



Horizontal Pump System —Candyne Paramount Carr (Skid serial # 021(-CA11, 021) -CA11)

Reference: HPS/RFQ-HPS-153928
Version: A
Release Date: 05-Jan-2011
EDMS UID:
Produced: 05-Jan-2011
Owner: Paramount

(Canada)

Private

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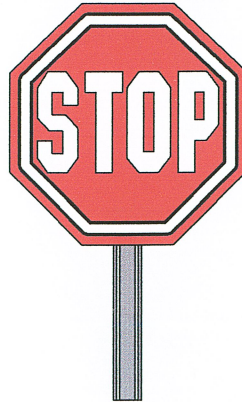
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Read The Following Before Starting This Equipment

DANGER

ALWAYS ground this equipment correctly
NEVER operate this equipment without safety guards
NEVER attempt to operate this piece of equipment at a ZERO FLOW condition
FOLLOW LOCK-OUT / TAG-OUT procedures when servicing this unit
DO NOT use piping or fittings that are damaged or have inadequate pressure ratings with this equipment

WARNING

ALWAYS follow correct start up procedure (see operators manual)
ALWAYS maintain pump flow and pressure within its recommended operating range (see operators manual)
CHECK that shaft clamps are removed prior to starting
ALWAYS lift from designated lifting points only
ALWAYS comply with recommended service intervals and use recommended lubricants
FAILURE to follow start up and operating procedures may void warranty

ADVISORY

NEVER operate this equipment without shutdown systems in place
USE a check valve (non-return valve) on the discharge to avoid 'back spinning' the pump
ALWAYS adjust valves slowly
IF OPERATING IN COLD CONDITIONS BEWARE OF LIQUID FREEZING IN PUMP

SLB QHSE STANDARDS



SLB QHSE S001.
Journey Management
and Driving



SLB QHSE S002. Event
Reporting and
Management



SLB QHSE S003.
Personal Protective
Equipment



SLB QHSE S004.
Business Continuity,
Emergency and Crisis
Management



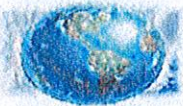
SLB QHSE S005.
Training and Competency



SLB QHSE S006. Health



SLB QHSE S007.
Management System
Audits



SLB QHSE S008.
Environment



SLB QHSE S009. Loss
Prevention Teams



SLB QHSE S010.
Management of Change
and Exemption



SLB QHSE S011.
Employee and Asset
Security



SLB QHSE S012.
Contracting



SLB QHSE S013.
Mechanical Lifting



SLB QHSE S014.
Pressure



SLB QHSE S015.
H2S



SLB QHSE S016.
Fire Prevention and
Mitigation



SLB QHSE S017.
Injury Prevention



SLB QHSE S018.
Radiation



SLB QHSE S019.
Explosives



SLB QHSE S020. Hazard
Analysis and Risk Control

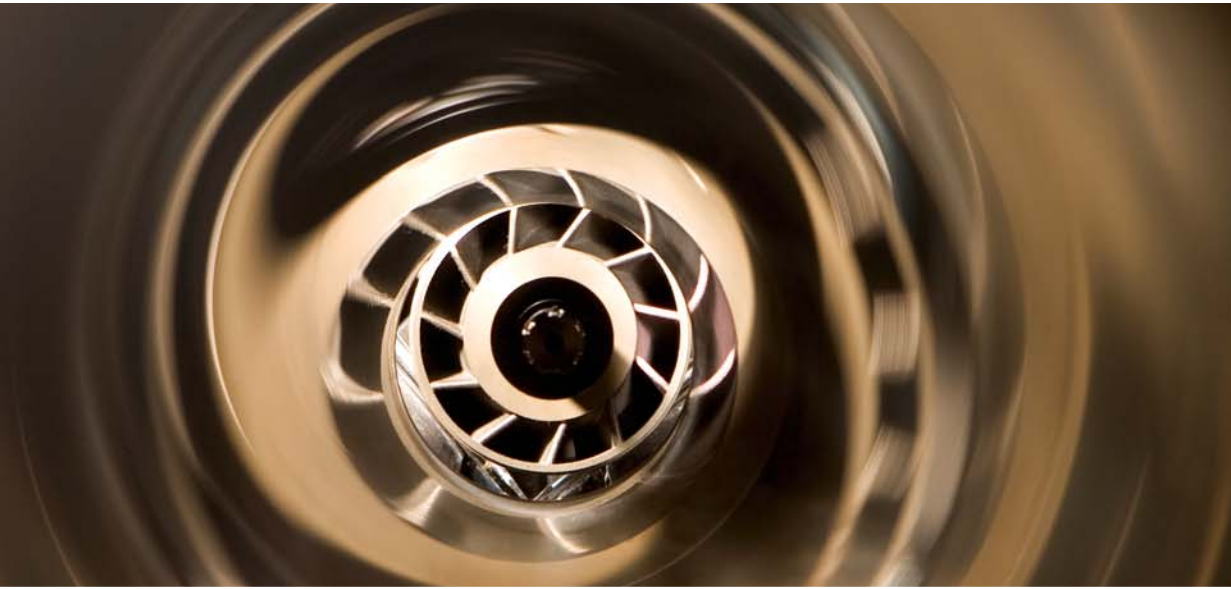


SLB QHSE S021. Data
Quality

Schlumberger



**Power you can count on
anytime, anywhere**



**RedaHPS Horizontal
Surface Pumping Systems**



The RedaHPS* horizontal multistage surface pumping system delivers power you can count on for your surface pumping applications.

The RedaHPS system has proved to be a long-term, cost-effective, low-maintenance alternative to conventional high-pressure pumps. RedaHPS pumps provide years of problem-free service in any environment, with packages customized for the harshest climates. From intense desert heat to extreme Arctic cold, our pumps keep the fluid moving.

The RedaHPS system uses the REDA* electric submersible pump (ESP) technology originally designed for harsh downhole pumping conditions.

These pumps offer exceptional performance in even the toughest operating environment and are designed to provide services for a wide range of surface applications. The durable and flexible units operate in applications varying from high-pressure water injection and crude-oil transfer to lean amine service, liquid natural gas (LNG) pumping, and refinery operations. No matter what the challenge, RedaHPS surface pumps perform—anytime, anywhere.



A POWERFUL PACKAGE

- 2,000 hp in a single unit
- 18,000 ft.lbf of thrust
- 1,850 galUS/min of flow
- 6,000 psi pressure rating

POCKET

A tradition of **dependability** and **power**

The RedaHPS horizontal multistage pump has a rich history of continuous product improvement, owing largely to quality assurance practices that were put in place soon after the REDA electric submersible pump system was awarded the original patent for ESPs worldwide. Since the 1940s, the RedaHPS pump series has been a reliable, cost-effective, flexible alternative to conventional pumping systems. The RedaHPS system is used today in a wealth of applications around the globe, from simple water injection and disposal to more complex refinery and offshore crude oil transfer and refinery pumping service. Cost-competitive and customizable for your specific needs, the RedaHPS equipment requires less inventory and delivery time than conventional equipment and has a lower life-cycle cost, thanks to minimized downtime and low maintenance requirements. The result is increased mean time between failures (MTBF), giving you a powerful pumping system you can count on.

■ Tradition

The RedaHPS series is the industry leader in ESP surface-style pumping equipment. With more than 60 years of experience, Schlumberger continues to build on a tradition of dependability and power.

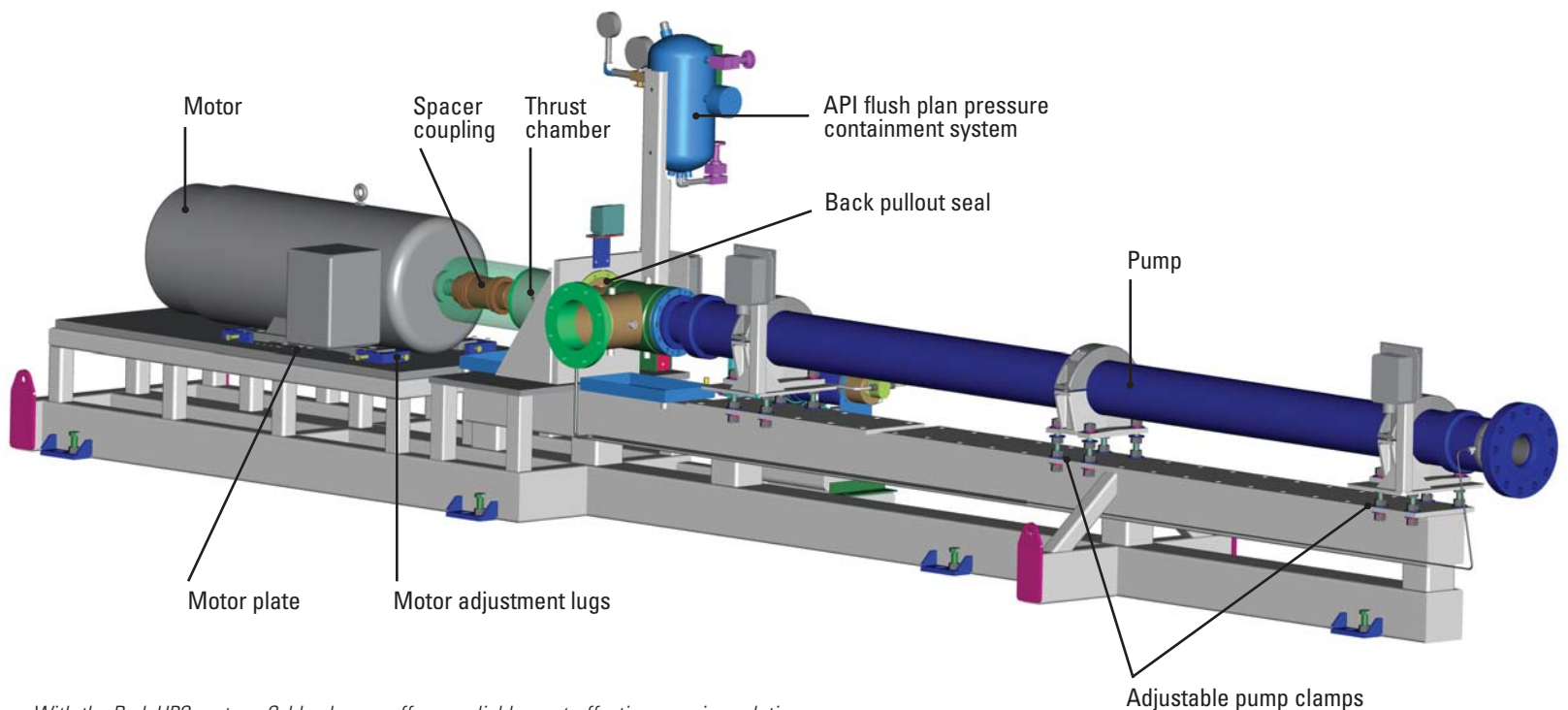
■ Dependability

The RedaHPS system incorporates flexible features and API 610 designs that maximize overall pump run life and minimize downtime. The pump's modular design enables easy modification whenever needed—all major components can be exchanged within 2 to 3 hours.

■ Power

The RedaHPS pumping system can deliver up to 2,000 hp in a single unit. Alternatively, multiple units can be configured in series or parallel to provide redundancy, additional volume, or pressure.

Cost-competitive and customizable for your specific needs



With the RedaHPS system, Schlumberger offers a reliable, cost-effective pumping solution that is delivered quickly and is flexible enough to be modified in the field. Features are built in to provide a low-maintenance, flexible, cost-effective system, including back pullout seals, spacer coupling, adjustable pump clamps, and an adjustable motor plate.

Reliable, flexible, modular design

APPLICATIONS

- Water injection and disposal
- Reservoir pressure maintenance
- Power fluid boost for hydraulic lift systems
- Coalbed methane fracturing
- Crude oil transfer
- Geothermal injection
- Effluent disposal
- Mine dewatering
- Lean amine charge
- Salt dome leaching
- LNG boosting and transfer
- Carbon dioxide boosting
- Boiler feedwater
- Pipeline boosting

PROVEN RELIABILITY AROUND THE WORLD

RedaHPS equipment is effective in both land-based and offshore installations. From the deserts of the Middle East to the tundra of Siberia and from the underground mines of Canada to the jungles of South America, RedaHPS units are working 24/7, giving years of dependable, trouble-free service.

SYSTEM FEATURES MEET A VARIETY OF NEEDS

The RedaHPS system is application-ready. Low-maintenance centrifugal pumps, boasting a field-friendly modular design, offer competitive pricing and delivery times for an array of applications. The API back-pullout feature means quick seal changes—which minimize downtime and protect the environment—and higher nozzle load capacity, which delivers on the promise of reliability and improved productivity.

In addition, the unit offers single, double, or triple thrust-bearing designs within one housing, with load capacity up to 18,000 ft.lbf for increased thrust loads. Optional motor frames and seal designs, adjustable clamps, and modular components set the RedaHPS equipment apart from conventional API 610 pumps and easily accommodate future modifications and upgrades. Minimal noise, vibration, and emissions make the RedaHPS pump a lower environmental risk as well.

MANUFACTURING AND TESTING CENTER REDUCES LEAD TIMES AND COSTS

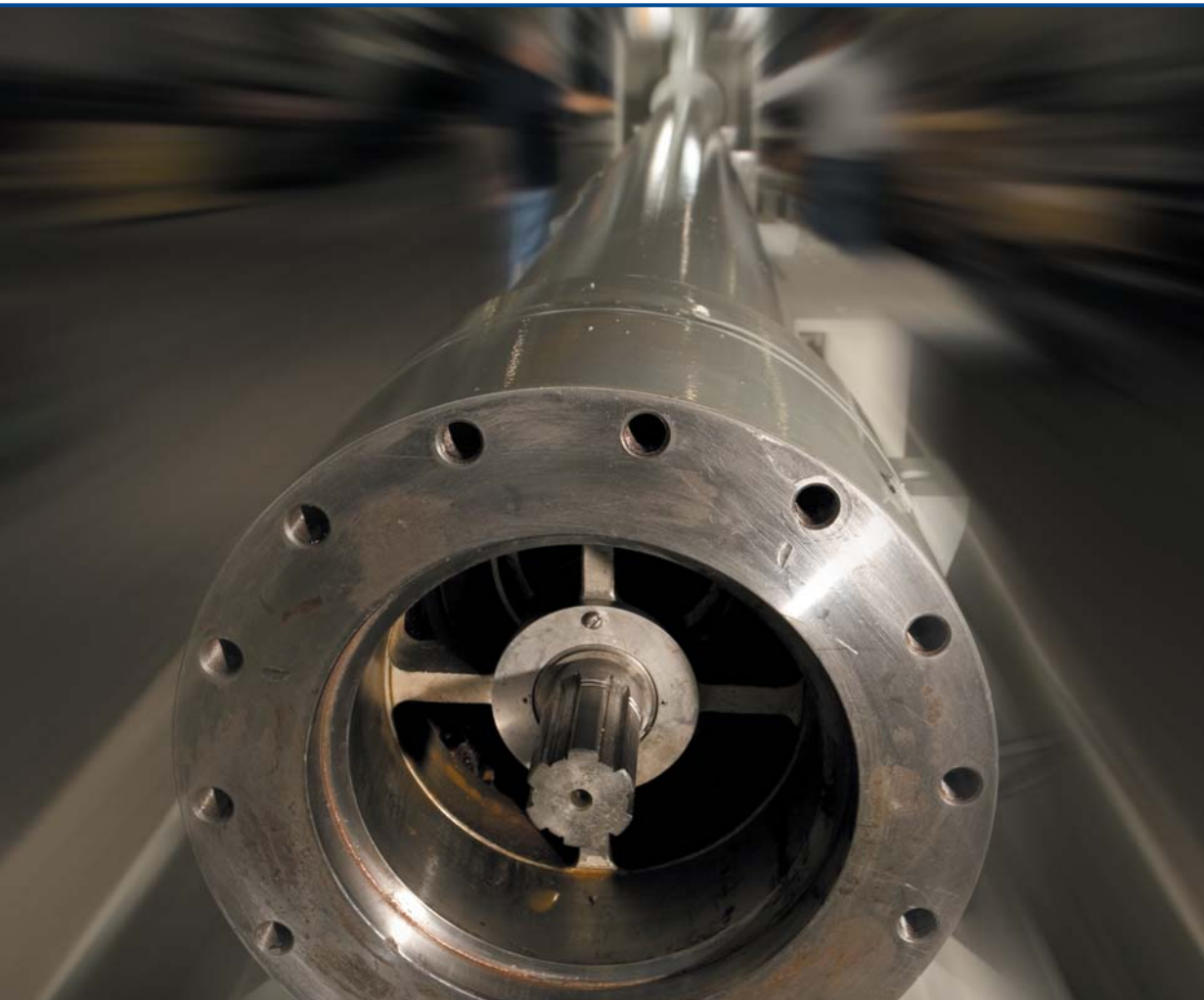
Rigorous testing at the Bartlesville Product Center (BPC) ensures that the RedaHPS system meets design specifications and exceeds industry standards. With its emphasis on quality, cost, and delivery, the new facility offers manufacturing and testing under one roof, significantly reducing production lead times and trimming costs. Using generators capable of 4 MW, the BPC can assemble and test units up to 2,000 hp at full load.

Quality at the source

Stringent testing of RedaHPS pumping equipment conducted at the BPC surpasses industry standards and assures production of a system that can reliably meet a host of customer needs.



RedaHPS Horizontal Surface Pumping Systems



Reliable, powerful,
cost-effective

RedaHPS pumps continue to gain recognition, thanks to competitive capital costs, superior MTBF, and reduced maintenance expense.

Choose the dependable RedaHPS horizontal multistage pumping system for your next high-pressure pump application.

www.slb.com/redahps

Schlumberger

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Design

1.1	Technical Design Data	_____	1-1
1.2	Pump Performance Data	_____	1-1

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Company: Paramount Resources Ltd.
Engineer: Gerardo Balmaceda

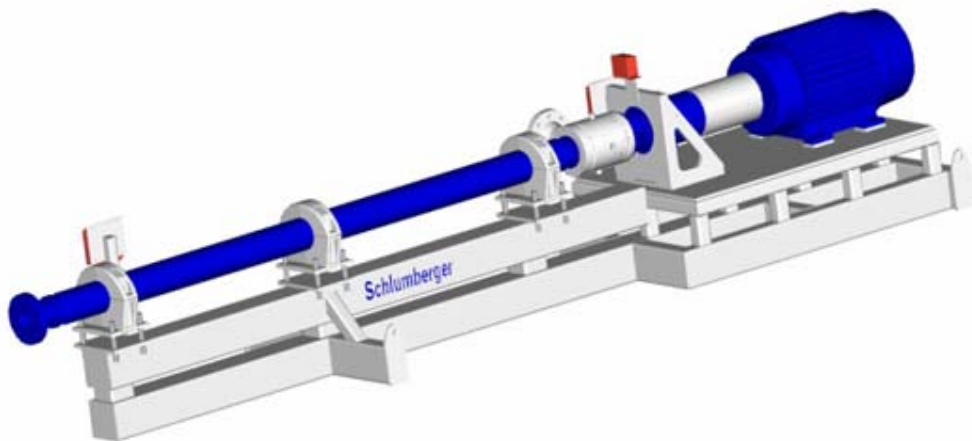
Project: Water Disposal Pumps
Date: 11/15/2010

REDA HPS
HORIZONTAL PUMPING SYSTEM
TECHNICAL DESIGN

Customer: Paramount Resources Ltd.
Project: Water Disposal Pumps

Flow: 82.5 GPM
Boost Pressure: 2751.12 psi
Discharge Pressure: 2801.1 psig

Pump: S75N 126 stages
Motor: SIEMENS, 250 hp, 460 Volts, 60 Hz



Date: 11/15/2010

Input Values

Process Input Data

Liquid Type	<i>Water</i>	
Specific Gravity	<i>1.1</i>	
Design Flow Rate	<i>82.5</i>	<i>GPM</i>
Design Suction Pressure	<i>50</i>	<i>psig</i>
Design Discharge Pressure	<i>2800</i>	<i>psig</i>
Design Boost Pressure	<i>2750</i>	<i>psi</i>
NOTES :		

System Input Data

Input Voltage		
Area Classification	<i>Class I Div II</i>	
Ambient Temperature	<i>80</i>	<i>°F</i>
Liquid Temperature	<i>50</i>	<i>°F</i>
Input Frequency	<i>60</i>	
NOTES :		

Results Summary

Pump Summary

Operating Frequency	<i>60</i>	<i>Hz</i>
Speed	<i>3570</i>	<i>RPM</i>
Power Required (@ Duty)	<i>202.8</i>	<i>hp</i>
Run out Power	<i>208</i>	<i>hp</i>
Pump Efficiency	<i>65.49</i>	<i>%</i>
Boost Generated	<i>2751.12</i>	<i>psi</i>

Pump Type	<i>S75N</i>
Stages	<i>126</i>
Shaft Type	<i>MONEL</i>
Pressure Rating	<i>5000 psig</i>
Shut in Pressure	<i>4015.4 psig</i>
TDH	<i>5768.93 ft</i>

Component Details

Motor

Classification	<i>Class I Div II</i>	
Voltage	<i>460</i>	<i>Volts</i>
Shaft Power	<i>250</i>	<i>hp</i>
Altitude Adjusted HP	<i>250</i>	<i>hp</i>
Enclosure	<i>TEFC</i>	
Frame	<i>449TS</i>	
Bearing Type	<i>BALL</i>	
NOTES :		

Thrust Chamber

TC Rating	<i>12000 lbf</i>
Peak Downthrust	<i>9504.64 lbf</i>
Operating Downthrust	<i>7632.52 lbf</i>
NOTES :	

Seal

Seal Type	<i>2</i>
Cartridge Seal	<i>NC</i>
Seal Flush Type	
NOTES :	

Skid Type

Model	<i>ND</i>
Overall Unit Length	<i>31.77 ft</i>
NOTES :	

Intake Flange

Size	<i>4</i>	<i>in</i>
Flange Class	<i>150</i>	
Configuration	<i>RF</i>	
Material	<i>316L SS</i>	
Intake Orientation	<i>0 deg. (Standard)</i>	

Discharge Flange

Size	<i>2</i>	<i>in</i>
Flange Class	<i>2500</i>	
Configuration	<i>RF</i>	
Material	<i>316L SS</i>	

Limits Summary

Process Input Data

Frequency	60	Hz	Controller kW	195.48
Voltage	460	Volts	Controller kVA	212.48
Motor Amps	267	Amps	PF at Controller	0.92
Motor Rating	250	hp		
Pump Power Draw	202.8	hp		
Motor Load Factor	81.12	%		

System Summary at Design Point

Pump

MAWP Rating	5000	psig
Discharge Pressure	2801.1	psig
Pressure Load Factor	56.02	%
Shaft Rating	261.1	hp
Required Power	202.8	hp
Shaft Load Factor	77.67	%
NPSHr	17.06	ft

Thrust Chamber

TC Rating	12000	lbf
TC Load Factor	63.6	%

Flanges

Intake Rating	230	psig
Load Factor	21.74	%
Discharge Rating	5000	psig
Discharge Load Factor	56.02	%

System Summary at Maximum Condition

Pump

MAWP Rating	5000	psig
Discharge Pressure	4015.4	psig
Pressure Load Factor	80.31	%
Shaft Rating	261.1	hp
Peak Required Power	208	hp
Shaft Load Factor	79.66	%
NPSHr	17.06	ft

Thrust Chamber

TC Rating	12000	lbf
TC Load Factor	79.21	%

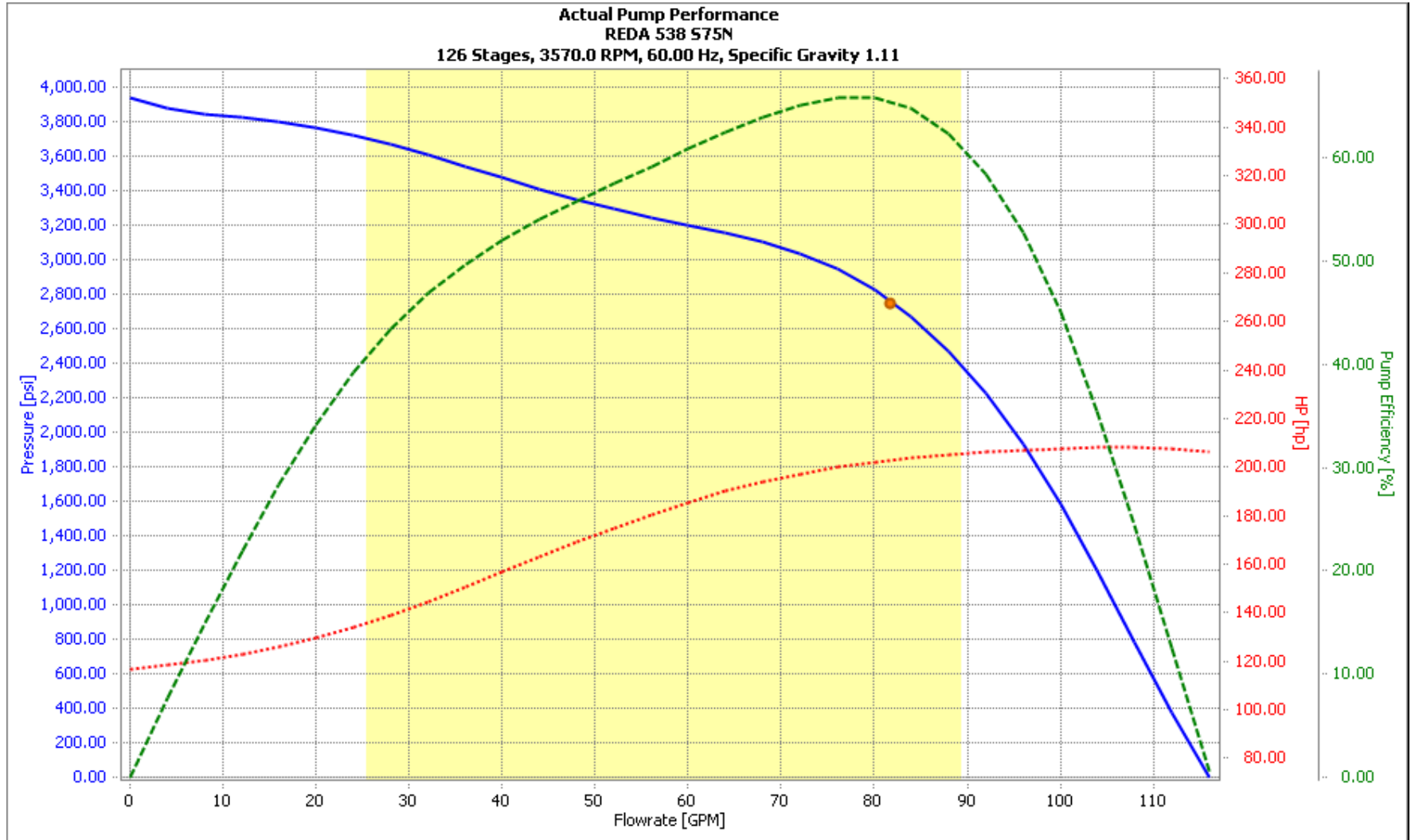
Flanges

Intake Rating	230	psig
Load Factor	21.74	%
Discharge Rating	5000	psig
Discharge Load Factor	80.31	%

