	Part Number	A	Bmin	Bmax	BC	C	D	E	F	G	H	L	M	S	Wt. (lbs)	Insert Bearing Number	Dodge Equivalent
15/16	PPCL215N	2 1/2	6 1/16	6 7/16	6 17/64	7 3/4	8	4 1/4	3/8	2 3/4	7/8	4 5/8	2 5/64	5/8	16	CLB215XN	F&B-DL-015
1-3/16	PPCL219N	2 1/2	6 1/16	6 7/16	6 3/32	7 3/4	7 7/8	4 1/4	3/8	2 3/4	7/8	4 5/8	2 15/32	5/8	16	CLB219XN	F&B-DL-103
1-7/16	PPCL223N	3	7 3/4	8 1/4	8 21/32	10	10 11/16	5 1/2	1/2	3 1/2	1	5 11/16	2 7/8	7/8	36	CLB223XN	F&B-DL-107
1-11/16	PPCL227N	3	7 3/4	8 1/4	8 33/64	10	10 59/64	5 1/2	1/2	3 1/2	1	5 11/16	3 17/64	7/8	36	CLB227XN	F&B-DL-111
1-15/16	PPCL231N	3 1/2	9 1/8	9 7/8	11 11/32	12	13 61/64	7	5/8	4 1/2	1 1/4	6 25/64	3 5/8	1 1/8	60	CLB231XN	F&B-DL-115
2-3/16	PPCL235N	3 1/2	9 1/8	9 7/8	11 11/32	12	14	7	5/8	4 1/2	1 1/4	6 25/64	3 29/32	1 1/8	56	CLB235XN	F&B-DL-203
2-7/16	PPCL239N	3 1/2	9 1/8	9 7/8	11 3/8	12	14 35/64	7	5/8	4 1/2	1 1/4	6 19/32	4 3/16	1 1/8	65	CLB239XN	F&B-DL-207

Load Ratings, Speed Limits

Shaft Diameter (in)	Std. Unit U200 Series Inserts P/N	Concentric Mount Unit Centrik-Lok CL CL200 Series Inserts P/N	Static Load Rating (lbs)	Basic Dynamic Load Rating (lbs)	Catalog Speed (rpm)
15/16	UB215XN	CLB215XN	1,760	3,150	6,800
1 3/16	UB219XN	CLB219XN	2,530	4,380	5,600
1 7/16	UB223XN	CLB223XN	3,440	5,780	4,800
1 15/16	UB231XN	CLB231XN	5,220	7,770	3,600
2 3/16	UB235XN	CLB235XN	6,570	9,760	3,200
2 7/16	UB239XN	CLB239XN	8,080	11,800	3,000

Note: The table values for Basic Dynamic Load rating should reduced by 23% for U200 series and 15% for CLB200 series bearings. The table shows the load ratings for a single insert bearing. When considering loading on a housing, the internal support loads for each bearing position must be determined.

For more information about Rexnord products, programs, and services, contact your Rexnord Customer Focus Team today at 866-REXNORD (866-739-6673).

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