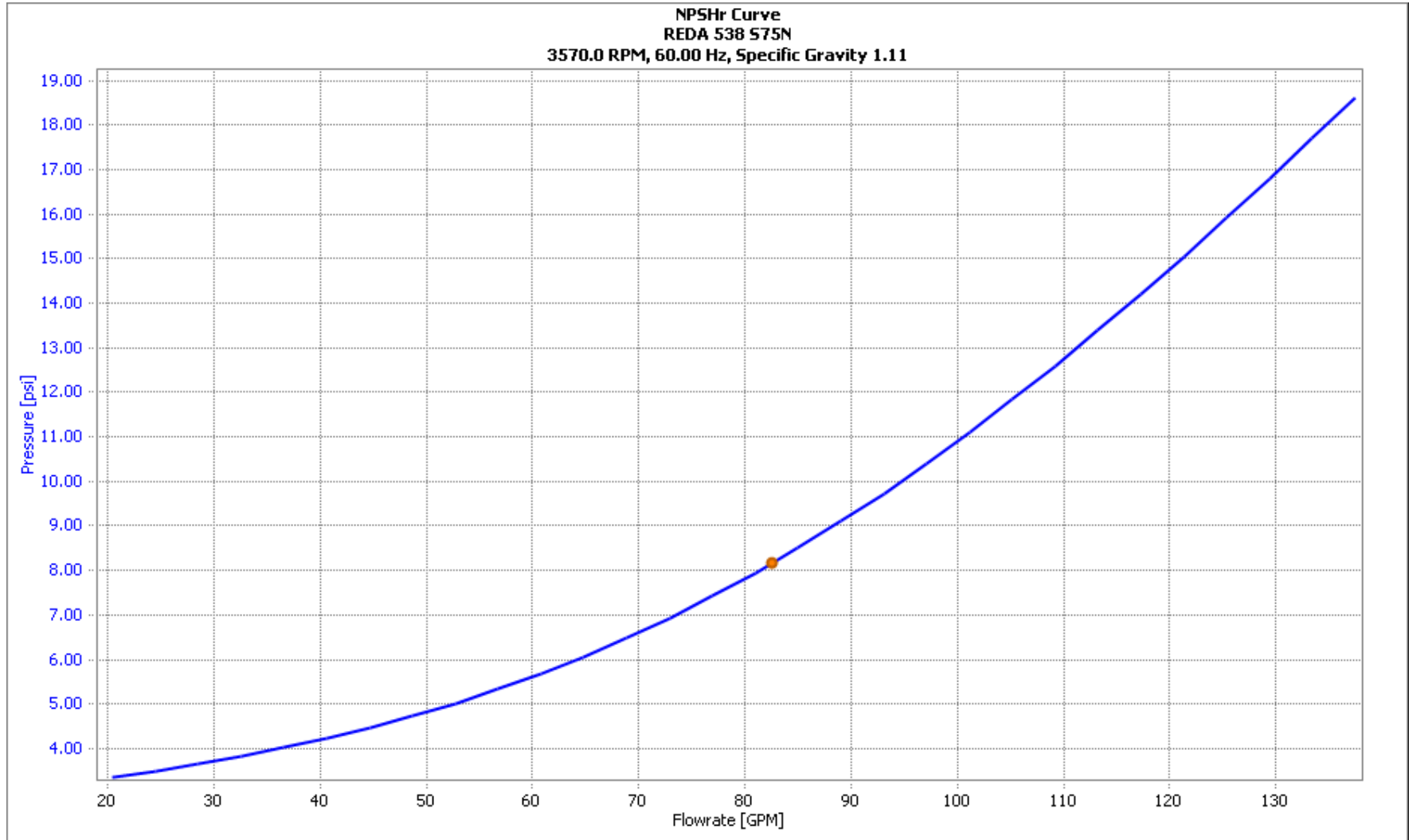
Company: Paramount Resources Ltd.
Engineer: Gerardo Balmaceda

Project: Water Disposal Pumps
Date: 11/15/2010

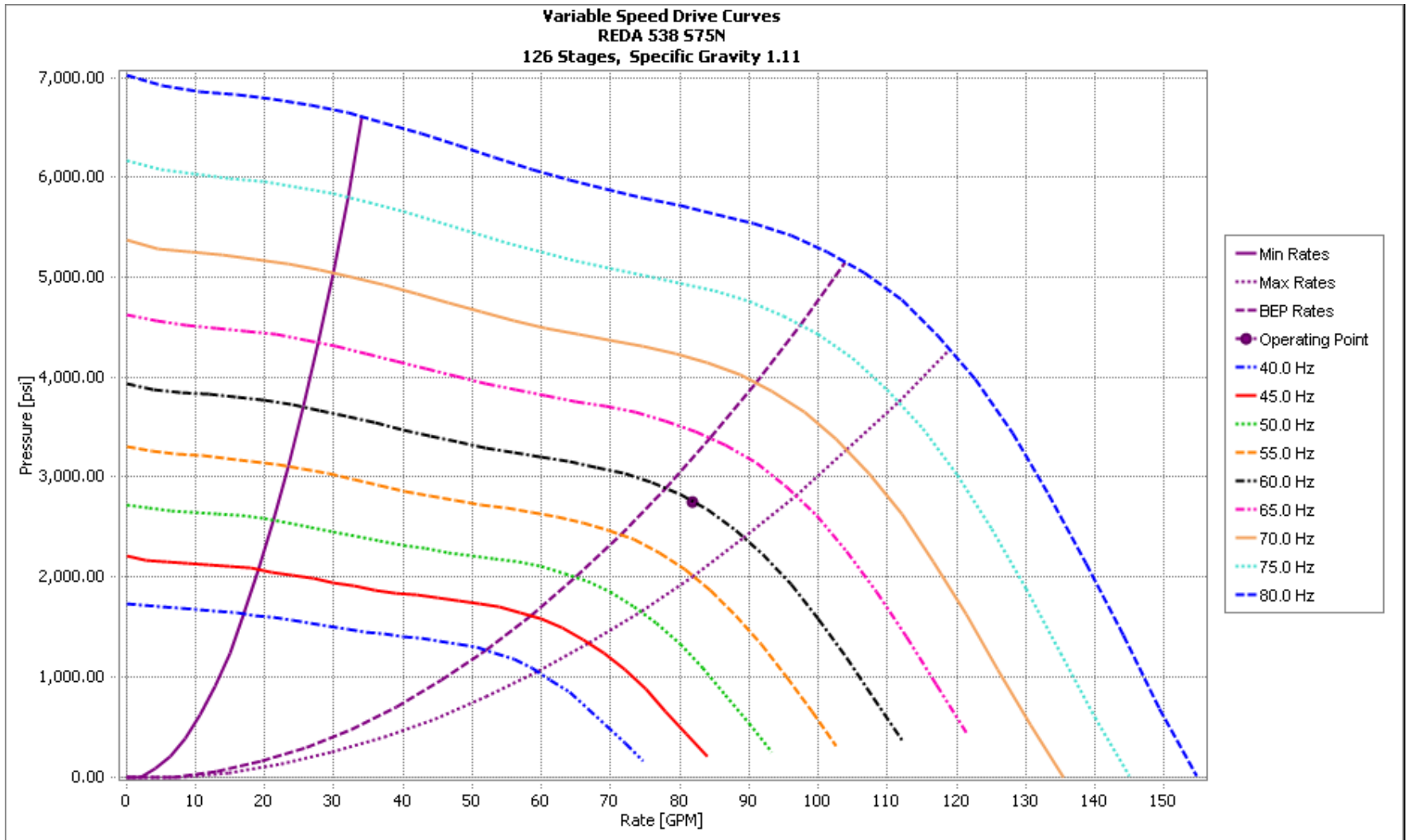
Actual Pump Curve



NPSHr Actual Pump Curve



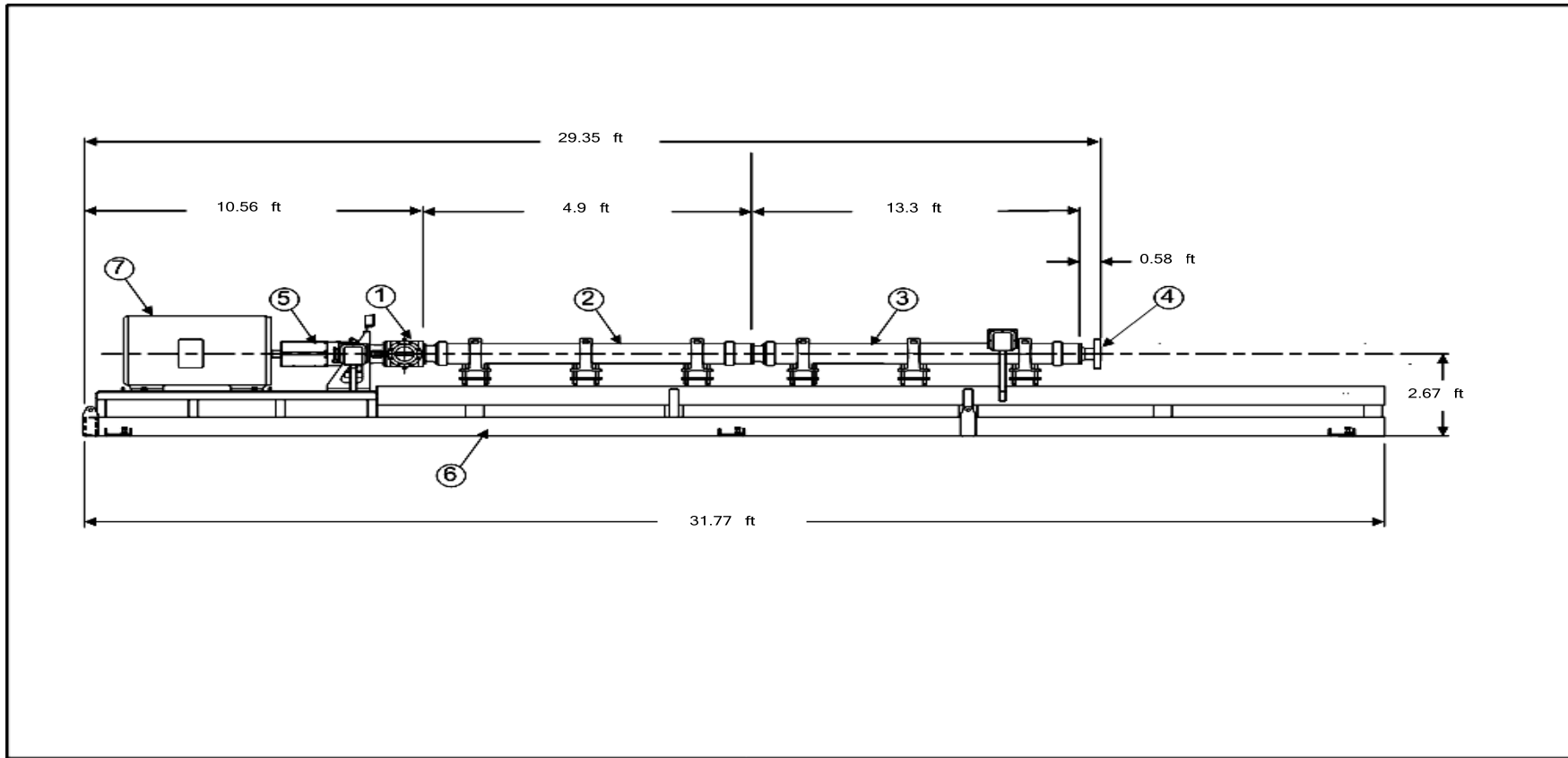
VSD Curves Plot



Company: Paramount Resources Ltd.
 Engineer: Gerardo Balmaceda

Project: Water Disposal Pumps
 Date: 11/15/2010

Skid Diagram



Parts List				For quotation purposes only, this drawing contains estimated dimensions and weights. Drawing not to scale. DO NOT CERTIFY	Confidential and trade secret. Do not disclose use or reproduce without prior written approval from Manufacturer	Paramount Resources Ltd.		
Item	Description					Water Disposal Pumps		
1	Intake Flange:	4 in	ANSI	150	Design Data			
2	Pump:	Stage 35	S75N					
3	Pump:	Stage 96	S75N		Designed By:	Gerardo Balmaceda	Length:	29.35 ft
4	Discharge Flange:	2 in	ANSI	2500	Approved By:		Width:	3.73 ft
5	Thrust Camber:	Bearing 2		12000 lbf	Date:	11/15/2010	Weight:	0 lbf
6	Skid Assembly:	ND		Clamps 5	Reda-HPS			
7	Motor:	250 hp	TEFC	460 Volts				

Customer: PARAMOUNT RESOURCES LTD. SUITE 4700, 888 - 3RD STREET S CALGARY Alberta T2P 5C5 Canada	Well Name: Field: County: State/Prov: Country: UWI Number:	External Ref: Ref Doc: PO: AFE: Cust Ref: Cust Cont #: Commercial Agreement: SLB Sales Rep: Gerardo Balmaceda
Estimated Job Date: 01-Jan-0001		SLB Location: 9253
		Rig:
Price Book: ALIV / ALS_GEOREF_CAD_2008_CAD_HPS Price Book		

Service Instructions:

THE ESTIMATED CHARGES AND DATA SHOWN BELOW ARE SUBJECT TO CORRECTION BY SCHLUMBERGER.

SPN	Description	Qty	UOM	Price	Disc	Amount	Opt
10 2008012	PUMP: S75N CR-CT 63 STG 538/540 60 CS BTHD, .87 HS MON, M-TRM, HSN, ARZ, SS HandB, BLUE PAINT	1	EA				
20 0178301	COUPLING: S/A, .87-6A SPLINE, MON	1	EA				
30 2008012	PUMP: S75N CR-CT 63 STG 538/540 60 CS BTHD, .87 HS MON, M-TRM, HSN, ARZ, SS HandB, BLUE PAINT	1	EA				
40 3920209	MOTOR: SIEMENS, 250HP 460V 267A 60HZ, 449TS, TEFC, BALL BRG, 3570 FLRPM, RGZESD	1	EA				
50 139020544	WELDMENT ASSY, G3, ND, 5 CLAMP, 11 INCH HEIGHT, STD GRAY	1	EA				
60 100155758	ASSEMBLY, COUPLING, METASTREAM, TSCS/TSKS 0135, W/7 IN SPACER, 2.375-2.375 BORE	1	EA				
70 100480871	GUARD: ASSY, HPS, CPLG, 16-22 INCHES	1	EA				
80 100447637	THRUST CHAMBER: ASSEMBLY, 2 BEARING, HPS, G3A, 1.18-6B SPLINE, STD BLUE	1	EA				
90 7005564	SEAL: SHAFT, 1.500, HSN, M-TRM, TYPE 2, JC P/N C055-95, MATL CODE B97058M058M	1	EA				
100 100538851	SEAL HOUSING: ASSY, G3, NON- CARTRIDGE, TYPE 2 SEAL, W/FLANGE O- RING	1	EA				
110 3909505	ASSEMBLY:INTAKE, 4 IN, 150, RFWN, 316L SS, MAWP-230 PSI	1	EA				
120 3909570	ADAPTOR,END,INTAKE,538/540 SERIES PUMP	1	EA				
130 0266445	COUPLING: S/A, .875-6A X 1.187-6B SPL,PMP,540	1	EA				
140 100330563	CLAMP: PUMP, HPS, 538 SERIES PUMP, STD GRAY	5	EA				
150 3909028	HEAD ASSY: DISCHARGE, 3 IN., 1500, RF, 540/538 SERIES, 316L SS, MAWP- 3000 PSI	1	EA				
160 3900501	SWITCH: MURPHY, VS2EX, VIBRATION TYPE, EXPLOSION PROOF	1	EA				
170 100102424	CP: HPS-G3, ND/MD, 5 CLAMP,COMPONENT HARDWARE DETAILS	1	EA				
180 100155122	KIT, MOTOR MOUNTING,0.625 BOLTS	1	EA				
190 100304355	KIT, HPS, O-RING SET, HSN, 538/540 SERIES TANDEM	1	EA				
200 100321016	KIT, DISCHARGE MOUNTING, 538 SERIES PUMP, MONEL, STD	1	EA				

Customer: PARAMOUNT RESOURCES LTD. SUITE 4700, 888 - 3RD STREET S CALGARY Alberta T2P 5C5 Canada	Well Name: Field: County: State/Prov: Country: UWI Number:	External Ref: Ref Doc: PO: AFE: Cust Ref: Cust Cont #: Commercial Agreement: SLB Sales Rep: Gerardo Balmaceda
Estimated Job Date: 01-Jan-0001		SLB Location: 9253
		Rig:
Price Book: ALIV / ALS_GEOREF_CAD_2008_CAD_HPS Price Book		


THE ESTIMATED CHARGES AND DATA SHOWN BELOW ARE SUBJECT TO CORRECTION BY SCHLUMBERGER.

SPN	Description	Qty	UOM	Price	Disc	Amount	Opt
210 3909357	ASSEMBLY:COOLER,OIL,BH,EXPLOSION PROOF,GEN 2	1	EA				
220 HPS-SPARE-003	Engineering Charges	1	EA				

Requested Total
for the unit
Quote Total (CAD)
for 02 units

THE ESTIMATED CHARGES SHOWN ABOVE MAY BE EXCLUSIVE OF TAX AND THE FINAL INVOICE WILL INCLUDE ALL APPLICABLE TAXES.

THIS QUOTATION IS VALID FOR A PERIOD OF 30 DAYS FROM THE DATE ABOVE, UNLESS OTHERWISE SPECIFIED BY SCHLUMBERGER, AND WILL BE PERFORMED IN ACCORDANCE WITH THE ATTACHED GENERAL TERMS AND CONDITIONS OR THE TERMS OF A MASTER SERVICE AGREEMENT IF ONE IS IN FORCE BETWEEN CUSTOMER AND SCHLUMBERGER. CUSTOMERS WRITTEN ACCEPTANCE OF THE TERMS OF THIS QUOTATION AND, IN THE ABSENCE OF A MASTER SERVICE AGREEMENT, THE ATTACHED GENERAL TERMS AND CONDITIONS SHALL TOGETHER FORM A BINDING CONTRACT BETWEEN THE PARTIES.

 John Crane EMA Nash Rd., Trafford Park Manchester M17 1SS UK	Technical Bulletin		
	Number EMA TB 001	Rev 1	Page 1 of 2
Title <p style="text-align: center;">Seal Selection for Hydrogen Sulphide (H₂S) Service</p>			

Issued <p style="text-align: center;">P E Bowden</p>	Approved <p style="text-align: center;">N M Wallace</p>
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Hydrogen sulphide is a highly toxic, colourless, flammable gas with an offensive odour. Very low concentrations of H₂S can be recognised by the highly characteristic smell, but this is only true when the gas is first encountered. Even at low concentrations, prolonged or repeated exposure tires the sense of smell, so that odour is not reliable as a warning.

The hazard posed by H₂S can be summarised as follows.

Concentration (in air)	Hazard
10 ppm	Long term exposure limit. (8-hour TWA reference period)
15 ppm	Short term exposure limit. (10-minute reference period)
20-150 ppm	Causes irritation of eyes and respiratory tract after one hour.
200 ppm	Dangerous if inhaled for an hour.
500 ppm	Very dangerous if inhaled for 15 to 30 minutes.
800-1000 ppm	May be fatal if exposed for more than 30 minutes.
1000 ppm +	May be instantly fatal.

H₂S presents us with two selection issues, environmental and hazard. While we can be pro-active in making seal recommendations for hazard considerations the environmental issue is one that will vary around the world. (We have experience of plant accepting single seals up to concentrations of 10,000 ppm and others specifying double seals for over 200 ppm.)

Seal selection for environmental issues should therefore be the responsibility of the user company or plant designer who will know local regulations and is responsible for their compliance.

For considerations relating to hazards and therefore safety we should have an agreed policy so that we can make recommendations on seal solutions when requested to do so by the user company.

Again we need to recognise that the user company/ plant designer has a local responsibility for safety matters and therefore we should be guided by their seal specifications.

John Crane recommendations for seals in H₂S service are for guidance only, local, national and environmental regulations must be observed.



John Crane EMA

Nash Rd., Trafford Park
Manchester M17 1SS UK

Technical Bulletin

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EMA TB 001

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1

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Title

Seal Selection for Hydrogen Sulphide (H₂S) Service

It is important to remember that these cannot be definitive since H₂S bonds to fluids in different ways i.e. H₂S will stay absorbed into amines but will be released to the atmosphere by oil. For this reason we must be guided by the plant user/ designer who has access to more detailed hazard and operational data than will normally be available to us

Concentration (in liquid)	Seal type
Up to 200 ppm	Single seal
Up to 500 ppm	Single seal with dry back-up
Up to 1000 ppm	Tandem seal ¹
Above 1000 ppm	Double seal

¹ Buffer liquid should be monitored regularly for H₂S contamination

The recommended procedure when asked to offer seals for H₂S services is as follows

- When no specification on seal types is given
 - We should advise of the dangers of airborne H₂S as detailed in the first table and recommend that a full safety assessment be made by the plant designer or user.
 - We offer our own guidelines for selection
 - We suggest opening up a dialogue with the customer to agree a safe solution in the specific circumstances of the application and the plant.
- When a seal specification is given
 - If the specification is more strict than our own guidelines we comply with the specification
 - If the specification is less strict we should follow the specification BUT point out the dangers of airborne H₂S emissions and make the comment that "It is important through a study of the process fluid, it's operating parameters and plant design, that airborne emissions are contained appropriately and safely". In this context, we will be guided by the recommendations of the plant designers or operators, they having taken these factors into account. If there is any doubt, we should recommend more detailed discussions and suggest the use of intrinsically safer solutions.
- When we are asked for our guidelines or advice.
 - We offer our guidelines together with comments on the dangers (as above).
 - We suggest discussion around specific applications

THESE GENERAL TERMS AND CONDITIONS OF CONTRACT CONTAIN EXCLUSION OF LIABILITY AND SPECIAL INDEMNITY PROVISIONS – READ CAREFULLY.**1. ACCEPTANCE.**

By requesting Schlumberger's services, equipment, or products under a field service contract or field service ticket, purchase order, work order, quotation, bid, proposal or other similar document (the "**Contract**") that incorporates by reference these General Terms and Conditions or to which these General Terms and Conditions are attached or printed on the reverse, the Customer accepts and agrees to be bound by these General Terms and Conditions. These General Terms and Conditions form part of the Contract, and Schlumberger's Services and Products under the Contract will be provided subject to and in accordance with these General Terms and Conditions. Similarly, all documents containing pricing, commercial, technical, logistics and safety details associated with the Services and Products offered and provided to the Customer by Schlumberger in connection with this Contract also form part of the Contract.

2. DEFINITIONS.

In these General Terms and Conditions, the following terms have the following meanings:

- (a) "**Claims**" means all losses, liabilities and claims of any kind, including all costs and expenses (including legal costs and disbursements on a full indemnity basis) related in any way to those losses, liabilities and claims;
- (b) "**Customer**" means the person, firm or other entity to which equipment or services are supplied or provided under the Contract;
- (c) "**Customer Group**" means (1) the Customer and its parent companies, subsidiaries and other affiliates and (2) each of the officers, directors, and employees of the entities listed in (1);
- (d) "**Products**" means any products or equipment sold or otherwise provided by Schlumberger under the Contract (including tools, supplies and materials);
- (e) "**Schlumberger**" means Schlumberger Canada Limited, an Ontario corporation;
- (f) "**Schlumberger Group**" means (1) Schlumberger and its parent companies, subsidiaries and other affiliates, and (2) each of the officers, directors, and employees of the entities listed in (1);
- (g) "**Services**" means the work and services provided by Schlumberger under the Contract; and
- (h) "**Parties**" means the Customer and Schlumberger and "**Party**" refers to either of them.

3. PAYMENT TERMS.

Payment for Services and Products must be made by cash in advance unless Schlumberger has approved the Customer's credit prior to the sale of Products or provision of Services. If the Customer's credit has been approved in advance, the total invoice amount is due 30 days from the date of the invoice. In either case, the Customer agrees to pay interest on past due balances at the lesser of 1.5% per month (18% annually) or the maximum rate allowed by applicable law. If the Customer's account becomes overdue, Schlumberger has the right to revoke any previously applied discounts, and the full invoice price will be immediately due and owing and subject to collection. If Schlumberger takes any steps to collect any amounts that are overdue, the Customer agrees to pay to Schlumberger, in addition to the overdue amount (including interest), the full cost of collecting these overdue amounts, including legal costs and disbursements on a full indemnity basis. Should Customer dispute a portion of an invoice, Customer shall notify Schlumberger in writing of the disputed charges and the reasons for disputing same within fifteen (15) days of receiving the invoice, and will pay without delay the undisputed portion, while the disputed portion will be paid promptly after the dispute is resolved.

4. TAXES.

Customer agrees to pay all taxes, duties, tariffs or other charges (other than income taxes) imposed by any government, governmental agency or similar authority with respect to any charges made by Schlumberger in connection with the delivery by Schlumberger of any Services or Products under the Contract. Prices quoted by Schlumberger do not include sales, goods and services or similar taxes and these taxes, where applicable, shall be added to the quoted prices and invoiced accordingly.

5. INDEPENDENT CONTRACTOR.

In providing any Services or Products under the Contract, it is the understanding and intention of the Parties that Schlumberger is an independent contractor of the Customer at all times, and in no circumstances will Schlumberger or anyone employed by Schlumberger be considered the agent, representative, employee or servant of the Customer.

6. OBLIGATIONS OF THE CUSTOMER.

(a) **Well or Facility Conditions; Notification of Hazardous Conditions.** As the Customer has or will have custody and control of the well or facility and superior knowledge of the conditions in and surrounding it, the Customer will provide Schlumberger with the information required to enable Schlumberger to provide its Products and Services safely and efficiently. Schlumberger's equipment used in the performance of the Services is designed to operate under normal oilfield conditions and this equipment may be seriously damaged by hazardous or unusual conditions. Likewise, the Products are designed to operate under certain circumstances and conditions, and their capabilities are specified in the relevant technical specifications documents. If hazardous or unusual conditions exist, including those in the wellbore, the Customer must notify Schlumberger in advance and the Parties will make the necessary additional contractual arrangements for servicing such wells or facilities and providing appropriate Products.

(b) **Substances.** The Customer agrees to bear sole responsibility and liability for the safe and lawful handling, management, transportation and disposal of all substances, waste or by-products of any kind including radioactive tracer material and other Products used in, consumed during, or resulting from the provision of Products or Services under the Contract by Schlumberger ("**Substances**"), even where the Substances are created, utilized or provided by Schlumberger. The Customer also understands and agrees that these Substances are the sole property of the Customer, even where these Substances are created, utilized or provided by Schlumberger, and that the Customer remains responsible for the cleanup and decontamination of any Schlumberger's equipment used in the performance of the Services, including equipment that is used as part of a radioactive tracer job and subsequently may become contaminated with radioactive material. Furthermore, the Customer agrees to:

- (i). WAIVE any Claim (including any civil or criminal claim or action under environmental or other legislation) that it, or any person claiming through it, may have against the Schlumberger Group related in any way to the use, generation, handling, management, transportation and disposal of Substances;
- (ii). RELEASE the Schlumberger Group from any Claim (including any civil or criminal claim or action under environmental or other legislation) that it, or any person claiming through it, may have against the Schlumberger Group related in any way to the use, generation, handling, management, transportation and disposal of substances;
- (iii). INDEMNIFY AND DEFEND the Schlumberger Group against any Claim (including any civil or criminal claim or action under environmental or other legislation) that any person may have or may bring against Schlumberger related in any way to the use, generation, handling, management, transportation and disposal of substances.

(c) **Radioactive sources.** In the course of providing Products or Services under the Contract, Schlumberger may use or provide radioactive sources as a component part of its equipment and tools or as a material or Product used or consumed in the Services and/or sold to the Customer. These radioactive sources are potentially dangerous. If any radioactive source is lost in a well, at the well site, while being transported from or to a well site, or while being transported by the Customer or a third party on behalf of the Customer, or while in the custody or control of the Customer, the Customer agrees that it will use its best efforts to recover the radioactive source, and agrees to take precautions in order to avoid breaking or damaging the radioactive source. If the Customer does not recover the radioactive source, or if the container is broken, the Customer agrees that it will immediately comply with all applicable laws and regulations governing radioactive sources, including isolating and marking the location of the radioactive source. The Customer also agrees that if a radioactive source is lost and not recovered, or if a radioactive source container is broken, the Customer will immediately inform Schlumberger, and will keep Schlumberger informed of all developments with respect to the radioactive source.

(d) **Fishing Operations.** The Customer agrees to assume all responsibility and liability for operations in which the Customer or its representatives fish for Schlumberger Group's equipment. Schlumberger Group will, without assuming any liability and only at the request of the Customer, render assistance for the recovery of such equipment.

7. WARRANTY FOR PRODUCTS AND SERVICES.

(a) **Services.** Schlumberger agrees to perform all Services in a good and workmanlike manner and in accordance with good oilfield practices. Schlumberger will exercise diligence to provide correct log, test and other data and safe transport of all log, test and other data. If the Customer believes that Schlumberger has materially failed to perform the Services that Schlumberger has agreed to provide under the Contract, the Customer must, within 24 hours from the time that the Customer becomes aware of the material failure, inform Schlumberger with written notice providing details of the material failure. If this written notice is provided by the Customer, and if the material failure is a result of circumstances or reasons that are solely within the control of Schlumberger, Schlumberger will do one of the following, at its sole discretion:

- (i). re-perform, within 7 days of receiving written notice from the Customer, the Services that it materially failed to perform; or
- (ii). provide a refund of the cost of that portion of the Services that it materially failed to perform.

The Customer agrees and acknowledges that Schlumberger's obligations in respect of services that it has failed to perform as agreed under the Contract are limited to those described above in 7(a)(i) and 7(a)(ii), and then only if (1) the customer has given written notice as described above; and (2) if the failure to perform is material and

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as a result of circumstances or reasons that are solely within the control of Schlumberger. The customer also agrees and acknowledges that if it fails to give notice as required, Schlumberger will have no obligation whatever in respect of Services that it has failed to perform as agreed under the Contract.

Schlumberger may provide the Customer with Schlumberger's interpretation of logs, tests or other data. Schlumberger may also provide the Customer with Schlumberger's recommendation regarding Services or Products required. The Customer understands and acknowledges that these interpretations and recommendations are mere opinions, based upon the judgment and experience of the person providing the interpretation or recommendation. The Customer understands and acknowledges that if it chooses to rely upon these interpretations and opinions, it does so at its own risk. The Customer also understands and acknowledges that in offering interpretations and recommendations, Schlumberger makes no warranty whatever with respect to the accuracy of the interpretation or recommendation, and shall not be responsible for Customer's use of said interpretations and recommendations.

Schlumberger will not be responsible for a accidental or intentional interception of or tampering with data by others, or for any other damage to or loss of data. Schlumberger does not guarantee the safe storage or the length of time of storage of any digital tapes, optical logs or prints, or other similar products or materials.

- (b) **Products.** Schlumberger agrees that Products supplied by it will be of the quality and specifications represented to Customer by Schlumberger. Schlumberger reserves the right, at its sole discretion, to use new, used or refurbished parts in the assembly of its Products. Schlumberger warrants all its Products to be free of defects in material and workmanship for a period of 12 months from the date of installation or the date of delivery to the Customer Ex Works Schlumberger facility set forth in the quotation or other document as agreed to by Schlumberger, whichever occurs first, provided that with respect to Schlumberger completions systems products, such products shall comply with the 12 months warranty described above from the date of delivery of such Products to Customer.

The Products warranty described above does not apply to:

- (i). Products that have been modified, uninstalled, dismantled, disassembled or subjected to improper handling, storage, installation, operation or maintenance, or to any Product normally consumed in operation;
- (ii). any item that is purchased by Schlumberger or furnished by the Customer as a component part of a Product, or not manufactured by Schlumberger and purchased for the Customer, except to the extent to which such items are covered by a warranty of the original manufacturer;
- (iii). the design, where Schlumberger prepares shop drawings, tracing drawings or lists from designs furnished by others;
- (iv). models or samples that are furnished to the Customer as illustrations only of the general properties of Schlumberger's Products and workmanship; or
- (v). damage to a Product caused by abrasive materials, corrosion, lightning, improper voltage supply, mishandling or misapplication.

The Customer must provide Schlumberger with written notice of each warranty claim within 24 hours from the time the Customer discovers the defect which is the subject of the warranty claim. The Customer agrees and acknowledges that if the Customer does not provide that written notice of a warranty claim within the 24 hours period from the time of discovery of the defect in the product, Schlumberger will have no obligation under this warranty for that defect.

The Customer must retain all Products alleged to be defective and in respect of which the Customer makes a warranty claim until 30 days after the warranty claim has been settled, unless the Product has already been returned and retained by Schlumberger. Schlumberger has the absolute right to inspect and test all Products claimed by the Customer to be defective in order to determine the cause of the defect, and at Schlumberger's request, the Customer will return to Schlumberger any Product claimed to be defective for which Schlumberger has accepted the claim and replaced the item. Any Products so returned to Schlumberger by the Customer become the property of Schlumberger.

Schlumberger's sole liability and the Customer's exclusive remedy under this Products warranty is expressly limited to the repair, replacement or the refund of an equitable portion of the purchase price, at Schlumberger's sole discretion, of products first that prove to be defective within the warranty period.

- (c) The warranties set out in paragraphs 7(a) and 7(b) for Services and Products are in lieu of all other warranties, whether oral, written, express, implied or statutory. Implied warranties of fitness for a particular purpose and merchantability shall not apply. Schlumberger's warranty obligations and Customer's remedies under such warranty obligations (except as to title) are solely and exclusively as stated in these paragraphs 7(a) and 7(b).

8. TITLE AND RISK OF LOSS.

- (a) Title to and risk of loss for Products sold pass to the Customer Ex Works Schlumberger facility set forth in the quotation or other document as agreed to by Schlumberger. The Customer agrees that title to and risk of loss for Products will still pass to and remain with the Customer Ex Works Schlumberger applicable facility, even if Schlumberger agrees to store the Products at a Schlumberger location for a later delivery at the Customer's request. Customer will pay or reimburse Schlumberger for all freight, preparation, and in-transit insurance costs from the Schlumberger facility to the location at which delivery to the Customer occurs.
- (b) Schlumberger retains a registrable security interest in the Products to the extent of any unpaid balance of the purchase price, and Schlumberger may use all reasonable efforts to retain or obtain possession of such Products or to perfect its security interest until the unpaid balance has been received and accepted by Schlumberger. The time, place or manner of payment by the Customer will not in any way limit Schlumberger's rights in and to the Products until payment has been received in full.

9. INDEMNITIES.

THIS SECTION CONTAINS INDEMNITIES IN FAVOUR OF SCHLUMBERGER AND PROVISIONS THAT LIMIT SCHLUMBERGER'S LIABILITY UNDER THE CONTRACT – READ CAREFULLY

- (a) **Personnel.**
- (i). Schlumberger:
 - (1) assumes all liability for; and
 - (2) agrees to defend and indemnify Customer Group and its insurers against, all Claims arising out of or in connection with personal injury, illness or death of any member of Schlumberger Group or its subcontractors, and which arise out of or are in connection with the Contract or the Services, regardless of the cause.
 - (ii). Customer:
 - (1) assumes all liability for; and
 - (2) agrees to defend and indemnify Schlumberger Group and its insurers against, all Claims arising out of or in connection with personal injury, illness or death of any member of Customer Group or its contractors (other than Schlumberger) and subcontractors, and which arise out of or are in connection with the Contract or the Services, regardless of the cause.
- (b) **Property.**
- Customer:
- (i). assumes all liability for; and
 - (ii). agrees to defend and indemnify Schlumberger Group and its insurers from and against, all Claims arising out of or in connection with:
 - (1) loss of and/or damage to the Customer Group's or its contractors' (other than Schlumberger) or subcontractors' property, equipment, materials or products (including recovery, repair and replacement expenses), regardless of the cause; and
 - (2) loss of and/or damage to Schlumberger Group's or its subcontractors' property, equipment, materials or products (including recovery, repair and replacement expenses), regardless of the cause, which occurs:
 - (A) in the hole or below the rotary table;
 - (B) while in transit or being moved on any form of transportation owned or furnished by Customer;
 - (C) while located at the well site or facility when Schlumberger personnel are not present;
 - (D) as a result of inferior integrity of or an improperly maintained lease road, private access road or work site; or
 - (E) while being used by or while under the custody or control of any person other than a Schlumberger employee, whether in an emergency or otherwise.
- In the event of a claim by Schlumberger under this paragraph (2), the Customer shall reimburse Schlumberger for the loss of the property, equipment, materials and products, it being understood that all lost or damaged items will be valued at their respective landed new replacement cost, unless a specific value for reimbursement to Schlumberger has been agreed beforehand in the Contract documents. Schlumberger shall charge the relevant amounts to Customer in invoices

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to be paid in accordance with section 3 above. With respect to paragraph (2)(A) above, rental charges on the equipment lost or damaged shall continue to be paid by Customer up to and including the date on which Schlumberger receives notice in writing of the loss or damage.

- (c) **Special Indemnity.** Notwithstanding anything to the contrary in these General Terms and Conditions, the Customer agrees to defend and indemnify Schlumberger Group and Schlumberger Group's insurers from and against all Claims arising out of or in connection with the Contract for property damage, personal injury or death, or loss of any kind, regardless of the cause, and resulting from:
- (i). blow-out, cratering, wild well or work performed to control a wild well;
 - (ii). pollution, contamination, or radiation damage, whether caused by the Customer's failure to properly handle, transport or dispose of any Substances as required by paragraphs 6(b), 6(c) and 6(d) or otherwise, including containment, clean-up and remediation of the pollutant and contamination, whether or not legally required;
 - (iii). reservoir or underground damage (including loss of oil, gas, other mineral substances or water or the well bore itself) or surface damage arising from subsurface or subsea damage;
 - (iv). costs to control a wild well, underground or above the surface, including any redrilling or reworking and related clean up costs;
 - (v). damage to property owned by, in the possession of, or leased by the Customer, or by the well or facility owner if different from the Customer (the term "owner" includes working and royalty interest owners or the owner of any drilling rig, platform or other structure at the well site or facility);
 - (vi). subsurface trespass; or
 - (vii). catastrophic facility failure, including fire and explosion, and the costs to control, remediate or rebuild same.
- (d) **Application of Indemnities.** The assumption of liability and indemnities in paragraph 9(a), (b) and (c) above shall apply to any loss, damage, claim, expense, injury, illness or death without regard to:
- (i). the cause, including unseaworthiness, strict liability, inherently dangerous activity, breach of express or implied warranty, imperfection of material, defect or failure of equipment, defect, ruin or other condition of premises (including any conditions that pre-exist the execution of the Contract); or
 - (ii). the negligence or other fault, whether sole, joint, concurrent, active, passive or gross, of the indemnified party or its contractors or subcontractors or its or their employees, agents or invitees.
- (e) **Anti-Indemnity and Insurance Savings Clause.** If any defence, indemnity or insurance provision contained in these General Terms and Conditions conflicts with, is prohibited by or violates public policy under any federal, provincial, territorial or other law determined to be applicable to a particular situation arising from or involving any Services or Products under the Contract, the Parties understand and agree that the conflicting, prohibited, or violating provision will be deemed to be automatically amended in that situation to the extent necessary to conform with, not be prohibited by and avoid violating public policy under that applicable law.
10. **NO INCIDENTAL OR CONSEQUENTIAL DAMAGES.**
The Parties expressly agree that Schlumberger and the members of the Schlumberger Group will not be liable under any circumstances to the Customer and the members of the Customer Group for any punitive, incidental, consequential, indirect or special damages, including any loss of profits or business interruption or loss of use, loss of production or loss of rig time. This exclusion of liability applies whether the liability is based in contract, tort (including negligence and strict liability), law, equity, statute or otherwise.
11. **LIMITATION OF LIABILITY TO SERVICE OR PRODUCT VALUE IN CONTRACT.**
Schlumberger's liability, however arising from or in connection with the Contract shall not in any circumstances exceed the price paid or payable under the Contract for the Services or Products specifically giving rise to that liability. This limitation of liability applies whether the liability is based in contract, tort (including negligence and strict liability), law, equity, statute or otherwise.
12. **INSURANCE.**
Each Party, in its role as an indemnifying party, must support the respective indemnity obligations it assumes under the Contract, by obtaining at its own cost, adequate insurance for the benefit of the other party with contractual indemnity provisions or endorsements. To the extent of a Party's assumed liability, that Party's insurance must waive subrogation against the indemnified Schlumberger Group or Customer Group, as applicable, and their respective insurers, and must name such indemnified group (Schlumberger Group or Customer Group, as applicable) as additional insured(s) and loss payee(s). This coverage of the indemnifying party must be primary to that carried by the indemnified group (Schlumberger Group or Customer Group, as applicable). The Customer may not self-insure without the prior written consent of Schlumberger.
13. **EMPLOYEE SOLICITATION.**
Except with the prior written consent of Schlumberger, the Customer shall not directly, indirectly or through a third party solicit, recruit or induce any Schlumberger employee, consultant or representative to terminate his or her employment or other relationship with Schlumberger in order to become an employee, consultant or representative of the Customer until at least one (1) year has elapsed from the time that the Customer receives the final invoice for the Services or Products provided under the Contract.
14. **INTELLECTUAL PROPERTY.**
Schlumberger owns all rights to the proprietary intellectual property embodied in its services and products or which are created in the course of providing such services or products to Customer. Schlumberger does not transfer any ownership rights in such intellectual property to Customer. Schlumberger will be liable for intellectual property infringement claims arising out of Customer's normal use of Schlumberger's products and services but will not be liable for infringement that arises: (i) out of Customer's use of Schlumberger products or services in combination with products or services not provided by Schlumberger; (ii) where Schlumberger products or services have been specially modified, designed and/or manufactured to meet Customer's specifications; (iii) out of unauthorized additions or modifications to Schlumberger products or services; or (iv) where Customer's use of Schlumberger products or services do not correspond to Schlumberger published standards or specifications.
15. **MISCELLANEOUS.**
- (a) Schlumberger shall not be liable for any delay or non-performance of its obligations under the Contract due to governmental regulation, labour disputes, hostile action, weather, fire, acts of God or any other causes beyond the reasonable control of Schlumberger.
 - (b) Any disputes arising under or in relation to the Contract shall be determined by binding arbitration pursuant to the *Arbitration Act* (Alberta), as amended. The arbitration will be conducted in Calgary, Alberta. Any judgment upon the award rendered by the arbitrator will be final and conclusive and may not be appealed by either Party.
 - (c) The Contract shall be governed by the laws of the Province of Alberta.

By signing below, the undersigned acknowledges that he or she has read and understood these General Terms and Conditions and agrees that they form a part of the Contract. The undersigned further confirms that he or she is authorized by the Customer to execute the Contract and bind the Customer to the Contract.

By: _____

Name:
Title:
Date:

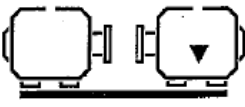
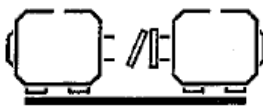
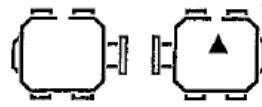
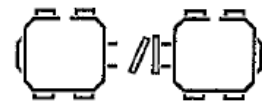
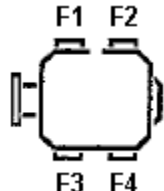
Equipment Information

2.1	HPS Assembly Checklist _____	2-1
2.2	Motor Information _____	2-1
2.3	Seal Information _____	2-1
2.4	Pressure Switchgauge Information _____	2-1
2.5	Vibration Switchgauge Information _____	2-1
2.6	Motor/TC Coupling Information _____	2-1
2.7	Thrust Chamber Information _____	2-1

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2-1

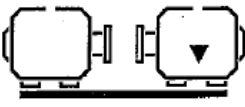
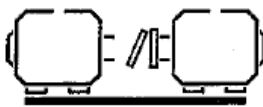
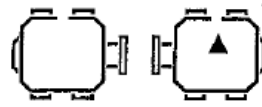
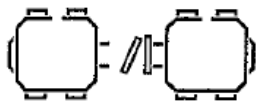
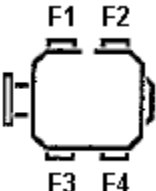
HPS Assembly Checklist

Date: April 4 2011		Work Order: 5063	
Customer: Candyne/Paramount		Serial Number: 0214-CA11	
Date Ordered:		Part Number: HPS-153928	
Verified motor to BOM and Blueprint:		Removed Unused Motor Nameplates (If Applicable):	
HP 250	Volts 460	Amps 267	Serial # K10T0711AE1-1
Motor Alignment:			
Vertical Offset  (+) ▲ (-) ▼	Vertical Gap  (+) / (-) /	Horizontal Offset  (+) ▲ (-) ▼	Horizontal Gap  (+) / (-) /
Motor Soft Foot  F1 F2 F3 F4	F1	F2	F3 F4
Sleeve Bearing <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No			
Alignment by: NR			
Coupling Size and Type used: 0135 METASTREAM			
Thrust Chamber:			
Serial Number: XDBOH-69554			
Thrust Chamber Model Number: G3A-2B			
Thrust Chamber Verified to BOM and Installed by: NR, RM			
Coupling Guard installed by: RM			
Verified Oil in Thrust Chamber by: RM			
Pump Seal Verified by: NR			
Pump Seal Installed by: NR, RM			
Pump Seal Type: 2, 7005564			
Cleats attached to intake (if required) by: N/A			

Intake:			
Serial Number: JPB1B-78995			
Intake verified to BOM and installed by: KB			
Visual Inspection of Intake: OKAY, 4" 150			
Cooler Package:			
Serial Number: FABIA-44901			
Correct Oil installed Verified by: RM			
Electrical Wiring Verified by:			
Oil & Fan correct rotation Verified by:			
Pump Alignment:			PUMP #1
Gap 0.005" 10-7	Height 0/64	Side to Side 0/64	
Down Thrust	Up Thrust	Total 0.063"	
Pump shimmed to: 0.002" LIFT			
Thickness of shims used: 0.315" PUMP SIDE			
Serial Number: 29E1C-55726		Stages 63	
Pump O-ring verified and installed by: NR			
Pump Alignment:			PUMP #2
N/A			
Gap 0.003" 2-8	Height 0/64"	Side to Side 0/64"	
Down Thrust	Up Thrust	Total 0.068"	
Pump shimmed to:	.003" LIFT	1/16	1/32
Thickness of shims used: 0.090" PUMP SIDE			
Serial Number: 29E1C-55727		Stages 63	
Pump O-ring verified and installed by: NR			

Pump Alignment:		N/A		PUMP #3	
Gap		Height		Side to Side	
Down Thrust		Up Thrust		Total	
Pump shimmed to:	Float	1/16		1/32	
Thickness of shims used:					
Serial Number:			Stages		
Pump O-ring verified and installed by:					
Discharge Head Assembly:					
Serial Number: 0214-CA11-2					
Discharge verified to BOM and installed by: KB					
Flush Plan: N/A					
Tubing installed by:			Fittings installed by:		
Type of Plan:					
Barrier Bottle (if required) <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No					
Lemco Bottle verified and installed by:					
Fittings Installed by:			Barrier Fluid filled by:		
Serial Number:			No Leaks		
Electrical: N/A					
Instruments verified and installed by:					
Wiring Installed and verified by:					
Programmable Logic Controller (PLC) Installed/Wired by (if applicable):					
PLC Serial Number:					
Wiring Diagram posted inside cover of Junction box:					

QA Final Check:	
System Test Number (if applicable):	
Verified jack pad bolts installed with locknuts by: NR	
Verified all nuts and bolts for tightness by: NR	
Verified all flange covers in place by: NR	
Verified name plates and sticker information installed by: NR	
Quality Control Plan (QCP) PDMS # (if applicable):	
Ready for Touch-up:	Date: April 4 2011
Comments (if any) on:	
Motor Alignment:	
Thrust Chamber:	
Cooler package:	
Pump Alignment:	
Flush Plan:	
Electrical:	

Date: April 4 2011		Work Order: 5064	
Customer: Candyne/Paramount		Serial Number: 0215-CA11	
Date Ordered:		Part Number: HPS-153928	
Verified motor to BOM and Blueprint:		Removed Unused Motor Nameplates (If Applicable):	
HP 250	Volts 460	Amps 267	Serial # G10T0711AE1-4
Motor Alignment:			
Vertical Offset  (+) ▲ (-) ▼	Vertical Gap  (+) / (-) /	Horizontal Offset  (+) ▲ (-) ▼	Horizontal Gap  (+) / (-) /
Motor Soft Foot  F1 F2 F3 F4	F1	F2	F3 F4
Sleeve Bearing <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No			
Alignment by: KB, RM			
Coupling Size and Type used: 0135 METASTREAM			
Thrust Chamber:			
Serial Number: XDB1A-41718			
Thrust Chamber Model Number: G3A-2B			
Thrust Chamber Verified to BOM and Installed by: NR, RM			
Coupling Guard installed by: KB			
Verified Oil in Thrust Chamber by: RM			
Pump Seal Verified by: NR			
Pump Seal Installed by: NR, RM			
Pump Seal Type: 2, 7005564			
Cleats attached to intake (if required) by: N/A			

Intake:			
Serial Number: JPB1B-78995			
Intake verified to BOM and installed by: NR			
Visual Inspection of Intake: OKAY, 4" 150			
Cooler Package:			
Serial Number: FABIA-44905			
Correct Oil installed Verified by: NR			
Electrical Wiring Verified by:			
Oil & Fan correct rotation Verified by:			
Pump Alignment:			PUMP #1
Gap 0.004" 3-6	Height 0/64	Side to Side 0/64	
Down Thrust	Up Thrust	Total 0.063"	
Pump shimmed to: 0.001" LIFT			
Thickness of shims used: 0.300" PUMP SIDE			
Serial Number: 29E1C-55728		Stages 63	
Pump O-ring verified and installed by: NR			
Pump Alignment:			PUMP #2
N/A			
Gap 0.004" 4-7	Height 0/64"	Side to Side 0/64"	
Down Thrust	Up Thrust	Total 0.068"	
Pump shimmed to:	.001" LIFT	1/16	1/32
Thickness of shims used: 0.090" PUMP SIDE			
Serial Number: 29E1C-55729		Stages 63	
Pump O-ring verified and installed by: NR			

Pump Alignment:		N/A		PUMP #3	
Gap		Height		Side to Side	
Down Thrust		Up Thrust		Total	
Pump shimmed to:	Float	1/16		1/32	
Thickness of shims used:					
Serial Number:			Stages		
Pump O-ring verified and installed by:					
Discharge Head Assembly:					
Serial Number: 0215-CA11-2					
Discharge verified to BOM and installed by: NR					
Flush Plan: N/A					
Tubing installed by:			Fittings installed by:		
Type of Plan:					
Barrier Bottle (if required) <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No					
Lemco Bottle verified and installed by:					
Fittings Installed by:			Barrier Fluid filled by:		
Serial Number:			No Leaks		
Electrical: N/A					
Instruments verified and installed by:					
Wiring Installed and verified by:					
Programmable Logic Controller (PLC) Installed/Wired by (if applicable):					
PLC Serial Number:					
Wiring Diagram posted inside cover of Junction box:					

QA Final Check:	
System Test Number (if applicable):	
Verified jack pad bolts installed with locknuts by: KB	
Verified all nuts and bolts for tightness by: NR	
Verified all flange covers in place by: RM	
Verified name plates and sticker information installed by: NR	
Quality Control Plan (QCP) PDMS # (if applicable):	
Ready for Touch-up:	Date: April 4 2011
Comments (if any) on:	
Motor Alignment:	
Thrust Chamber:	
Cooler package:	
Pump Alignment:	
Flush Plan:	
Electrical:	

2-2

Motor Information

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

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

INTRODUCTION

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

QUALIFIED PERSON

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

- a) Is trained and authorized to energize, de-energize, clear, ground and tag circuits and equipment in accordance with established safety practices.
- b) Is trained in the proper care and use of protective equipment such as rubber gloves, hard hat, safety glasses or face shields, flash clothing, etc., in accordance with established safety practices.



DANGER

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



WARNING

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



CAUTION

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

INSPECTION

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

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



WARNING

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

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

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

STORAGE

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

INSTALLATION

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

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

OPERATION

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

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

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



CAUTION

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

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

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

230°F (110°C) for class "B" insulation

275°F (135°C) for class "F" insulation

302°F (150°C) for class "H" insulation

VOLTAGE REGULATION

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

- a. When the variation in voltage does not exceed 10% above or below normal, with all phases balanced.
- b. When the variation in frequency does not exceed 5% above or below normal.
- c. When the sum of the voltage and frequency does not exceed 10% above or below normal (provided the frequency variation does not exceed 5%).

MAINTENANCE

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

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

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

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

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

BEARING LUBRICATION



CAUTION

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

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

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

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

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

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

INSULATION RESISTANCE

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

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

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

CLEANING



WARNING

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

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

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

VERTICAL MOTOR THRUST BEARINGS

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

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

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

SERVICE

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

2-3

Seal Information

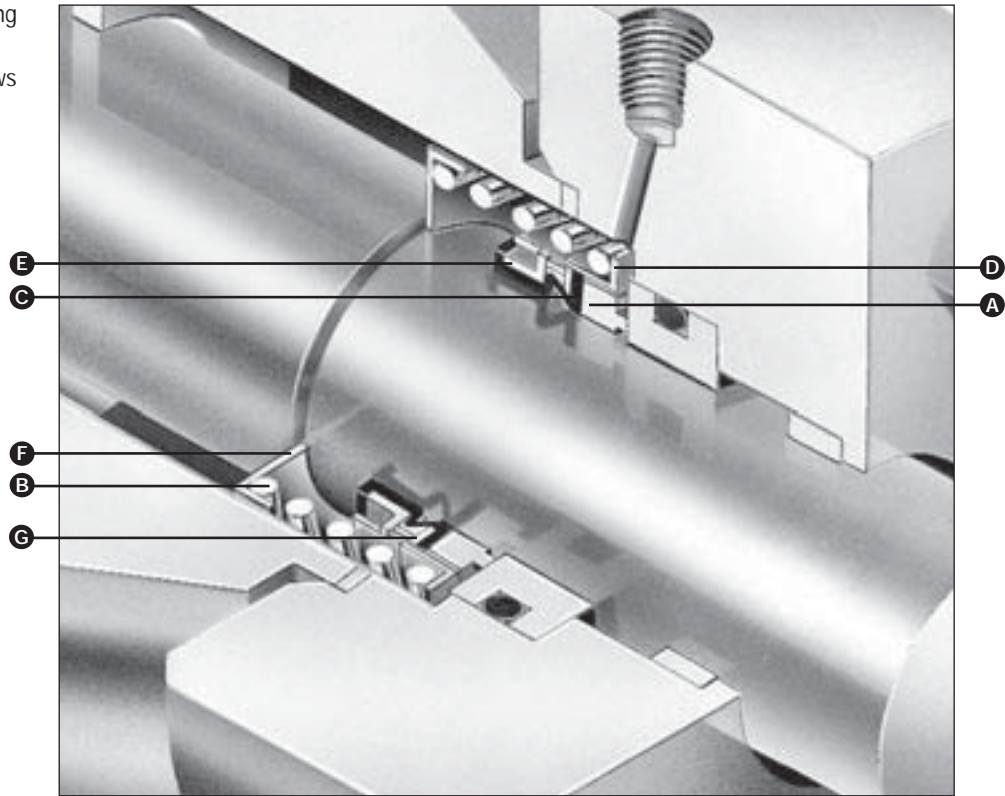


TYPE 2/2B

Elastomer Bellows Seals

2/2B

- A – Face/Primary Ring
- B – Spring
- C – Elastomer Bellows
- D – Retainer
- E – Drive Band
- F – Spring Holder
- G – Disc



Product Description

John Crane Type 2 Elastomer Bellows Seals are specified in more original equipment than any other seal from any other manufacturer. With the highest success rate of any seal of their type, they are suitable for a wide range of service conditions, including water, refrigeration, oils and chemicals.

- Fits equipment with confined space requirements and limited seal chamber depths in pumps, mixers, blenders, agitators, compressors and other rotary shaft equipment.
- For pulp and paper, food processing, water, wastewater, refrigeration, chemical processing and other demanding applications.
- Type 2B is a balanced seal used in higher pressure applications, offering greater operating speeds and reduced face wear.

Performance Capabilities

- Temperature:
-40°C to 205°C/-40°F to 400°F
(depending on materials used)
- Pressure:
2: Up to 29 bar g/425 psig
2B: Up to 83 bar g/1200 psig
- Speed:
See enclosed Speed Limits chart.

Design Features

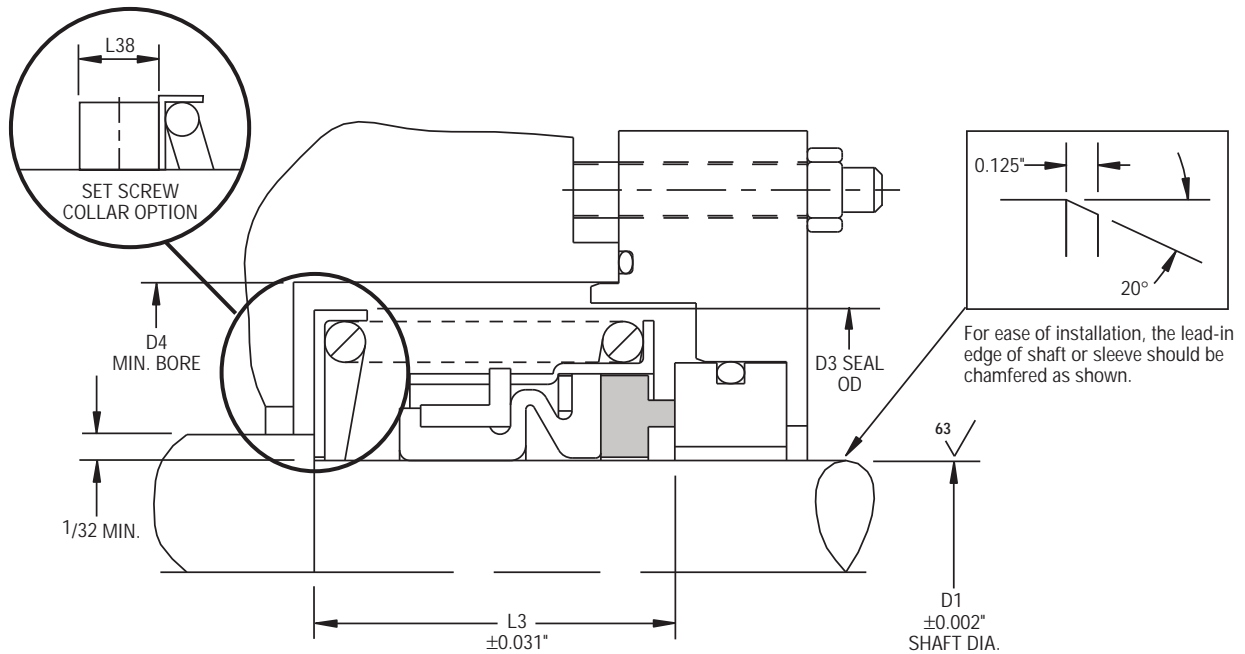
- Mechanical Drive — Eliminates overstressing of the elastomer bellows.
- Self-Aligning Capability — Automatic adjustment compensates for abnormal shaft end play runout, primary ring wear and equipment tolerances.
- Special Balancing — Allows operation at higher pressures.
- Non-Clogging, Single-Coil Spring — Not affected by buildup of solids.



TYPE 2/2B

Elastomer Bellows Seals

Type 2 Typical Arrangement/Dimensional Data



Type 2 Dimensional Data (inches)

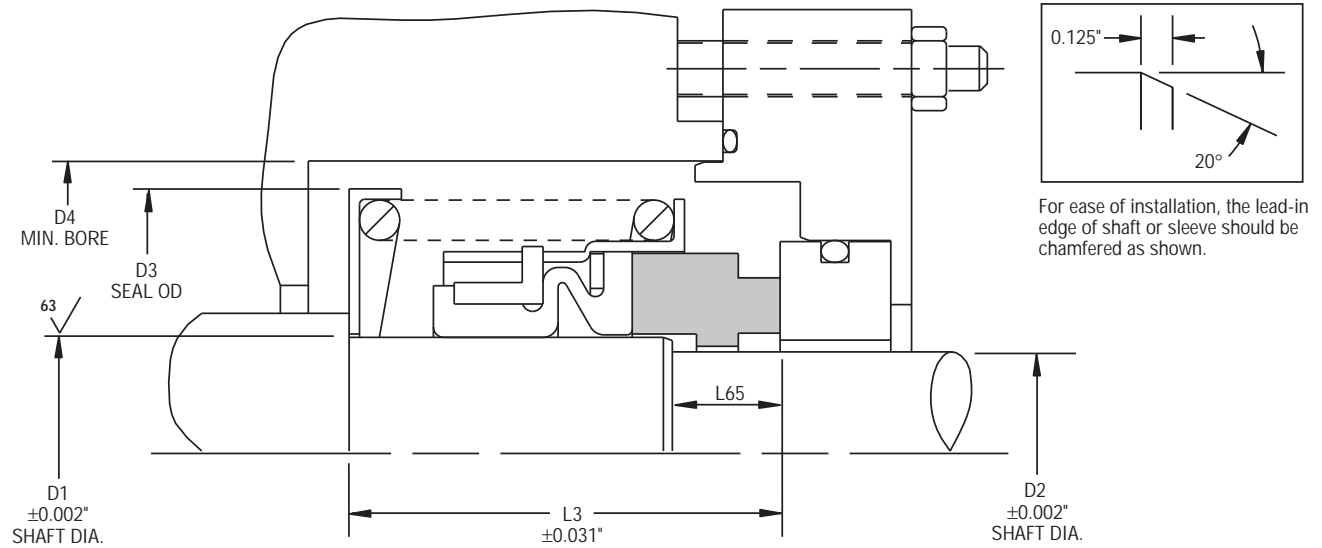
Seal Size/D1 (inches)	D3	D4	L3	L38
1.000	1.812	2.000	1.000	0.375
1.125	1.937	2.125	1.062	0.375
1.250	2.062	2.250	1.062	0.375
1.375	2.250	2.437	1.125	0.375
1.500	2.375	2.562	1.125	0.375
1.625	2.718	2.937	1.375	0.375
1.750	2.750	3.062	1.375	0.375
1.875	2.875	3.187	1.500	0.375
2.000	3.000	3.312	1.500	0.375
2.125	3.250	3.625	1.687	0.500
2.250	3.375	3.750	1.687	0.500
2.375	3.500	3.875	1.812	0.500
2.500	3.625	4.000	1.812	0.500
2.625	3.875	4.312	1.937	0.500
2.750	4.000	4.437	1.937	0.500
2.875	4.125	4.562	2.062	0.500
3.000	4.250	4.687	2.062	0.500
3.125	4.562	5.000	2.187	0.500
3.250	4.687	5.125	2.187	0.500
3.375	4.812	5.250	2.187	0.500
3.500	4.937	5.500	2.187	0.500
3.625	5.125	5.687	2.312	0.562
3.750	5.250	5.812	2.312	0.562
3.875	5.437	6.000	2.312	0.562
4.000	5.562	6.125	2.312	0.562



TYPE 2/2B

Elastomer Bellows Seals

Type 2B Typical Arrangement/Dimensional Data



Type 2B Dimensional Data (inches)

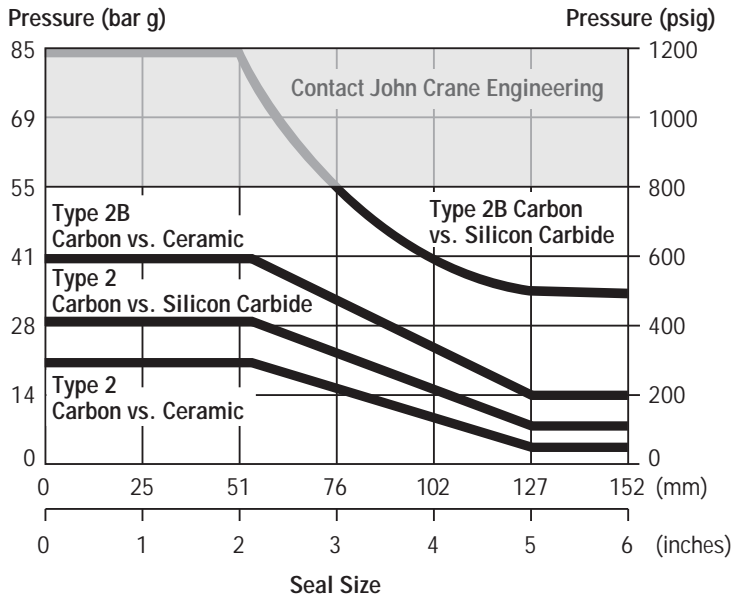
Seal Size/D1 (inches)	D2	D3	D4	L3	L65
1.000	0.875	1.812	2.000	1.312	0.343
1.125	1.000	1.937	2.125	1.375	0.343
1.250	1.125	2.062	2.250	1.375	0.343
1.375	1.250	2.250	2.437	1.437	0.343
1.500	1.375	2.375	2.562	1.437	0.343
1.625	1.500	2.718	2.937	1.750	0.437
1.750	1.625	2.750	3.062	1.750	0.437
1.875	1.750	2.875	3.187	1.875	0.437
2.000	1.875	3.000	3.312	1.875	0.437
2.125	2.000	3.250	3.625	2.062	0.500
2.250	2.125	3.375	3.750	2.062	0.500
2.375	2.250	3.500	3.875	2.187	0.500
2.500	2.375	3.625	4.000	2.187	0.500
2.625	2.500	3.875	4.312	2.312	0.562
2.750	2.625	4.000	4.437	2.312	0.562
2.875	2.750	4.125	4.562	2.437	0.562
3.000	2.875	4.250	4.687	2.437	0.562
3.125	2.875	4.562	5.000	2.562	0.625
3.250	3.000	4.687	5.125	2.562	0.625
3.375	3.125	4.812	5.250	2.562	0.625
3.500	3.250	4.937	5.500	2.562	0.625
3.625	3.375	5.125	5.687	2.687	0.625
3.750	3.500	5.250	5.812	2.687	0.625
3.875	3.625	5.437	6.000	2.812	0.625
4.000	3.750	5.562	6.125	2.812	0.625



TYPE 2/2B

Elastomer Bellows Seals

Basic Pressure Rating



To determine the maximum pressure for the Type 2 or 2B required, multiply the maximum pressure by the Multiplier Factors to obtain the maximum operating pressure.

The Basic Pressure Rating is based on a standard Type 2 or Type 2B seal installed according to the criteria given in this data sheet and according to generally accepted industrial practices. The Basic Pressure Rating assumes stable operation at 1800 rpm in a clean, cool, lubricating, non-volatile liquid, with an adequate flush rate. When used with the Multiplier Factors, the Basic Pressure Rating can provide a conservative estimate of the dynamic pressure rating.

Contact John Crane Engineering for process services outside this range and with more detailed application information in order to obtain the actual dynamic pressure rating.

Multiplier Factors

	Selection Considerations	Multiplier Factor
Speed	1800 rpm Above 1800 rpm	x 1.00 *
Sealed Fluid Lubricity	Petrol/Gasoline, Kerosene, or Better Water and Aqueous Solutions Flashing Hydrocarbons** (Specific Gravity <0.65)	x 1.00 x 0.75 x 0.60
Sealed Fluid Temperature (for carbon only)	Below 79°C/175°F From 79°C to 121°C/175°F to 250°F From 121°C to 177°C/250°F to 350°F Above 177°C/350°F	x 1.00 x 0.90 x 0.80 x 0.65

* Multiplier = 1800/new speed Example: If new speed = 2700 rpm
Multiplier = 1800/2700 = 0.67

** The ratio of sealed pressure to vapor pressure must be greater than 1.5, otherwise consult John Crane. If the specific gravity is less than 0.60, consult John Crane.

Example for Determining Pressure Rating Limits:

Seal: 76mm/3" diameter Type 2B

Product: Water

Face Material: Carbon vs. Silicon Carbide

Temperature: 16°C/60°F

Shaft Speed: 1800 rpm

Using the Basic Pressure Rating chart, the maximum pressure would be 55 bar g/800 psig.

From the Multiplier Factors chart, apply the multipliers for the specific service requirements to determine the maximum dynamic pressure rating for the application.

$$55 \text{ bar g/800 psig} \times 1 \times 0.75 \times 1 = 41 \text{ bar g/600 psig}$$

At 1800 rpm with the service conditions noted, a 76mm/3" diameter Type 2B seal has a dynamic pressure rating of 41 bar g/600 psig. If operating pressure exceeds this dynamic rating, consult your John Crane Sales/Service Engineer.



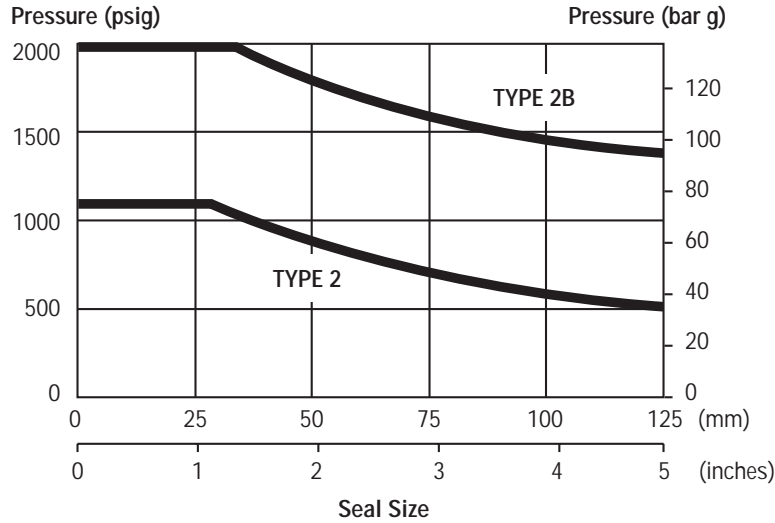
TYPE 2/2B

Elastomer Bellows Seals

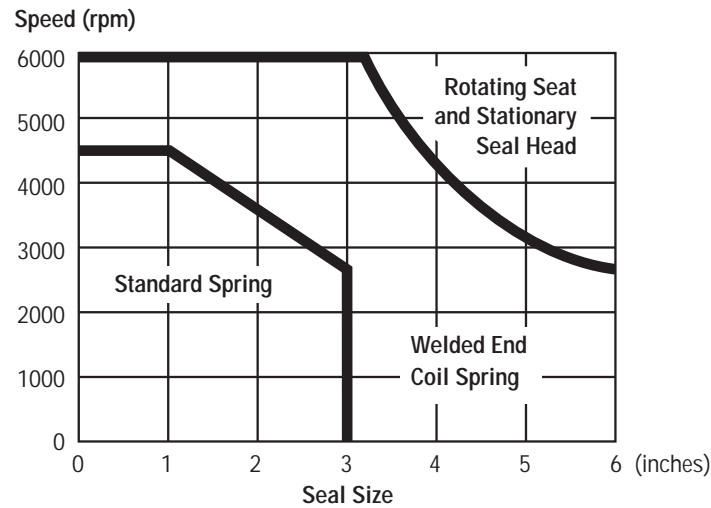
Breakout (Starting) Torque Consumption for Seal

For Starting Torque Power Consumption, consult John Crane Engineering.

Hydrostatic Pressure Limits



Speed Limits for Coil Springs



Criteria for Installation

Shaft/Sleeve	Limits
Surface Finish	1.00" to 3.125" dia. / 63 Ra 3.125" dia. & up / 32 Ra
Ovality/Out of Roundness (Shaft)	0.051mm/0.002"
End Play/Axial Float Allowance	±0.13mm/0.005"



TYPE 2/2B

Elastomer Bellows Seals

Materials of Construction

SEAL COMPONENTS	MATERIALS	
	Description	Options
Face/Primary Ring	Carbon	Antimony-Impregnated Carbon Tungsten Carbide Silicon Carbide
Retainer Drive Band Disc Spring Holder	18-8 Stainless Steel	Monel® Alloy 20 CB-3 Stainless Steel 316 Stainless Steel
Bellows	Buna-N	Aflas® Fluoroelastomer Ethylene Propylene Neoprene® (Chloroprene)
Springs	18-8 Stainless Steel	Monel Alloy 20 CB-3 Stainless Steel 316 Stainless Steel

Aflas is a registered trademark of the Asahi Glass Co. Ltd.
 Monel is a registered trademark of Inco Alloys International, Inc.
 Neoprene is a registered trademark of DuPont.

Application Criteria

Type 2/2B elastomer bellows seals can be customized for specific installations after review and evaluation by John Crane Engineering. The following data is needed to evaluate the proposed service:

- Make and Model of Equipment
- Shaft or Sleeve OD
- Direction of Shaft Rotation
Viewed from Drive End
- Seal Cavity Dimensions
- Speed
- Process Fluid
 - Specific Gravity
 - Box Pressure
 - Vapor Pressure
 - Temperature
 - Viscosity



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Latin America
São Paulo, Brazil

Tel: 55-11-3371-2500
Fax: 55-11-3371-2599

Middle East, Africa, Asia
Dubai, United Arab Emirates

Tel: 971-4-3438940
Fax: 971-4-3438970

North America
Morton Grove, Illinois USA

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For your nearest John Crane facility, please contact one of the locations above.

If the products featured will be used in a potentially dangerous and/or hazardous process, your John Crane representative should be consulted prior to their selection and use. In the interest of continuous development, John Crane Companies reserve the right to alter designs and specifications without prior notice. It is dangerous to smoke while handling products made from PTFE. Old and new PTFE products must not be incinerated.

2-4

Pressure Switchgauge Information

Not Applicable on this order

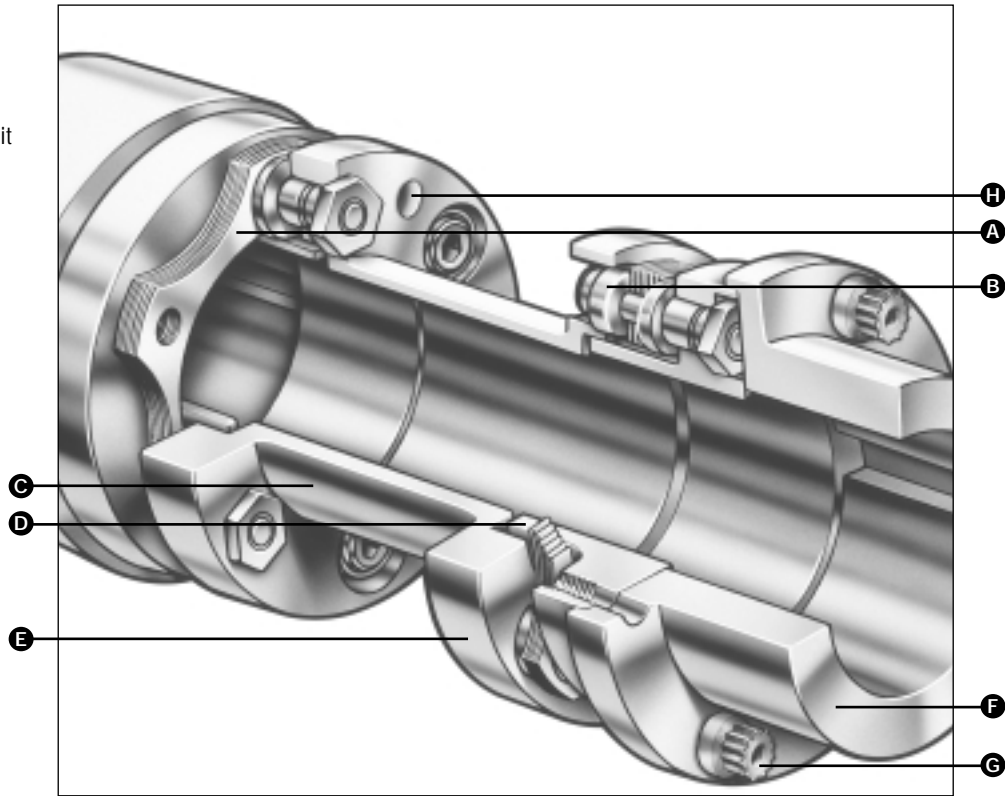
2-5

Vibration Switchgage Information

2-6

Motor/Tc Coupling Information

- A – Stainless Steel Flexible Discs
- B – Overload Collars
- C – Cartridge Transmission Unit
- D – Anti-Fly Feature
- E – Anti-Corrosion Treatment
- F – Hubs with Puller Holes
- G – Externally Wrenched Bolts
- H – Jacking Bolt Feature



Product Description

Metastream® T Series Couplings, pioneered by John Crane Flexibox®, incorporate a scalloped, stainless steel flexible disc design. This design gives the most flexible solution for high torque and misalignment.

- Easy to fit.
- Meets API 610 8th edition. Can be supplied to meet API 671.
- Intrinsic balance meets AGMA class 9.
- Ideally suited for electric motors and turbine drives in critical process industry, marine, and power generation applications.

Design Features

- Excellent power-to-weight ratio.
- High misalignment capability.
- Low imposed forces on machinery leading to:
 - Reduced machinery vibration
 - Maximized bearing life
- Stainless steel flexible discs for maximum life.
- Cartridge transmission unit eases assembly and gives repeatable balance.
- Overload collars are fitted to protect the flexible discs in case of a more severe torsional overload.
- Anti-fly retention of the spacer in the unlikely event of flexible disc failure.
- Jacking bolt feature for easy installation and removal of spacer assembly.
- Puller holes incorporated into hubs as standard.



TSC

METASTREAM® T Series Couplings

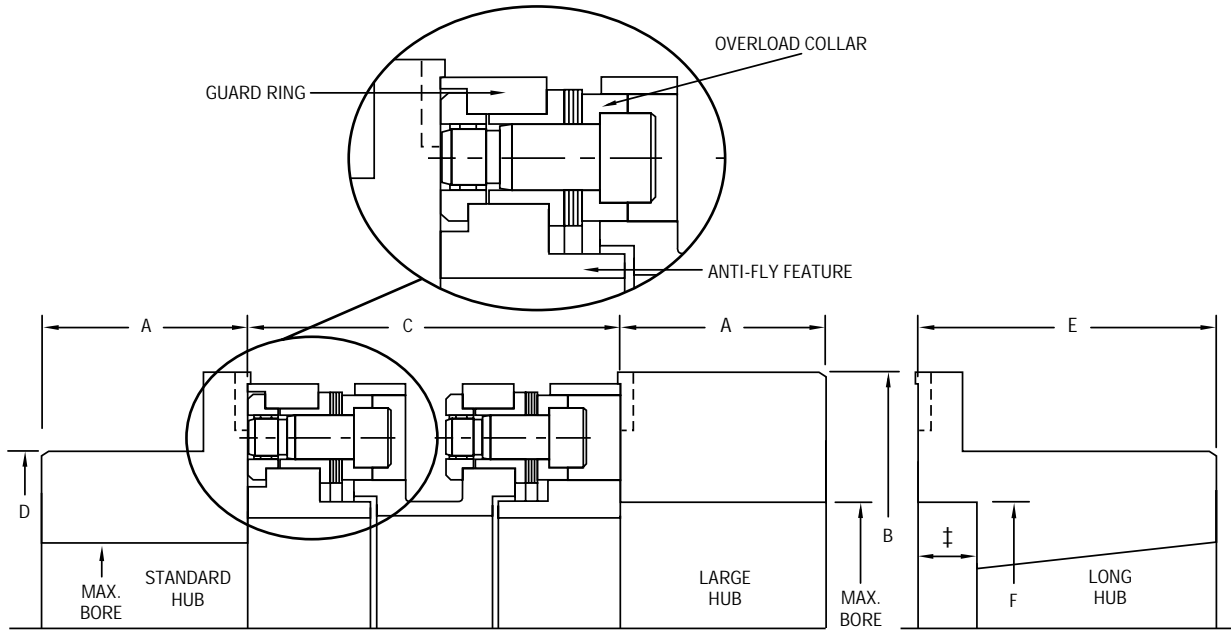
TSC Technical Data

Coupling Size	Rating HP/100 rpm	Max.		Max. rpm	Weight - Transmission Unit (lb.)		Weight - Unbored Hub (lb.)		
		Continuous Torque lb. in.	Peak Overload Torque lb. in.		Minimum DBSE	Per Inch Extra DBSE	Standard	Large	Long
0013	1.7	1,068	2,670	25,500	3.0	0.2	1.9	4.0	-
0033	4.4	2,770	6,920	20,000	5.9	0.3	3.4	6.7	-
0075	10.0	6,300	15,750	16,500	11.2	0.4	7.5	12.6	8.2
0135	18.0	11,340	28,350	14,400	19.5	0.6	12.2	19.4	14.8
0230	31.0	19,520	48,800	12,000	28.1	0.7	19.4	30.6	24.4
0350	47.0	29,600	74,000	10,500	35.2	0.7	35.9	-	41.4
0500	67.0	42,200	105,000	9,500	44.2	0.9	46.2	-	57.6
0740	99.0	62,360	155,900	8,000	55.9	1.1	66.4	-	81.9
0930	125.0	78,740	196,850	7,000	71.7	1.3	85.0	-	110.7
1400	188.0	118,440	296,100	6,000	101.6	1.8	115.7	-	159.5

Note that for the complete coupling, weights of two appropriate hubs plus a transmission unit are required.

Hubs will be supplied unbored unless specified. Consult your local sales office regarding standard bore and keyway tolerances.

TSC Typical Arrangement



† To Suit Specific Applications

TSC Dimensional Data (inches)

Coupling Size	A	B	C		D	E	F	MAXIMUM BORES		
			Distance Between Shaft Ends Min.	Stocked*				Standard Hub**	Large Hub**	Long Hub***
0013	1.562	3.375	2.50	3.5, 4.375, 5.0, 7.0	2.125	-	-	1.375	2.000	-
0033	1.750	4.125	3.00	3.5, 4.375, 5.0, 7.0	2.750	-	-	1.750	2.750	-
0075	2.187	5.125	3.68	4.375, 5.0, 7.0	3.500	2.437	2.938	2.250	3.375	2.250
0135	2.437	6.000	4.56	5.0, 7.0	4.437	3.031	3.875	2.875	4.000	2.875
0230	2.750	7.000	4.81	7.0	5.187	3.593	4.625	3.375	4.750	3.375
0350	3.562	8.000	4.94	7.0	6.437	4.187	5.750	4.375	-	4.375
0500	3.750	9.000	5.00	7.0	7.125	4.750	6.500	4.625	-	4.625
0740	4.250	10.000	5.12	8.0	8.125	5.312	7.375	5.500	-	5.500
0930	4.500	11.000	5.50	9.0	8.750	6.031	8.000	5.750	-	5.750
1400	5.125	12.000	6.31	10.0	9.750	7.187	9.000	6.500	-	6.500

All dimensions in inches, and should not be used for construction. Certified dimensions furnished upon request.

NOTES: * These Distance Between Shaft End (DBSE) sizes are stocked. Other lengths to suit specific shaft separations are available.

** Maximum bores shown are based on standard AGMA square key dimensions.

*** Accommodates NEMA standards for taper bores.



TSC

METASTREAM® T Series Couplings

Selection Procedure

1. Select appropriate service factor SF from table.
2. Calculate coupling rating from

$$R = \frac{HP \times 100 \times SF}{N}$$
 where:
 HP = driver rated power (horsepower)
 N = speed (rev./min.)
3. Select a coupling with the same or higher rating.
4. Check that the hub bore capacity is suitable.
5. Check peak torque capability is suitable for application.
6. Check speed capability.
7. Check whether additional dynamic balancing is required.
8. Specify Distance Between Shaft Ends (DBSE).

Example: 150 HP electric motor to centrifugal pump at 3600 rpm.

$$R = \frac{150 \times 100 \times 1}{3600}$$

R = 4.17 HP per 100 rpm

Selection: TSC - 0033

Standard hub bore up to 1.75"
 Large hub bore up to 2.75"
 Peak torque capability: 6920 lb.-in.

Additional dynamic balancing should not be required.

Service Factor SF

Suggested service factors for electric motor, steam turbine, and gas turbine drivers are given below.

Torque Variation		Service Factor
Constant Torque	Centrifugal Pump Centrifugal Compressor Axial Compressor Centrifugal Blower	1.0*
Slight Torque Fluctuation	Screw Compressor Gear, Lobe and Vane Pumps Forced Draft Fan Medium Duty Mixer Lobe Blower	1.5
Substantial Torque Fluctuations	Reciprocating Pumps Heavy Duty Mixers Induced Draft Fans	2.0

*Use a minimum service factor of 1.25 on electric motor drives through a gearbox.

The examples given are for typical machines and are empirically based guidelines. Knowledge of actual torque characteristics may indicate a different service factor. Consult John Crane for advice.



A Windows® based computer selection program for the TSC is available. This selection program provides all necessary technical data, inertias, torsional stiffness, etc. Contact John Crane.

Available Options

- Spark-resistant couplings for hazardous zone operation.
- Special materials for low temperature applications and/or higher corrosion resistance.
- Electrical insulation.

- Torque limiting and shear pin designs.

Consult John Crane for any other special requirements. Metastream couplings can be adapted to suit virtually all power transmission coupling needs.



TSC

METASTREAM® T Series Couplings

Coupling Alignment

Correct installation and alignment of couplings is essential for reliable machinery performance.

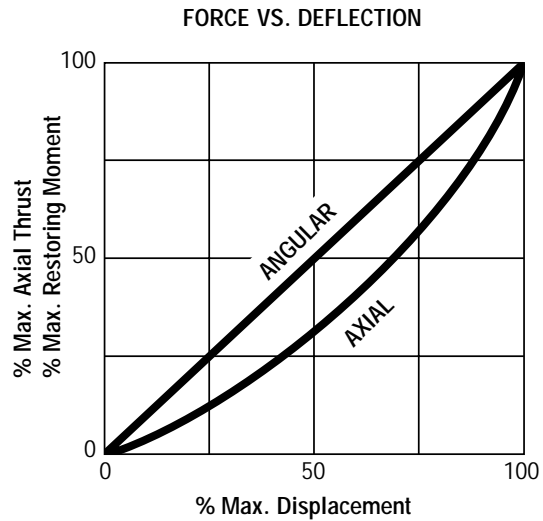
John Crane supplies a variety of shaft alignment equipment and offers alignment training courses.

TSC MISALIGNMENT				
Coupling Size	Max. Axial Misalignment*		Max. Parallel Misalignment**	
	+/- in.	Equivalent Thrust-lb.	in.	Restoring Moment lb.-in.
0013	±0.040	47	0.020	36
0033	±0.050	63	0.020	54
0075	±0.060	81	0.022	78
0135	±0.080	126	0.024	104
0230	±0.100	166	0.040	130
0350	±0.110	175	0.040	300
0500	±0.130	243	0.040	360
0740	±0.150	286	0.048	420
0930	±0.170	331	0.055	480
1400	±0.200	608	0.060	540

NOTES: * Meets NEMA end float specifications without modification.

** Values based on angular deflection of 1/2° per end and minimum stock DBSE. Greater misalignment accommodation is possible by increasing dimension C.

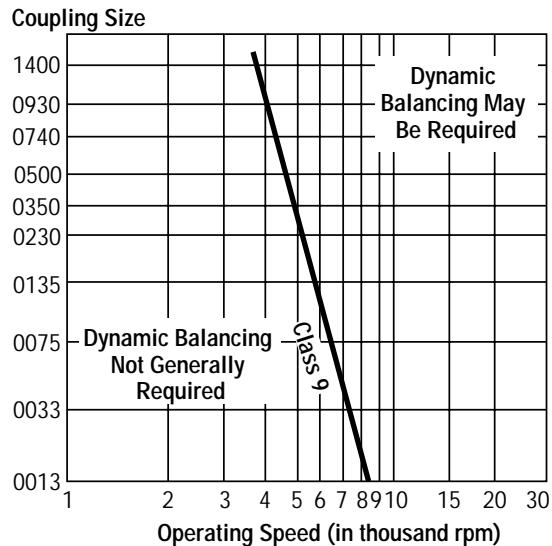
The angular and axial restoring forces in the table below left are given at maximum deflections. The chart can be used to determine forces across the full deflection range. The nonlinear characteristics can detune a system to prevent high amplitude axial vibration.



Balance Recommendations

The chart illustrates the relationship between the TSC sizes and their operating speeds to meet AGMA class 9, which is appropriate for most applications.

The inherent balance of the TSC range meets AGMA standard 9000-C90 class 9. Use this chart as a general guide to determine if dynamic balance improvement is required.



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2-7

Thrust Chamber Information

Schlumberger

REDA Production Systems

HORIZONTAL UNIT MAINTENANCE AND REPAIR

G3 THRUST SECTION

The thrust chamber reservoir is filled with the recommended lubricant prior to shipment. The fluid level will be at or near the center of the sight glass located on the side of the reservoir. As long as fluid is visible in the sight glass, it is not necessary to add oil.

MODEL G3 THRUST CHAMBER

A lubricant change is recommended every six months of continuous operation. A plug for draining the lubricant can be removed from the bottom of the reservoir. This plug is a 1" pipe plug and can be removed with an adjustable wrench. Fill the chamber through the vent cap located on top of the reservoir.

Caution should be taken not to fill the reservoir to a level above the center of the sight glass. The capacity is 1.0 gallon (3.79 liters). Do not overfill as overfilling causes excess heat build up in the thrust chamber.

It is not unusual to have a small amount of oil seepage from the front and rear seal of the bearing chamber. The leakage is minimal and replenishing of the oil level should not be required more than once in a six-month period.

Use only Reda recommended thrust chamber lubricant, Royal Purple, Synfilm 46 GT, Part Number 100179556 (five gallon).

Cartridge & Non-Cartridge Seal

The Cartridge type (or Non-Cartridge type) mechanical seal isolates the fluid from the thrust section. If this seal should leak, the fluid will be visible in the area between the intake and thrust section. When the seal requires changing out, the spacer coupling between the motor and the thrust chamber is removed. Any SS tubing connected to the seal cartridge needs to be removed (make sure the intake and discharge valves for the pump are closed and the pressure in the pump is bleed down). Provision should be made to prevent spillage of the oil. The thrust chamber and seal section is now ready to remove as a unit. The assembly must be supported during removal; the assembly weight is approx. 275 lbs. The ring of bolts on the seal-retaining bracket is removed. The assembly moves toward the motor until the "O"-ring has cleared. The assembly should move freely toward the motor. The thrust chamber shaft is coupled to pump shaft with a splined coupling. Inside the coupling is a set of shim washers. The shims are critical to the operation of the pump and must be installed when the unit is assembled. Once the assembly is moved back and the thrust chamber shaft has cleared the intake housing remove the splined coupling.

Cartridge Seal Removal

The seal and seal chamber is removed by first unscrewing four 7/16" Allen head bolts located on the fluid side of the adapter spool. The bolts are located on the same lip as the "O"-ring. The setscrews on the seal-driving sleeve are loosened. The shaft has to be cleaned of any foreign material. After the shaft is clean the seal and seal chamber is removed by use of two jacking bolts (use the 7/16 Allen head bolts). Once the seal chamber has cleared its mounting plate slide it down the shaft. The seal is removed from the seal chamber by removing the four bolts and separating the two pieces. The throat bushing located in the seal chamber should be inspected and replaced if damaged or worn.

Non-Cartridge Seal Removal

Thoroughly clean the shaft and primary ring surface area. Reverse the dismantle process to install the seal. O-Ring lubricant should be used when replacing the mating ring to facilitate installation. The use of tool Part Number 3900672 will also facilitate this installation. Use a quality non-detergent oil on the shaft to install the primary mating assembly.

All "O"-rings should be lubricated with silicon grease before assembly. The new seal is installed in the seal chamber and tighten. The rest of the components are assembled in the reverse order to disassembly.

Replacement of Thrust Chamber Bearing Sub-Assembly

The procedure for replacing the subassembly is basically the same as replacing the seal down to the point where the seal chamber is to be removed from the shaft. The eight bolts located at the junction of the bearing sub-assembly and the adapter spool are removed. This will separate the bearing sub-assembly and the adapter spool.

The new sub-assembly is attached to the adapter spool and then the seal chamber is installed as instructed above. Upon completion, it will be necessary to re-set or check the shaft setting. See Shaft Setting procedure.

Pump Replacement

The upper half of the pump clamps need to be loosened or removed the entire length of the skid. The base of the pump at the intake end is to be unbolted from the intake adapter. A section of the discharge piping, i.e., dropout spool, will have to be removed to allow the pump to be moved toward the discharge end of the skid 10 to 12 inches. The pump jacks need to be placed on the main beam accordingly to allow the entire pump to be lifted slightly by the jacks. Slide the pump away from the intake. If possible, leave the coupling between the intake and pump on the pump shaft. This coupling has been shimmed on the pump side. To avoid losing the shims, do not remove them from the coupling. The pump should be free. Using a two-point sling lift the pump out of the saddles and set aside. In the case of multiple pumps lift the pumps out in sections

starting with the pump farthest from the motor. Install the new pumps in the reverse manner shimming the pumps as described in the attached shimming procedure.

Since the top half of the pump support saddles have been removed from the skid, they must be replaced in the same manner as they were removed. The top and bottom half of each saddle has a number stenciled on one side only of each half. These numbers must match and be on the same side.

BOLTING TORQUE SPECIFICATIONS

- 3/8" bolts
- 1/2" heads
- 20 ft-lbs.
- If using a torque wrench (Part Number 1156926) with adapter (Part Number 0047225), set at 17 ft-lbs.

- 7/16" bolts
- 5/8" heads
- 30 ft-lbs.
- If using a torque wrench (Part Number 1156926) with adapter (Part Number 0047225), set at 26 ft-lbs.

- 1/2" bolts
- 3/4" heads
- 50 ft-lbs.
- If using a torque wrench (Part Number 1156926) with adapter (Part Number 0047233), set at 43 ft. lbs.

- 9/16" bolts
- 13/16" heads
- 70 ft-lbs.
- If using a torque wrench (Part Number 1156926) with adapter (Part Number 0047225), set at 61 ft-lbs.

- 5/8" bolts
- 15/16" heads
- 80 ft-lbs.
- If using a torque wrench (Part Number 1156926) with adapter (Part Number 0047225), set at 70 ft-lbs.

- 1" bolts
- 1 1/4" heads
- 100 ft-lbs.
- If using a torque wrench (Part Number 1156926) with adapter (Part Number 0047225), set at 87 ft-lbs.

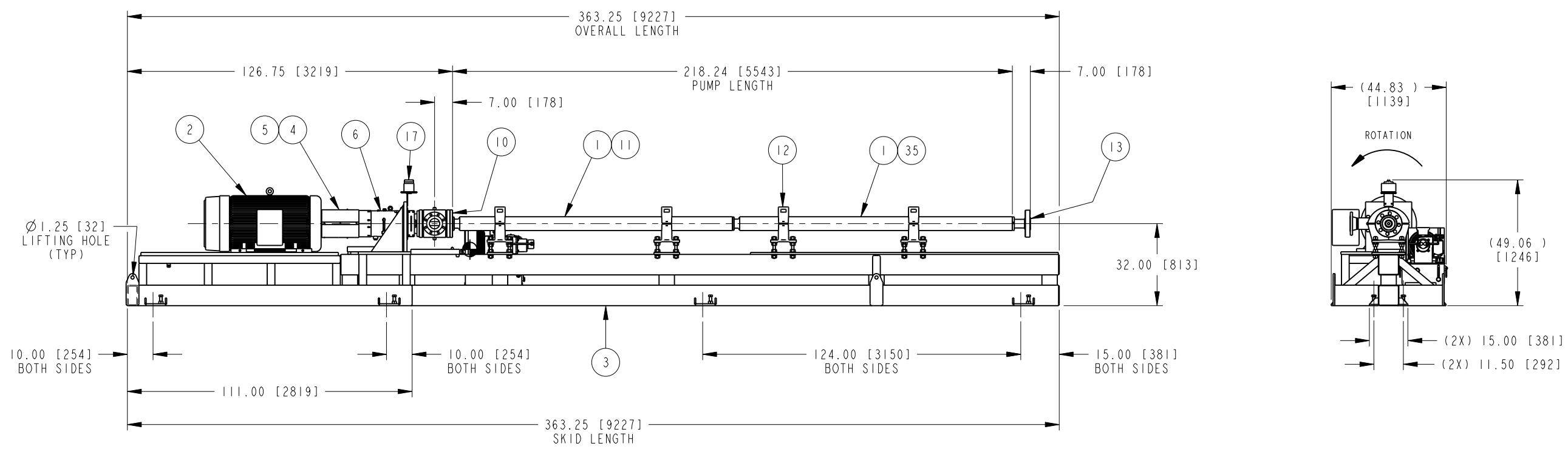
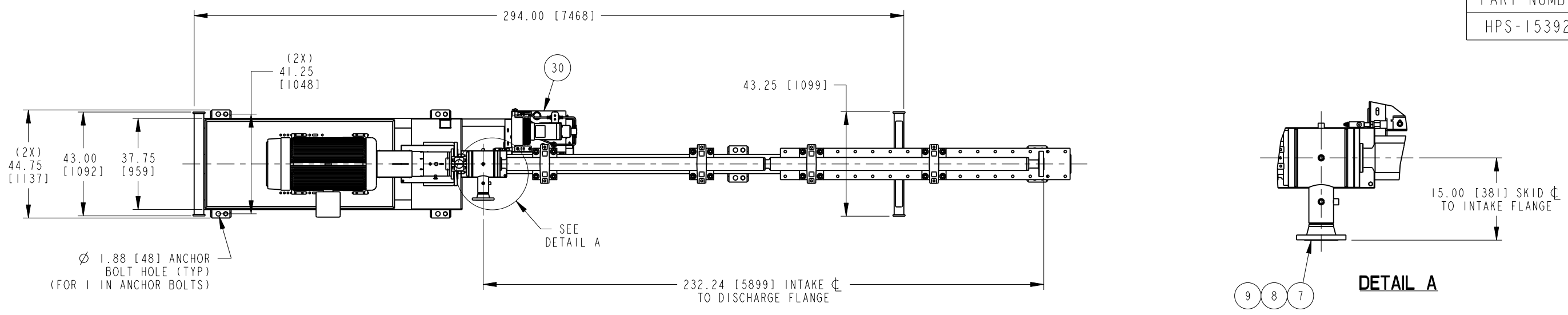
Drawings and Bills of Materials


3.1	General Assembly Drawing and Bill of Materials _____	3-1
3.2	Thrust Chamber Serviceable Parts Drawing and Bill of Materials	3-1
3.3	Seal Drawing _____	3-1
3.4	Motor Drawing _____	3-1
3.5	Electrical Drawing _____	3-1
3.6	Pump Shaft Setting Procedure _____	3-1
3.7	Pump Drawing and Bill of Material _____	3-1

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PART NUMBER
HPS-153928



2. CENTER OF GRAVITY SYMBOL  IS FOR REF ONLY AND LOCATED 21" VERTICALLY FROM MOUNTING SURFACE AND 132" HORIZONTALLY FROM MOTOR END.

1. DIMENSIONS IN [] ARE IN MM

CUSTOMER: PARAMOUNT RESOURCES
PROJECT: WATER DISPOSAL
LOCATION:
RFQ NO. 153928
ESTIMATED UNIT WEIGHT: 9,250 LBS.

REVISED		
CHECKER		
ENGINEER	BLACK	5-JAN-2011
DESIGNER	BLACK	5-JAN-2011

Schlumberger
BARTLESVILLE TECHNOLOGY CENTER
A DIVISION OF SCHLUMBERGER TECHNOLOGY CORPORATION




DWG. GA: G3N24.
PARAMOUNT RESOURCES, RFQ 153928

	FORMAT B	SCALE 0.022	UNITS IN	HPS-153928D	REVISION AA	PAGE 1/1
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Part SLB HPS-153928 AA: Specifications and Engineering Bill of Materials

Robert Brandabura
Apr 26, 2011

												EBOM Values		Specification Values	
Type	Name	Rev	Last Rev	Strong Link Rev	Description	State	U of M	Qty	Item Num	General Notes	Relationship Name	Reference Designator	Usage	Document Usage	Files
ProE Drawing	HPS-153928D	AA	AA		DWG, GA: G3N24, PARAMOUNT RESOURCES, RFQ 153928	Released		0.0			Part Specification			Described By	hps-153928d.asm.20 hps-153928d.drw.13 hps-153928d.ps hps-153928d.pdf
General Spec	HPS-DOC-INDEX	AC	AC		HPS PROCEDURE / SPECIFICATION INDEX	Released		0.0			Part Specification			Reference Document	HPS-DOC-INDEX.doc HPS-DOC-INDEX.pdf
Part SLB	7005564	-0	-0		SEAL: JC, TYPE 2, 1.50 SZ, NON-CART, MONEL, HSN, CF-SP-93410-8	Released	EA	1.0	007		EBOM		Uses		
Part SLB	3920209	-C	-C		MOTOR: SIEMENS, 250HP 460V 269A 60HZ, 449TS, TEFC, BALL BRG, 3570 FLRPM, SD100 NEMA PREMIUM	Released	EA	1.0	002		EBOM		Uses		
Part SLB	3909570	AB	AB		ADAPTER: INTAKE,PMP 538/540,SS,12 HOLES	Released	EA	1.0	010		EBOM		Uses		
Part SLB	3909505	AE	AE		ASSEMBLY: INTAKE, 4 IN, 150, RFWN, 316L SS, MAWP-230 PSI	Released	EA	1.0	009		EBOM		Uses		
Part SLB	3909357	-R	-R		ASSEMBLY: COOLER, OIL, BH, EXPLOSION PROOF, 60HZ, 115/230V, 1PH, WITH INTERCONNECT KIT	Released	EA	1.0	030		EBOM		Uses		
Part SLB	3909028	-D	-D		HEAD ASSY: DISCHARGE, 3 IN., 1500, RF, 540/538 SERIES, 316L SS, MAWP-3000 PSI	Released	EA	1.0	013		EBOM		Uses		
Part SLB	3908566	--	--		COUPLING ASSY:PUMP,.87-6A SPLINE	Released	EA	1.0	035		EBOM		Uses		
Part SLB	2008012	AK	AK		PUMP: S75N CR-CT 63 STG 538/540 60 CS BTHD, .87 HS MON, M-TRM, HSN, ARZ, SS H&B, BLUE PAINT	Released	EA	2.0	001		EBOM		Uses		
Part SLB	139020444	AB	AB		WELDMENT ASSY, G3, ND, 4 CLAMP, 11 INCH HEIGHT,STD GRAY	Released	EA	1.0	003		EBOM		Uses		
Part SLB	100538851	AB	AB		SEAL HOUSING: ASSY, G3, NON-CART, TYPE 2 SEAL, W/FLANGE O-RING	Released	EA	1.0	008		EBOM		Uses		
Part SLB	100480871	AC	AC		GUARD: ASSY, HPS, CPLG, 16-22 INCHES	Released	EA	1.0	005		EBOM		Uses		
Part	100467474	AB	AB		KIT, MOTOR MOUNTING,0.625 BOLTS, ND/MD SKID	Released	EA	1.0	022		EBOM		Uses		
Part SLB	100447637	AK	AK		THRUST CHAMBER: ASSEMBLY, 2 BEARING, HPS, G3A, 1.18-6B SPLINE, STD BLUE	Released	EA	1.0	006		EBOM		Uses		
Type	Name	Rev	Last Rev	Strong Link Rev	Description	State	U of M	Qty	Item Num	General Notes	Relationship Name	Reference Designator	Usage	Document Usage	Files
Part SLB	100335857	AP	AP		KIT: SWITCH, VIBRATION, MURPHY VS2EX	Released	EA	1.0	017		EBOM		Uses		
Part SLB	100330563	AA	AA		CLAMP: PUMP, HPS, 538 SERIES PUMP, STD GRAY	Released	EA	4.0	012		EBOM		Uses		
Part SLB	100321016	AA	AA		KIT, DISCHARGE MOUNTING, 538 SERIES PUMP, MONEL, STD	Released	EA	1.0	024		EBOM		Uses		
Part	100304355	AA	AA		KIT, HPS, O-RING SET, HSN, 538/540 SERIES TANDEM	Released	EA	1.0	023		EBOM		Uses		

Part SLB	100155758	AC	AC	ASSEMBLY, COUPLING, METASTREAM, TSCS/TSKS 0135, W/7 IN SPACER, 2.375- 2.375 BORE	Released	EA	1.0	004	EBOM	Uses	
Part	100102423	AJ	AJ	CP: HPS-G3, ND/MD, 4 CLAMP, COMPONENT HARDWARE DETAILS	Released	EA	1.0	020	EBOM	Uses	
Part SLB	0266445	-J	-J	COUPLING: ASSY, 1.18-6B X 0.875-6A SPLINE, 2.75 IN., MONEL	Released	EA	1.0	011	EBOM	Uses	

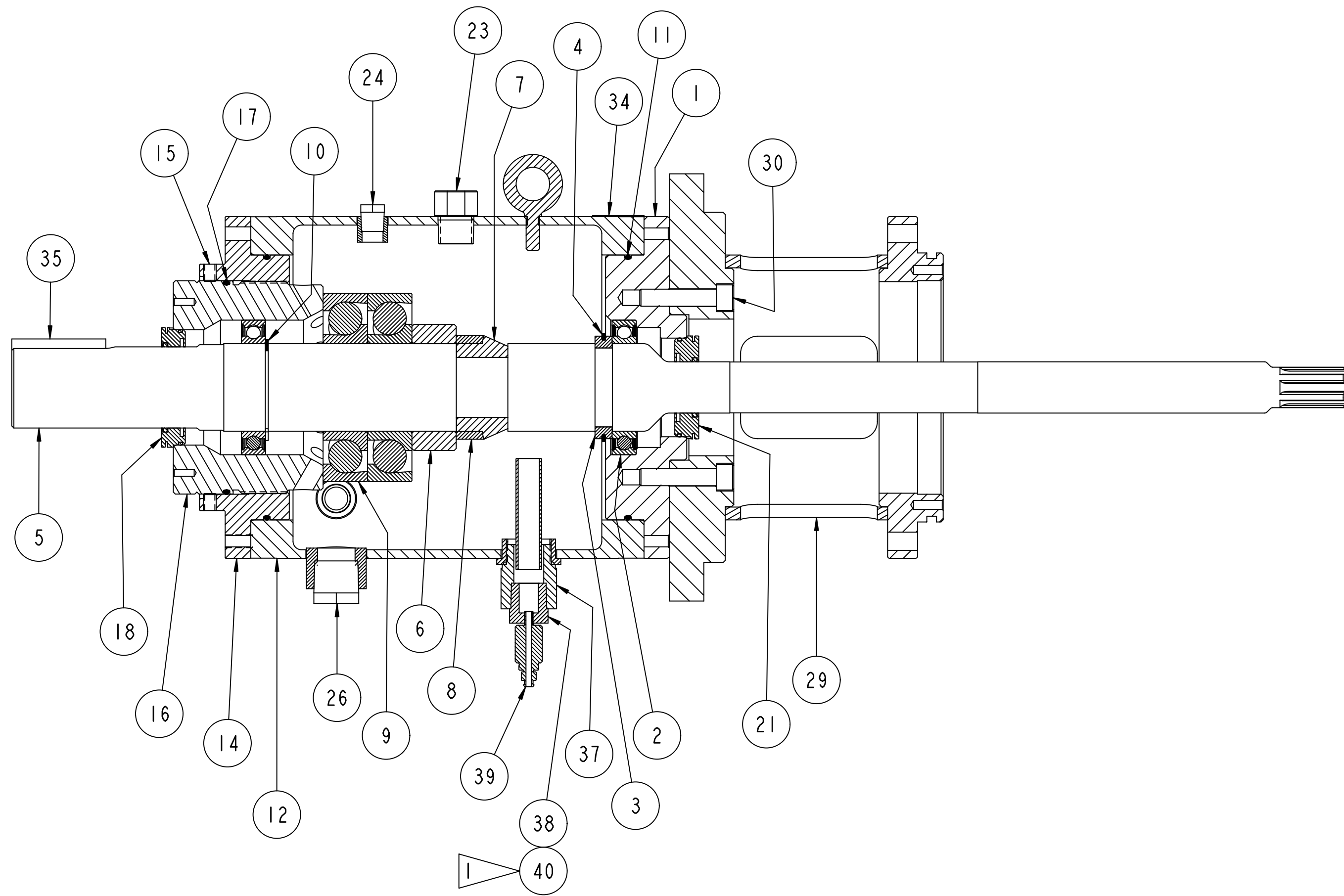
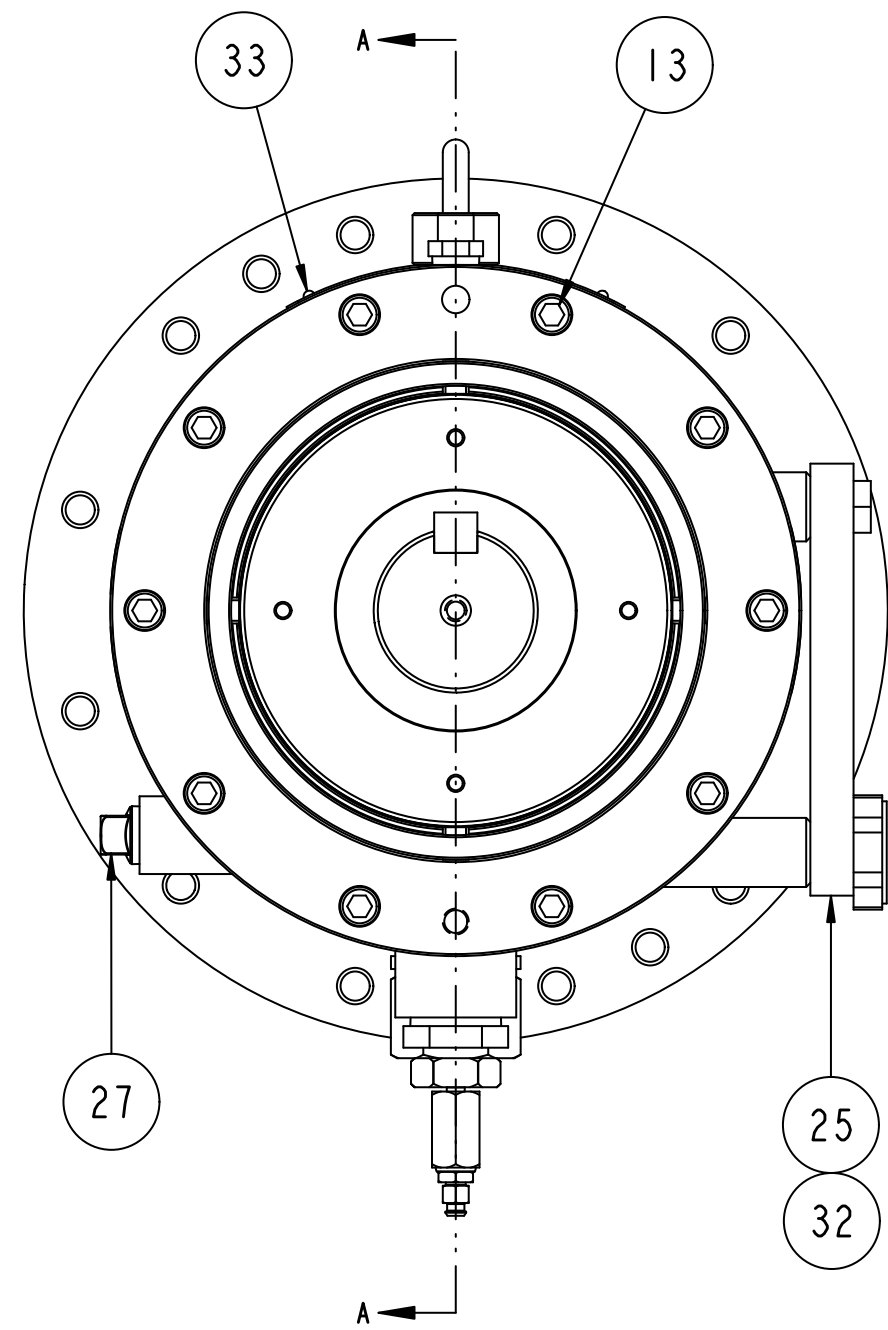
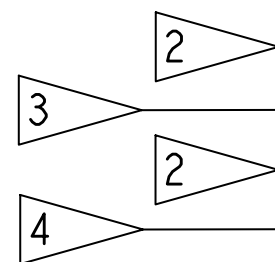
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PART NUMBER	SHAFT MAT'L	SPLINE
100447637	SS	1.18
100534287	SS	1.50
100566464	SS	1.18
100537182	SS	1.18
100806632	SS	1.18



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- 4 MUNSELL PETROBRAS GREEN.
- 3 MUNSELL GRAY MARINE PAINT.
- 2 FOR CHAMPION 501C SEAL.
- 1 USE FOR STORING AND SHIPPING ONLY.

REVISED	HARKER	17-MAY-2010	Schlumberger BARTLESVILLE TECHNOLOGY CENTER A DIVISION OF SCHLUMBERGER TECHNOLOGY CORPORATION
CHECKER			
ENGINEER	BLACK	10-SEP-2008	
DESIGNER	HARKER	10-SEP-2008	

DWG, THRUST CHAMBER: ASSEMBLY,
2 BEARING, HPS, G3A

⊕	FORMAT	SCALE	UNITS	100447637D	REVISION	PAGE
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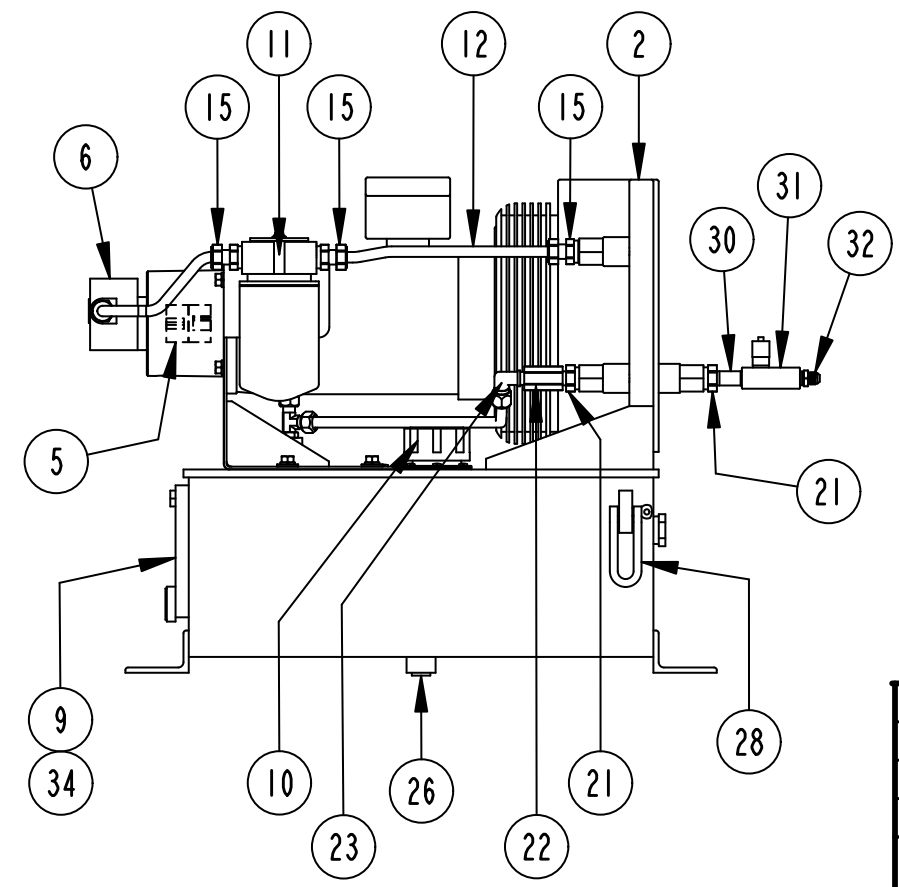
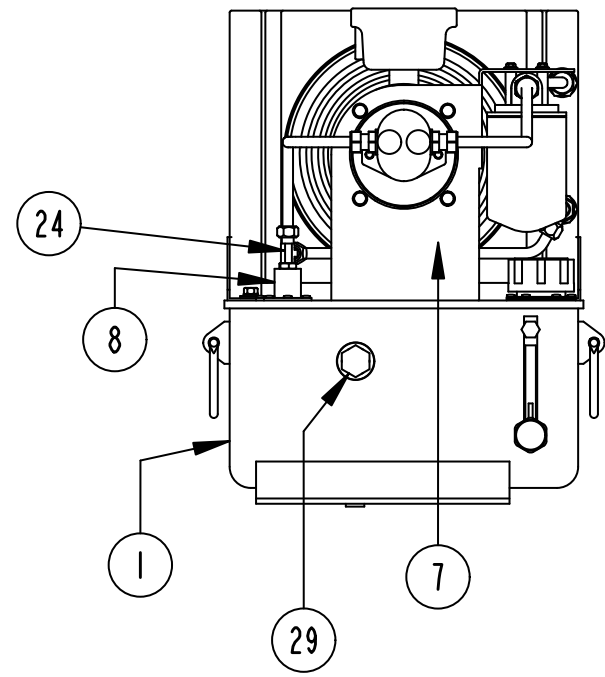
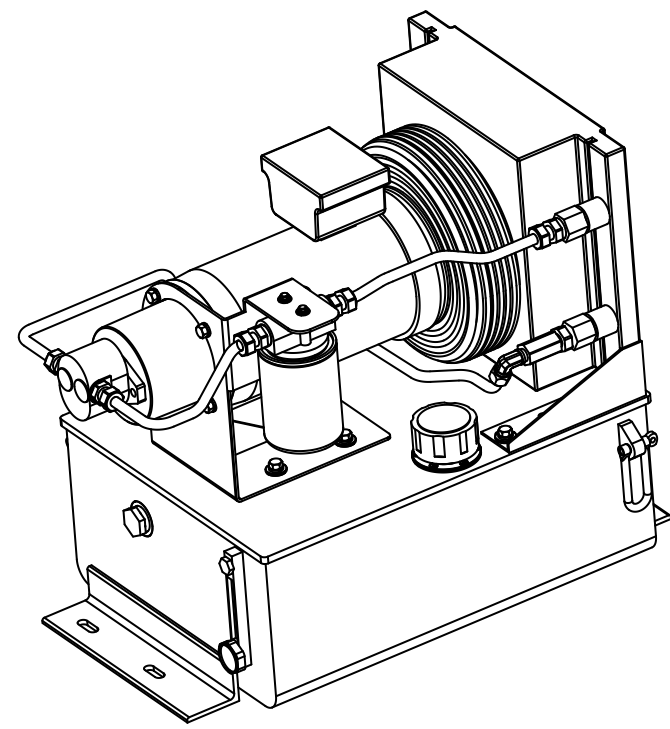
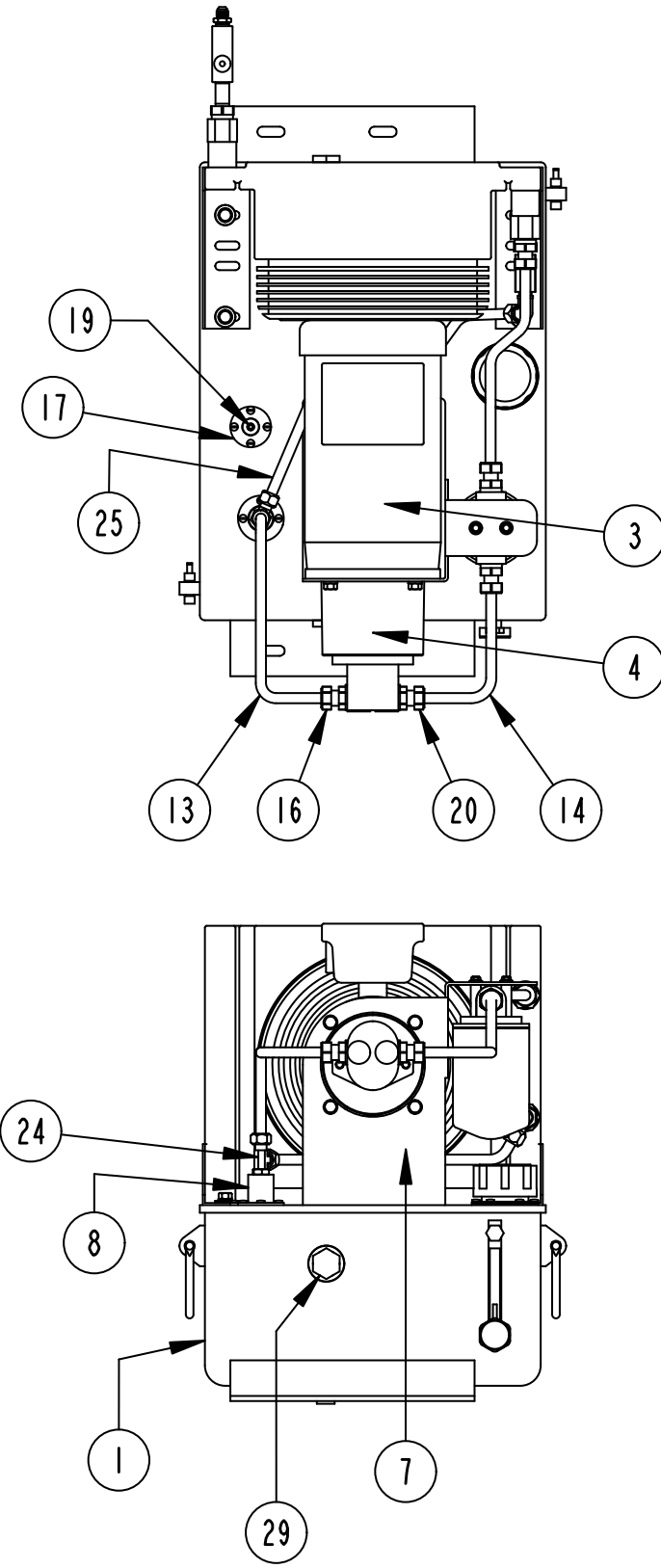
Part SLB 100447637 AK: Specifications and Engineering Bill of Materials

Robert Brandabura
Apr 26, 2011

Type	Name	Rev	Last Rev	Strong Link Rev	Description	State	U of M	Qty	Item Num	General Notes	Relationship Name	EBOM Values		Specification Values		
												Reference Designator	Usage	Document Usage	Files	
Instruction-Procedure	100098119	AJ	AJ		MPI-56116, STANDARD PAINT PROCEDURE - HPS EQUIPMENT	Released		0.0			Part Specification			Reference Document	100098119.doc 100098119.pdf	
ProE Drawing	100447637D	AH	AH		DWG, THRUST CHAMBER: ASSEMBLY, 2 BEARING, HPS, G3A	Released		0.0			Part Specification			Described By	100447637d.drw.2 100447637d_1.dxf 100447637d.pdf	
Document	100516236	AJ	AJ		MPI-56137, HPS - G3A THRUST CHAMBER ASSEMBLY PROCEDURE	Released		0.0			Part Specification			Reference Document	100516236.docx 100516236.pdf	
General Spec	GED-001	CE	CE		EQUIPMENT SERIAL NUMBERING SYSTEM	Released		0.0			Part Specification			Reference Document	GED-001.docx GED-001_RSG.doc GED-001.pdf GED-001_RSG.pdf	
Part SLB	100588618	AA	AA		HOUSING: THRUST CHAMBER, HPS, G3A, FINAL MACHINE	Released	EA	1.0	012		EBOM		Uses			
Part	100662025	AB	AB		CRATE: SHIPPING, HPS TC, 42 INCH	Released	EA	1.0	042		EBOM		Uses			
Part SLB	3900997	--	--		PLUG, PIPE: 1/4NPT SS SQHD	Released	EA	1.0	040	For storage and shipping only	EBOM		Uses			
Part SLB	100673498	AA	AA		T-PIN, 1-1/4" LONG	Released	EA	1.0	041		EBOM		Uses			
Part SLB	100666563	AA	AA		OIL: LUBE, ROYAL PURPLE, THRUST CHAMBER, SYNFILM, GRADE 46 GT	Released	GA	0.75	031		EBOM		Uses			
Part SLB	3920149	-C	-D		SCREW: SHC, 1/2-20 UNF X 2-1/4 IN. LG, UNBRAKO, ALLOY STEEL, 170 K MIN. YIELD, HIGH ST	Released	EA	8.0	030		EBOM		Uses			
Part SLB	100307037	AD	AD		BEARING: NSK, ANGULAR CONTACT BALL BEARING, 7313BEAMRSUCNB, SINGLE ROW, 40 DEGREE CONTACT ANGLE, MACHINED BRASS CAGE	Released	EA	2.0	009		EBOM		Uses			
Part SLB	100390497	AA	AA		SEAL: BRG ISOLATOR, PMP END, 1.50, HPS, G3 TC, INPRO #TN09633	Released	EA	1.0	021		EBOM		Uses			
Part SLB	3900388	-D	-D		PLUG: DRAIN, 3/8 IN. NPT, HEX HEAD	Released	EA	1.0	024		EBOM		Uses			
Part	100084422	AB	AB		PUMP END HOUSING, G3 TC	Released	EA	1.0	001		EBOM		Uses			
Part SLB	0825901	-E	-E		SCREW: DRIVE, #2 X 1/8 316SS, TYPE U ANSI/ASME B18.6.4, 1981	Released	EA	2.0	033		EBOM		Uses			
Type	Name	Rev	Last Rev	Strong Link Rev	Description	State	U of M	Qty	Item Num	General Notes	Relationship Name	Reference Designator	Usage	Document Usage	Files	
Part SLB	0826339	-B	-C		SCREW, SET, 3/8-16UNC-3 X 1/2 HEX SCKT CUP POINT 410 STAINLESS ANSI/ASME B18.3,	Released	EA	4.0	015		EBOM		Uses			
Part SLB	100447640	AB	AB		SEAL: BRG ISOLATOR, 2.375, HPS, G3 TC, INPRO TN	Released	EA	1.0	018		EBOM		Uses			
Part SLB	0014982	AB	AB		RING: RETAINER, TRUARC #5100-300	Released	EA	1.0	004		EBOM		Uses			
Part SLB	0866582	-D	-D		RING, O: 2-25B, VITON, V884-75	Released	EA	1.0	017		EBOM		Uses			
Part SLB	3900434	-D	-D		RING: SNAP, #N5100-255 OR EQUAL	Released	EA	1.0	010		EBOM		Uses			
Part SLB	100448339	AB	AB		FITTING: PIPE, REDUCER BUSHING, 1.00 MNPT X .25 FNPT, SAE 140140, PARKER #1 X 1/4 PTR, OR EQUIV	Released	EA	1.0	038		EBOM		Uses			
Part	100420623	AA	AA		COLLAR: THRUST, HPS G3 TC, INPRO SEALS	Released	EA	1.0	016		EBOM		Uses			
Part SLB	100307054	AC	AC		BEARING: NSK, DEEP GROOVE BALL, 6013ZC3E EA2S, SINGLE ROW, CONRAD STYLE, DOUBLE SHIELDS, C3 CLEARANCE, SYNTHETIC GREASE	Released	EA	2.0	002		EBOM		Uses			
Part SLB	100148881	AA	AA		SPOOL, BEARING HOUSING, MACHINING, G3	Released	EA	1.0	029		EBOM		Uses			

Part	100090755	AC	AC		PLUG: DRAIN, MAGNETIC, HEX, 1 INCH, HPS, G3 TC	Released	EA	1.0	026		EBOM		Uses				
Part SLB	3908811	-D	-D		GAUGE: LEVEL, FLUID, 0-220F, VENDOR PN G615-05-A3	Released	EA	1.0	025		EBOM		Uses				
Part SLB	100479718	AA	AA		ASSEMBLY: STAND TUBE, G3A, TC	Released	EA	1.0	037		EBOM		Uses				
Part	100090972	AA	AA		RING, 2 PIECE, RETAINER, G3 TC	Released	EA	1.0	007		EBOM		Uses				
Part SLB	100448300	AA	AA		ADAPTER: BLEED, PIPE, MALE, VENDOR PN 1/4HPBA	Released	EA	1.0	039		EBOM		Uses				
Part SLB	100115650	AA	AA		RING, O: VITON 2-264 PARCO CMPD 9009-75	Released	EA	2.0	011		EBOM		Uses				
Type	Name	Rev	Last Rev	Strong Link Rev	Description	State	U of M	Qty	Item Num	General Notes	Relationship Name	Reference Designator	Usage	Document Usage	Files		
Part SLB	3900618	-C	-C		PLUG: PIPE, 1/2 IN. NPT, SQUARE HEAD, FORGED STEEL, PLATED	Released	EA	1.0	027		EBOM		Uses				
Part	100082461	AA	AA		SPACER: THRUST BEARING, 2.561 X 1.296L, 4140, G3	Released	EA	1.0	006		EBOM		Uses				
Part	100160301	AB	AB		SHAFT: THRUST CHAMBER, HPS, G3, STANDARD, 1.18-6B SPLINE	Released	EA	1.0	005		EBOM		Uses				
Part SLB	3908703	-D	-D		NAMEPLATE: HPS THRUST CHAMBER, BLANK, STAINLESS STEEL	Released	EA	1.0	034		EBOM		Uses				
Part SLB	100236108	AA	AA		LABEL: OIL LEVEL, THRUST CHAMBER, HPS, G3	Released	EA	1.0	032		EBOM		Uses				
Part SLB	3902629	-B	-B		PAINT: AMERON, SLB BLUE, PSX700, W/CATALYST	Released	GA	0.25	036		EBOM		Uses				
Part SLB	3920078	-D	-D		SCREW: SHC, .375-.24 UNF X 1.25 IN LG, UNBRAKO OR EQUIV, ALLOY STEEL, 170 K MIN. YIELD, HIGH STRENGTH	Released	EA	20.0	013		EBOM		Uses				
Part SLB	100461781	AB	AB		RING: RETAINER, THRUST BEARING, G3 TC	Released	EA	1.0	008		EBOM		Uses				
Part	100082463	AA	AA		RING: TWO PIECE RETAINER, G3 TC	Released	EA	1.0	003		EBOM		Uses				
Part	100084414	AA	AA		BREATHER: VENT PLUG, G3 TC	Released	EA	1.0	023		EBOM		Uses				
Part	100084421	AB	AB		MOTOR END HOUSING, G3 TC	Released	EA	1.0	014		EBOM		Uses				
Part SLB	100188102	AB	AB		KEY: THRUST CHAMBER, SHAFT, G3, .625 IN. X .585 IN. X 2.75 IN. LG.	Released	EA	1.0	035		EBOM		Uses				

CONFIDENTIAL AND TRADE SECRET. DO NOT DISCLOSE, USE, OR REPRODUCE WITHOUT WRITTEN APPROVAL FROM SCHLUMBERGER.



PART NUMBER	MOTOR INFORMATION	INTERCONNECT KIT	SKID TYPE
3909357	60 Hz SINGLE PHASE	YES	LD / ND
100150753	50 Hz SINGLE PHASE	YES	LD / ND
100430007	60 Hz SINGLE PHASE	YES	MD
100457032	60 Hz SINGLE PHASE	YES	MD
100730318	50 Hz SINGLE PHASE	YES	MD

NOTE:
 1. TACK WELD MOTOR SHROUD TO FAN COVER
 ON INSIDE OF FAN COVER AND PAINT BOTH

REVISED	HARKER	25-MAR-2010
CHECKER		
ENGINEER		
DESIGNER	BUSH	01-OCT-2001

Schlumberger
 BARTLESVILLE TECHNOLOGY CENTER
 A DIVISION OF SCHLUMBERGER TECHNOLOGY CORPORATION

DWG, ASSEMBLY: COOLER, OIL, BH, EXPLOSION PROOF

	FORMAT	SCALE	UNITS	REVISION	PAGE
	B	0.110	IN	3909357_F AN	1/1

Part SLB 3909357 -R: Specifications and Engineering Bill of Materials

Robert Brandabura
Nov 10, 2010

Type	Name	Rev	Last Rev	Strong Link Rev	Description	State	U of M	Qty	Item Num	General Notes	Relationship Name	EBOM Values		Specification Values	
												Reference Designator	Usage	Document Usage	Files
ProE Drawing	3909357_F	AP	AP		DWG, ASSEMBLY: COOLER, OIL, BH, EXPLOSION PROOF	Released		1.0			Part Specification			Described By	3909357_f.drv 3909357_f_1.c 3909357_f.pdf
Document	100536529	AD	AD		MPI-56144, THRUST CHAMBER COOLER ASSEMBLY	Released		0.0			Part Specification			Reference Document	100536529.do 100536529.pd
Part SLB	3920276	-B	-B		FITTING: PIPE, MALE CONN TO SAE STRAIGHT THREAD, SAE 8 TO 1/2 IN TUBE	Released	EA	1.0	020		EBOM		Uses		
Part SLB	3908919	-B	-B		FITTING: TUBE, ELL, 3/8FNPT X 1/2 IN. TUBE, 90 DEG., PARKER# 8-6-DBZ	Released	EA	1.0	023		EBOM		Uses		
Part SLB	3901080	-A	-A		WASHER: LOCK, 1/4 IN., SS	Released	EA	2.0	047	Mount Filter	EBOM		Uses		
Part SLB	100105573	AA	AA		WASHER: FLAT, 1/4 X 5/8, USS, S.S.	Released	EA	2.0	046	Mount Filter	EBOM		Uses		
Part SLB	100105572	AB	AB		SCREW: HHC., 25-20 UNC X .75 IN LG, SS	Released	EA	2.0	044	Mount Filter	EBOM		Uses		
Part SLB	3902350	-A	-A		COUPLING ASSY: COOLER, LOVEJOY #L075, BORE & KEY HUBS TO 5/8 IN. & 1/2, W/SPIDER, FOR	Released	ST	1.0	005		EBOM		Uses		
Part SLB	100030602	AC	AC		SCREW: HHC., 375-16 UNC X 1.00 IN LG, GRD 5, ZINC PLATED	Released	EA	10.0	039	Mount Cooler to Reservoir, Motor and Pump to Bracket	EBOM		Uses		
Part SLB	100486595	AA	AA		SCREW, SET, 5/16-24UNF-3 X 5/16, SCKT CUP POINT ALY STL, BLK OX, MCMASST# 91375A596 OR EQUIV	Released	EA	1.0	041	Attach fan blade to shaft	EBOM		Uses		
Part	100127418	AA	AA		LABEL: OIL LEVEL WITH COOLER, HPS, G3 TC	Released	EA	1.0	034		EBOM		Uses		
Part SLB	3908918	-A	-A		VALVE: CHECK, 3/8MNPT X 3/8MNPT, 25 MICRON FILTER, C SERIES, PARKER#6M-C6L-25-SS	Released	EA	1.0	022		EBOM		Uses		
Part SLB	3900124	-C	-C		FILTER ASSY: SPIN-ON, 25 MICRON, CELLULOSE, 3/4", PARKER #12AT25CN15BBLI	Released	EA	1.0	011		EBOM		Uses		
Part SLB	3908817	-B	-B		WELDMENT: PICK-UP, OIL	Released	EA	1.0	008		EBOM		Uses		
Part SLB	100429829	AA	AA		SCREW, MACHINE, #10-32 X 1/2 IN. LG., PAN HEAD SLOTTED, ZINC PLTD STL, MASTER-CARR, #90283A829 OR EQUIV	Released	EA	14.0	035	Mount Pick-up tube, Level Gauge, and Breather	EBOM		Uses		
Type	Name	Rev	Last Rev	Strong Link Rev	Description	State	U of M	Qty	Item Num	General Notes	Relationship Name	Reference Designator	Usage	Document Usage	Files
Part SLB	100021725	AA	AA		WASHER: LOCK 3/8 IN, STD	Released	EA	10.0	040	Mount Cooler to Reservoir, Motor and Pump to Bracket	EBOM		Uses		
Part SLB	3920341	AD	AD		FITTING: TEE, 1/2 FLARELESS TUBE, SAE 8 RUN, PARKER P/N 8 R5BU-SS, SAE 080428	Released	EA	1.0	024		EBOM		Uses		
Part SLB	100485826	AE	AE		ASSEMBLY: LEVEL SWITCH, COOLER	Released	EA	1.0	019		EBOM		Uses		
Part SLB	3908810	-D	-D		WELDMENT: TANK, RESERVOIR, OIL COOLER	Released	EA	1.0	001		EBOM		Uses		
Part SLB	3909359	-B	-B		TUBE: PICKUP TO PUMP, EX PROOF, GEN 2 OIL COOLER	Released	EA	1.0	013		EBOM		Uses		
Part SLB	3902238	-B	-B		ADAPTOR: COOLER, MOTOR/PUMP, FOR COOLER ASSY, GRAINGER #4F322 (MANU. IS VESCOR)	Released	EA	1.0	004		EBOM		Uses		
Part SLB	3908832	-B	-B		FITTING: TUBE, STR, 3/4 MNPT X 1/2 IN. TUBE, PARKER# 8-12FBZ	Released	EA	3.0	015		EBOM		Uses		
Part SLB	3909384	AH	AH		KIT: INTERCONNECT, G2 OIL COOLER	Released	EA	1.0	033		EBOM		Uses		
Part SLB	3920086	-B	-B		PLUG: SAE 8, SOCKET HEAD, #8HP50N	Released	EA	1.0	026		EBOM		Uses		
Part SLB	100464449	AA	AA		CONNECTOR: SWITCH, FLUID, 1/8 NPT	Released	EA	1.0	017		EBOM		Uses		
Part SLB	3920142	-C	-C		SHACKLE: TYPE 316, D-STYLE, LONG BOW, #35685T55	Released	EA	2.0	028		EBOM		Uses		
Part SLB	3909358	-A	-A		TUBE: FILTER TO COOLER, EX PROOF, GEN 2 OIL COOLER	Released	EA	1.0	012		EBOM		Uses		
					GAUGE: LEVEL, FLUID, 0-220F, VENDOR PN										

Type	Name	Rev	Last Rev	Strong Link Rev	Description	State	U of M	Qty	Item Num	General Notes	Relationship Name	Reference Designator	Usage	Document Usage	Files
Part SLB	3908811	-D	-D		G615-05-A3	Released	EA	1.0	009		EBOM		Uses		
Part SLB	3902640	-C	-C		PLUG: PIPE, 1 IN., MNPT, HEX HEAD, CS, BLACK	Released	EA	2.0	029		EBOM		Uses		
Part SLB	3908835	-B	-B		FITTING: TUBE, STR, SAE10 X 1/2 IN. TUBE, PARKER#8-10ZHBA	Released	EA	1.0	016		EBOM		Uses		
Part SLB	3908920	-B	-B		BUSHING: REDUCER, 3/4MNPT X 3/8 FNPT, PARKER#12-6RB	Released	EA	2.0	021		EBOM		Uses		
Part SLB	3901371	-C	-C		BREATHER: FILLER, LUBE DEVICES, FB103	Released	EA	1.0	010		EBOM		Uses		
Part SLB	3920110	-C	-C		MOTOR: BALDOR, 1/2HP, XP, CLASS 1, GRP D, DBL SHAFT, 56CZ, 1725, BALDOR #35S274-0154G1	Released	EA	1.0	003		EBOM		Uses		
Part	100026612	AA	AA		FITTING: PIPE, NIPPLE, 3/8 IN. NPT X 2 IN. LG, SS	Released	EA	1.0	030		EBOM		Uses		
Part SLB	3900394	-B	-B		PUMP: GEAR, 1GPM, COOLER, .168 IN3/REV, DISP, PARKER #DO7AA2A OR MCARR #6296K12	Released	EA	1.0	006		EBOM		Uses		
Part SLB	3909362	-B	-B		WELDMENT: BRACKET, MOTOR, EXPLOSION PROOF	Released	EA	1.0	007		EBOM		Uses		
Part SLB	3908917	-B	-B		TUBE: CHECK VALVE TO PICKUP TUBE	Released	FT	1.0	025		EBOM		Uses		
Part SLB	3909360	-A	-A		TUBE: PUMP TO FILTER, EX PROOF, GEN 2 OIL COOLER	Released	EA	1.0	014		EBOM		Uses		
Part SLB	3920396	AB	AB		VALVE, FLOW CONTROL, PARKER, 3/8 NPT BOTH ENDS (F600B)	Released	EA	1.0	031		EBOM		Uses		
Part SLB	3920113	AA	AA		FITTING: TUBE, STR, 3/8NPTM X 3/8JICM, SS, PARKER# 6-6 FTX	Released	EA	1.0	032		EBOM		Uses		
Part SLB	3908930	-C	-C		COOLER: OIL, LESS MOTOR, AIR COOLED, 2 PASS WITH EXTRA CONN, TT#AOC-19-99695	Released	EA	1.0	002		EBOM		Uses		

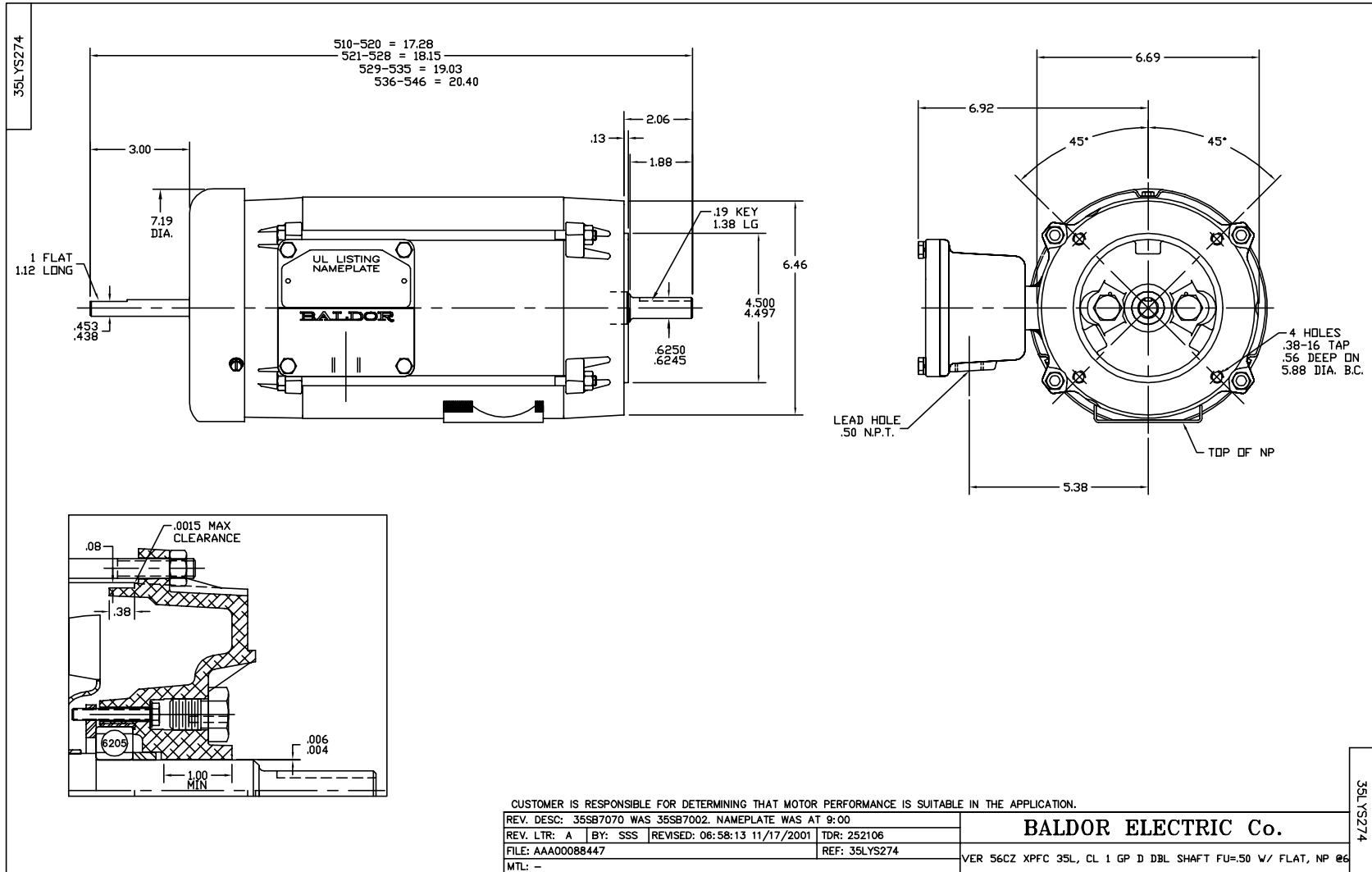
BALDOR® • RELIANCE

Product Information Packet

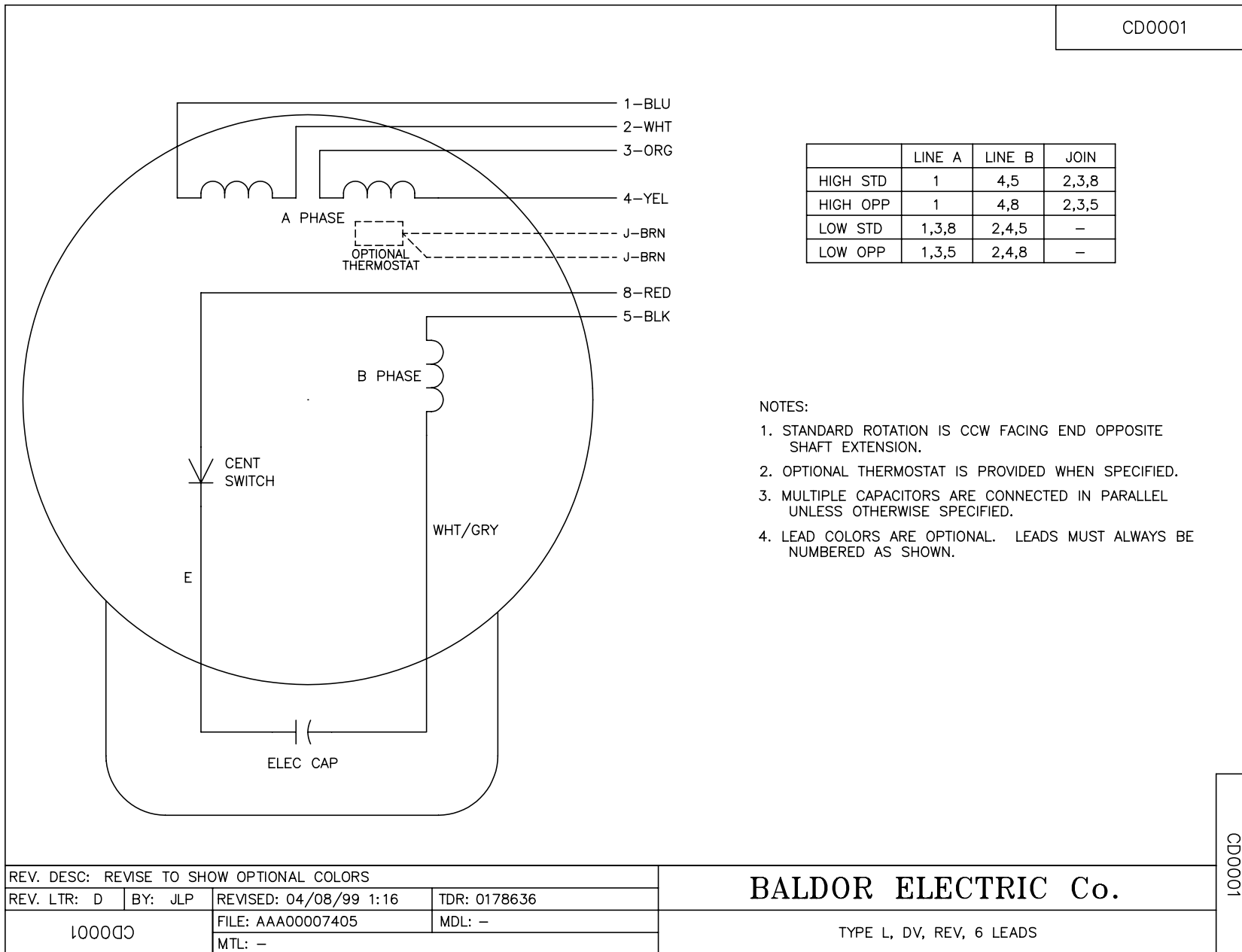
Schlumberger Technology Corp.

.5HP,1725RPM,1PH,60HZ,56CZ,3520L,XPFC,F1

Product Detail							
Revision:	H	Status:	PRD/A	Change #:		Proprietary:	No
Type:	AC	Prod Type:	3520L	Elec. Spec:	35WG0154	CD Diagram:	CD0001
Enclosure	XPFC	Mfg Plant:		Mech Spec:	35S274	Layout:	35LYS274
Frame:	56CZ	Mounting:	F1	Poles:	04	Created Date:	
Base:	N	Rotation:	R	Insulation:	B	Eff. Date:	03-09-2007
Leads:	6#18					Replaced By:	
Nameplate NP0015XP							
NO.		CC					
SER.							
SPEC.	35S274-0154G1						
CAT.NO.							
HP	.5	T. CODE	T2C				
VOLTS	115/230						
AMPS	8/4						
RPM	1725						
HZ	60	PH	1	CL	B		
SER.F.	1.00	DES	N	CODE	L		
RATING	40C AMB-CONT						
FRAME	56CZ	NEMA-NOM-EFF	64	PF	63		
USABLE AT 208V							



CD0001



	LINE A	LINE B	JOIN
HIGH STD	1	4,5	2,3,8
HIGH OPP	1	4,8	2,3,5
LOW STD	1,3,8	2,4,5	-
LOW OPP	1,3,5	2,4,8	-

NOTES:

1. STANDARD ROTATION IS CCW FACING END OPPOSITE SHAFT EXTENSION.
2. OPTIONAL THERMOSTAT IS PROVIDED WHEN SPECIFIED.
3. MULTIPLE CAPACITORS ARE CONNECTED IN PARALLEL UNLESS OTHERWISE SPECIFIED.
4. LEAD COLORS ARE OPTIONAL. LEADS MUST ALWAYS BE NUMBERED AS SHOWN.

REV. DESC: REVISE TO SHOW OPTIONAL COLORS			
REV. LTR: D	BY: JLP	REVISED: 04/08/99 1:16	TDR: 0178636
100000		FILE: AAA00007405	MDL: -
		MTL: -	

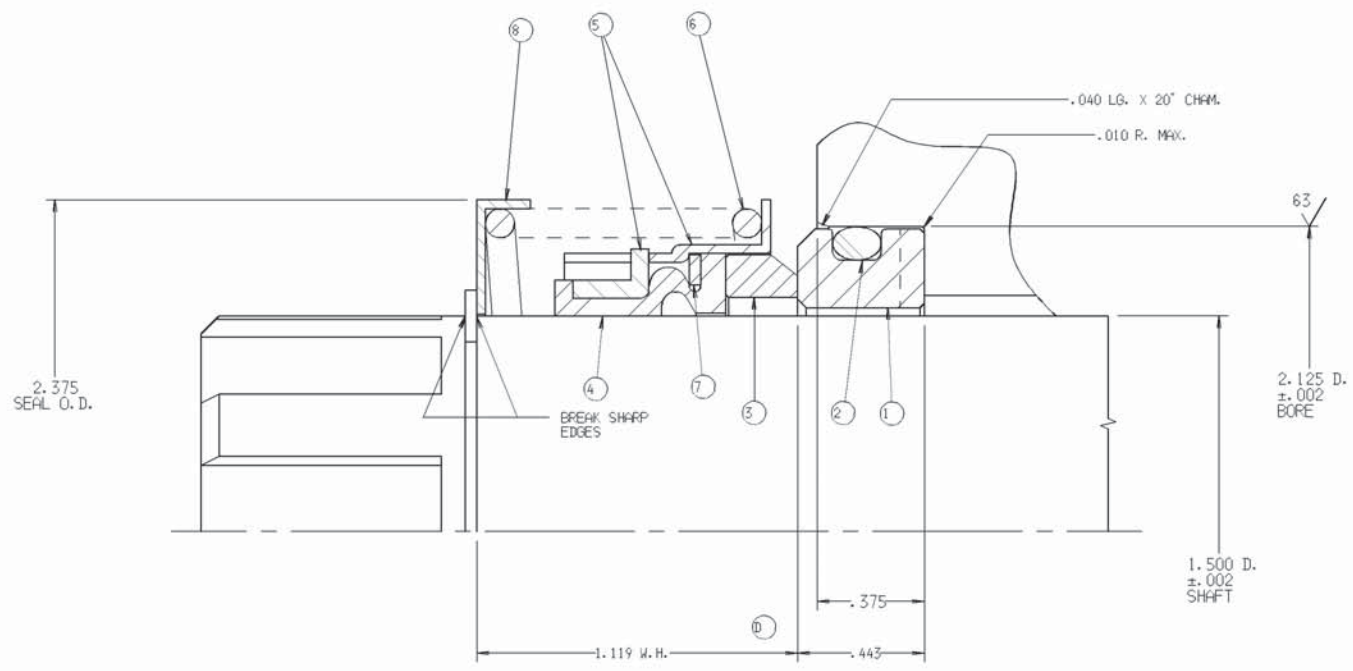
BALDOR ELECTRIC Co.

TYPE L, DV, REV, 6 LEADS

CD0001



DO NOT TREAT BELLOWS



ITEM	COMPONENT	DESCRIPTION	MATERIAL	QTY	SPARES
1	D 1500 902 9221	MATING RING	SILICON CARBIDE	1	X
2	0000 225 5543	O-RING	BUNA(HSN)	1	X
3	D 1501 270 9221	PRIMARY RING	SILICON CARBIDE	1	X
4	D 1500 278 3848	BELLOWS	BUNA(HSN) (NOTE 30)	1	X
5	D 1500 086 1800	RETAINER ASSEMBLY	MONEL	1	
6	1546	SPRING	MONEL	1	
7	D 1500 725 1800	DISC	MONEL	1	
8	D 1501 497 1800	SPRING HOLDER	MONEL	1	
9					
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11					
12					
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35					

NOTE:
 ITEM #3 IS MATTE FINISH.

 RETAINER ASS'Y. CONSISTS OF:
 RETAINER D-1501-204
 DRIVE BAND D-1500-088
 REDA PROTECTOR WITH 1-1/2" D. SHAFT

SEAL ASS'Y NO. D-1501-237	BILL OF MATERIALS NUMBER
MTG. PG. ASS'Y NO.	COMPLETE
	SEAL HD.
	MTG. PG.
	ASS'Y. ITEMS NUMBER

EQUIPMENT REFERENCE:	CUSTOMER INFORMATION:
UNIT BY: REDA PUMP	CUSTOMER: REDA HPS
EQUIPMENT TYPE:	P. O. NO.
<input checked="" type="checkbox"/> PUMP <input type="checkbox"/> AGITATOR	END USER: REDA HPS
<input type="checkbox"/> COMPRESSOR <input type="checkbox"/> OTHER	LOCATION: OWASSO, OK.
MODEL/SIZE	REQ. NO.
SERIAL NO.	INSTALLED AT:

SEAL DATA	
SEAL DESCRIPTION A021	MATERIAL CODE B97 Q58 M 058 M
A. P. I. CODE	A. P. I. PLAN N/A

SERVICE DATA		
FLUID N/A	SUCT. PRESS. N/A	BARRIER FLUID N/A
SEAL PRESS. N/A	TEMPERATURE N/A	VISC. AT P. T. N/A
SHAFT SPEED N/A	DISCH. PRESS. N/A	V. P. AT P. T. N/A
	SP. GR. N/A	HAZARD CODE N/A

REFERENCE DATA	DRAWN	DATE	CHK'D	APP'D	SCALE	INST CODE
DATA PER RON DAVIS ENG. PROJ. #: 98-0938	BCL	101698	JMA	SAS	3=1	

CAD ENGINEERED	FILE REFERENCE	CAT	DRAWING No.	ISSUE
TULSA # 65		C	CF-SP-93410-8	A

SEAL SIZE: Ø 1.500
 SEAL TYPE: T-2

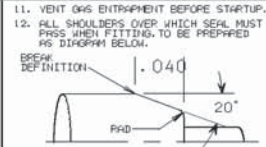
JOHN CRANE INC.
 International Sealing Systems
 8400 Oakton Street
 Morton Grove, IL 60053, U.S.A.

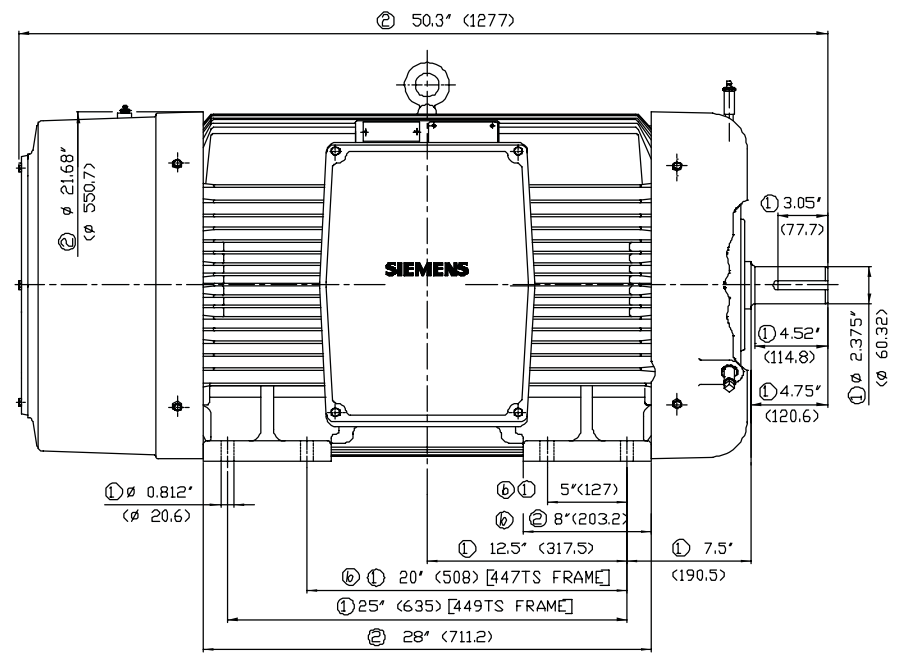
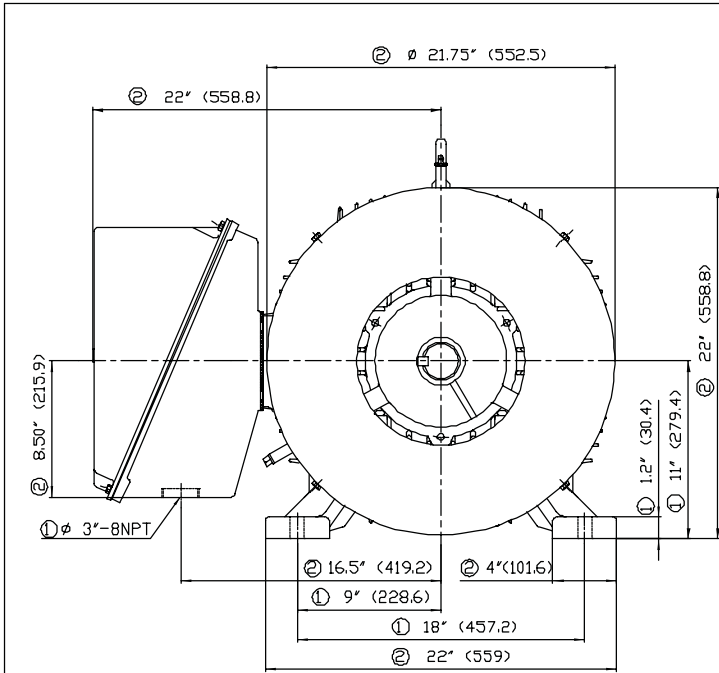
WARRANTY APPLIES TO DIMENSIONAL DATA ONLY

30. ITEM #4 WILL HAVE TWO (2) WHITE COLOR CODED MARKS.
 NO SUBSTITUTION ALLOWED FOR ITEMS #2 & #4.

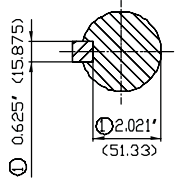
THE FOLLOWING NOTES ARE IMPORTANT AND MUST BE OBSERVED FOR CORRECT SEAL INSTALLATION AND OPERATION

- REMOVE ALL SHARP EDGES ON SHAFT &/OR SLEEVE BEFORE INSTALLATION OF SEAL
- SURFACE OF SHAFT OR SLEEVE ON WHICH SEAL IS INSTALLED MUST BE MACHINED TO 63 RA FINISH OR BETTER.
- LUBRICATE SHAFT/SLEEVE & SEAL WEDGE RING/O-RING/BELLOWS TO ASSIST INSTALLATION OF SEAL WITH
- LUBRICATE MATING RING (SEAT), SEALING MEMBER & HOUSING TO ASSIST INSTALLATION.
- MUST BE CIRCULATED AROUND PRIMARY RING (SEAL FACE) THROUGH MATING RING (SEAT) (AT NOT LESS THAN
- WHEN SHAFT IS SLEEVED THROUGH STUFFING BOX, SLEEVE MUST BE LIQUID TIGHT THROUGH BORE.
- SHAFT OR SLEEVE MUST BE OF CORROSION RESISTANT MATERIAL WITH A HARDNESS OF 125 BRINELL MINIMUM & BE MACHINED TO DIMENSIONS & TOLERANCES STATED.
- END OF SEAL CHAMBER & AXIS OF SHAFT MUST BE AT 90° TO EACH OTHER WITHIN .002 F. I. M.
-
- BEFORE COMPLETING SEAL INSTALLATION WIRE LAPPED SURFACES OF MATING RING (SEAT) & PRIMARY RING (SEAL FACE) PERFECTLY CLEAN.





- ① Tolerances According to NEMA Std.
- ② All these dimensions corresponding to assemblies and castings shall have a tolerance as per DIN standard 1686-GTB-19.



Keyseat detail

CERTIFIED PRINT						
CUSTOMER SCHLUMBERGER						
PDR RHP 16799		SOP 3003235062				
HP 250	RPM 3600	FRAME 449TS	TYPE SD100	VOLTS 460	PH 3	HZ 60
PART# 3920209						

F280/0195

Tolerance in mm according to DIN-1686-GTB-19	Quantity
to 18	± 4.5
Over 18 to 30	± 4.7
Over 30 to 50	± 5
Over 50 to 80	± 5.5
Over 80 to 120	± 6
Over 120 to 180	± 6.5
Over 180 to 250	± 7
Over 250 to 315	± 7.5
Over 315 to 400	± 8
Over 400 to 500	± 8.5
Over 500 to 630	± 9.5
Over 630 to 800	± 10

Quantity	Parts and Measure	Drawing No. Norm No.	Item No.	Material	Weight Los.
04 03 02 01	European Projection				
	Dimensions in inches:				
	Drawn 30.09.02	Date 30.09.02	Name	Dimension Drawing NEMA	
	Checked			Type: RGZESD, RGZEESD	449TS FRAME
	Std. Ckcd			3MSE 750 0655 b)	
	Remark			Ref.	Replace. 3MSE 750 0655 a)
					Scale W/D
					2/2

b) Yoke changed to 8 holes, to add 447 Frame mounting option
 09.30.02

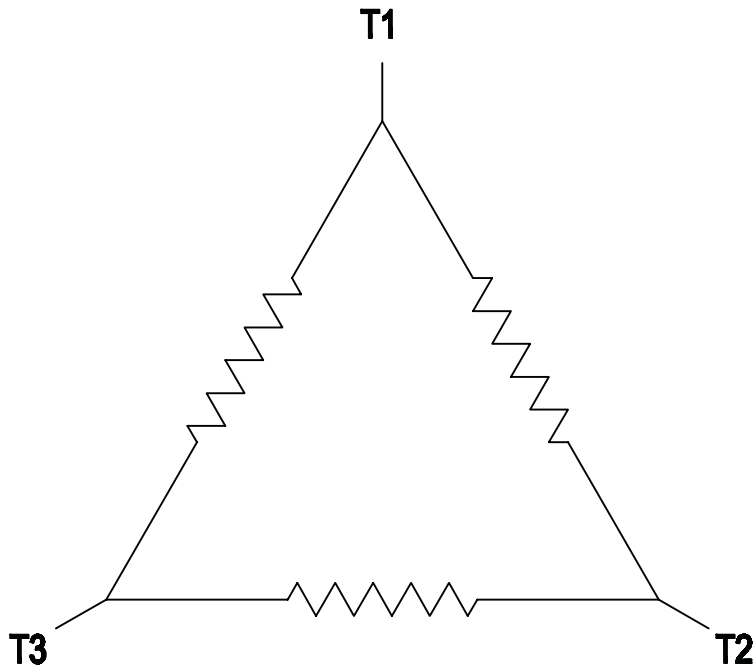
SIEMENS
 FABRICA GUADALAJARA

2

1

3 PHASE - 3 LEADS - DELTA

L1	L2	L3	CONN.
T1	T2	T3	△



B

B

A

A

THIS IS A CAD DRAWING
DO NOT MAKE MANUAL CHANGES

01 | 09-27-07

TYPE
SD10

-CONFIDENTIAL-

PROPERTY OF

Siemens Energy & Automation, Inc.
Industrial Motor Division - Little Rock, AR

FRAME
449TS

HP
250

NAME
WIRING DIAGRAM

VOLTS 460	RPM 3600	HZ 60	PH 3
--------------	-------------	----------	---------

Customer
SCHLUMBERGER

DRAWN 9.24.07	DATE JRH
CHECKED	DATE
APP	DATE

PO # RHP 16099

SO # 3003005034

SHEET
1 OF 1

Sim. To

PART NO.
51-382-114-504

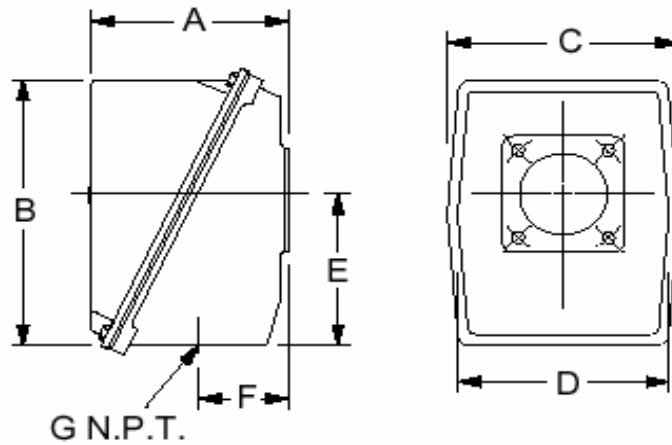
A

2

1

Application Manual for NEMA Motors

Standard Conduit Boxes -- TEFC-Severe Duty -- Types RGZPSD, RGZESD, RGZEESD(X)



Frame	External Dimensions (in)							Approx. internal volume (in ³)	no. of cover bolts
	A	B	C	D	E	F	G		
140	2.68	4.60	4.15	3.58	2.36	1.00	0.75	27	4
180	3.07	4.76	4.49	3.92	2.48	1.24	0.75	36	4
210	3.86	7.05	5.49	4.90	3.66	1.56	1.00	85	4
250	3.86	7.05	5.49	4.90	3.66	1.56	1.25	85	4
280	5.50	8.31	7.12	6.38	4.75	2.44	1.50	226	4
320	6.44	10.00	8.50	7.62	5.50	3.00	2.00	380	4
360	8.06	12.31	10.50	9.50	7.00	3.50	3.00	762	4
400	8.06	12.31	10.50	9.50	7.00	3.50	3.00	762	4
444-447	8.06	12.31	10.50	9.50	7.00	3.50	3.00	762	4
449	10.19	15.70	13.50	12.50	8.50	5.00	3.00	1696	4
S449	10.19	15.70	13.50	12.50	8.50	5.00	4.00	1696	4

S449 is type RGZESD, RGZEESD(X) only

3-5
Electrical Drawing

Not Applicable on this order

HPS 538/540 SERIES SHAFT SETTING PROCEDURE

THE HORIZONTAL CONFIGURED "S" TYPE PUMPS, 538/540 SERIES, BUILT WITH COMPRESSION THRUST DESIGN REQUIRE THE SHAFT TO BE SPACED CORRECTLY TO THE THRUST CHAMBER IN ORDER TO PROPERLY TRANSFER PUMP THRUST. IF THE UNIT IS A TANDEM, EACH PUMP-TO-PUMP SHAFT MUST ALSO BE PROPERLY SPACED TO EACH OTHER.

INSTALLATION/ SPACING TOOL, SHIMS, AND INSTRUCTIONS:

SHAFT SPACING INSTRUCTIONS FOR DOWNHOLE PUMPS NORMALLY USE SHAFT "LIFT", "MATCH" AND "DROP" AS SHAFT POSITIONING FROM A PUMP VERTICAL, SHAFT FULL DOWN REFERENCE. "LIFT" WILL ALSO BE USED IN THIS DOCUMENT TO DESIGNATE SHAFT POSITIONING, BEGINNING FROM A PUMP HORIZONTAL, WITH SHAFT "FULL-DOWN", TOWARD THE BASE.

.550 DIAMETER MONEL SHIMS:

- 1/64" P/N 1146497
- 1/32" P/N 1146505
- 1/16" P/N 1146513

"H" TOOL:

- 538/540 TO THRUST CHAMBER, AND 538/540 PUMP-TO-PUMP: P/N 1083930

1. WITH PUMP OUT OF THE WAY FORWARD, COUPLING IN PLACE ON THRUST CHAMBER SHAFT, BOLT "H" TOOL #1083930 ONTO THE THRUST CHAMBER FLANGE AS SHOWN IN FIGURE "I". LOOSEN JAM NUT (2) AND TURN BOLT (3) DOWN UNTIL IT BOTTOMS ON THE COUPLING DIVIDER PLATE. TIGHTEN BOLT (SNUG ONLY) THEN TIGHTEN JAM NUT.
2. REMOVE TOOL FROM THRUST FLANGE, AND BOLT IT ONTO THE PUMP BASE FLANGE, AS SHOWN IN FIGURE "II".
3. FROM PUMP HEAD END, PUSH ALL SHAFT PLAY DOWN, TOWARD THE BASE, TO OBTAIN A "FULL-DOWN" SHAFT POSITIONING.
4. SELECT APPROPRIATE SHIM(S) NECESSARY TO FILL OPEN SPACE "A" BETWEEN PUMP SHAFT AND BOLT HEAD (4) FIGURE "II". (*TAKE PRECAUTIONS NOT TO INADVERTENTLY MOVE SHAFT!*)
5. FOR ARZ ONLY: AFTER THE TOTAL SHIM STACK IS DETERMINED, REMOVE A 1/64" SHIM FROM THE STACK. GREASE AND PLACE THE REMAINING SHIMS INTO THE COUPLING. NON-ARZ REQUIRE SHAFT "MATCHING", NOT "DROPPED".
6. REMOVE TOOL, AND BOLT PUMP TO THRUST CHAMBER.

IF THE INSTALLATION IS NOT TANDEM, SHAFT SPACING IS COMPLETED.

IF THE INSTALLATION INCLUDES TANDEMS, THE OTHER PUMP SECTIONS MUST HAVE THEIR SHAFTS "MATCHED", (PUMP-TO-PUMP).

(ONLY THE FIRST SECTION OF AN ARZ CONFIGURED UNIT REQUIRES THE "DROP". EACH ADDITIONAL SECTION WILL BE SPACED WITH SHAFTS "MATCHED".)

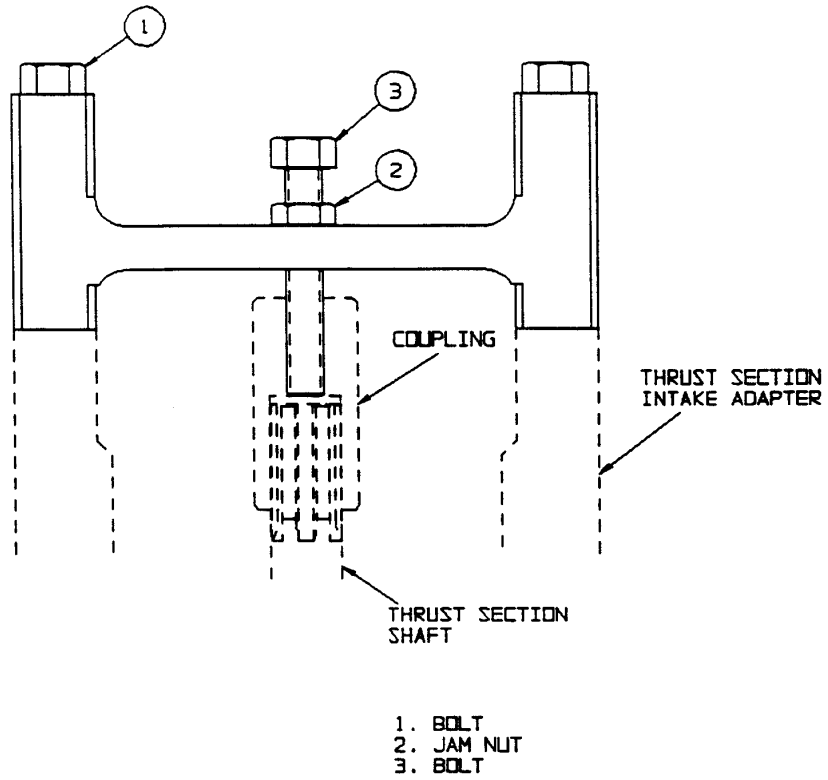


Figure 1: Shaft setting tool on flange of 538 Series Thrust Section

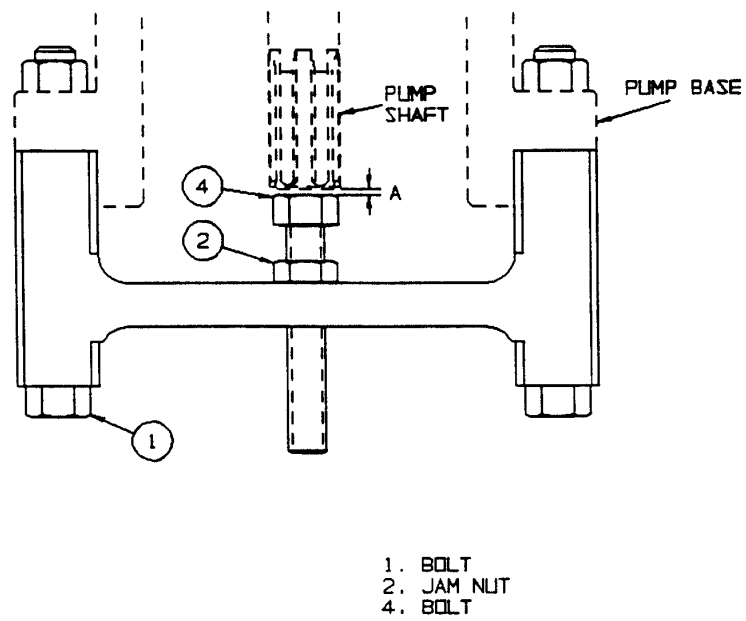


Figure 2: Shaft Setting Tool on 538 Series Pump Base

Pump Performance Tests and Reports

4.1	Pump Test Results and Hydro Test Certs _____	4-1
4.2	Hydrostatic Test Certs (Intake and Discharge) _____	4-1

Schlumberger Artificial Lift - Nisku Service Center
HORIZONTAL PUMP TEST RESULT

3/31/2011 12:03:20

Working Pressure : 0
 Work Order Number : BFP55726
 Log Number : NISP12011033103
 Pump Serial Number : 29E1C55726
 Stage Type : HS75N
 Number of Stages : 63
 Max Recommended Flow: 3060
 Curve RPM : 3570
 Avg Water Temperature : 33
 PumpStart : 3/31/2011 11:51:42 AM

BEP Flow : 2674

Hydrostatic Test Pressure: 0
 Part Number : 2008012
 Well Site : CALGARY
 Thrust Type : CR
 Bearing Type : ARZ
 Pump Config : CT
 Min Recommended Flow : 1632
 Torque Factor : 1.34
 Test Category : New
 Pump Stop : 3/31/2011 12:02:09 PM

Customer : CANDYNE
 Comments : 60HSGTzero 0.125

Operator Number : KEVIN.D

---values are corrected to 3570 RPM---

	BPD	INLET PSI	OUTLET PSI	TORQUE RAW	PUMP RPM	EFF	BPD	HEAD/ STAGE	HP/ STAGE
Point 1	3477.28	43.90	683.81	136.43	3511	0.419	3535.71	10.57	1.5161
Point 2	3006.51	43.84	1048.98	135.22	3511	0.574	3057.04	16.59	1.5020
Point 3	2616.65	44.00	1244.08	131.28	3513	0.614	2659.11	19.79	1.4564
Point 4	1598.69	44.37	1507.93	105.41	3516	0.571	1623.24	24.10	1.1648
Point 5	482.42	44.72	1677.66	70.58	3520	0.288	489.27	26.83	0.7734

TEST DEVIATION FROM CURVE

values are per stage corrected to 3570 RPM

FLOW BPD	IN RANGE	TEST HEAD	HEAD DEV	HEAD-FL % DEV	TEST HP	HP DEV	HP % CURVE	TEST EFF	EFF DEV	EFF % CURVE	
Point 1	3535.71	NO	10.57	1.16	1.4	1.5161	0.0189	1.3	41.86	4.14	11.0
Point 2	3057.04	MAX	16.59	-0.89	-1.6	1.5020	0.0223	1.5	57.37	-3.99	-6.5
Point 3	2659.11	BEP	19.79	-1.27	-3.3	1.4564	0.0105	0.7	61.39	-4.41	-6.7
Point 4	1623.24	MIN	24.10	-0.25	-0.8	1.1648	-0.0453	-3.7	57.06	1.57	2.8
Point 5	489.27	NO	26.83	-0.77	-2.7	0.7734	-0.1216	-13.6	28.84	3.21	12.5

VIBRATION DATA

	Peak Hz	Ampl	Peak Hz	Ampl
Half Speed Inline				
Top	0.00	0.000	0.00	0.000
Middle	0.00	0.000	0.00	0.000
Bottom	0.00	0.000	0.00	0.000
Rotating Speed Inline				
Top	57.50	0.068	0.00	0.000
Middle	57.50	0.155	0.00	0.000
Bottom	57.50	0.148	0.00	0.000
Half Speed Offset				
Rotating Speed Offset				

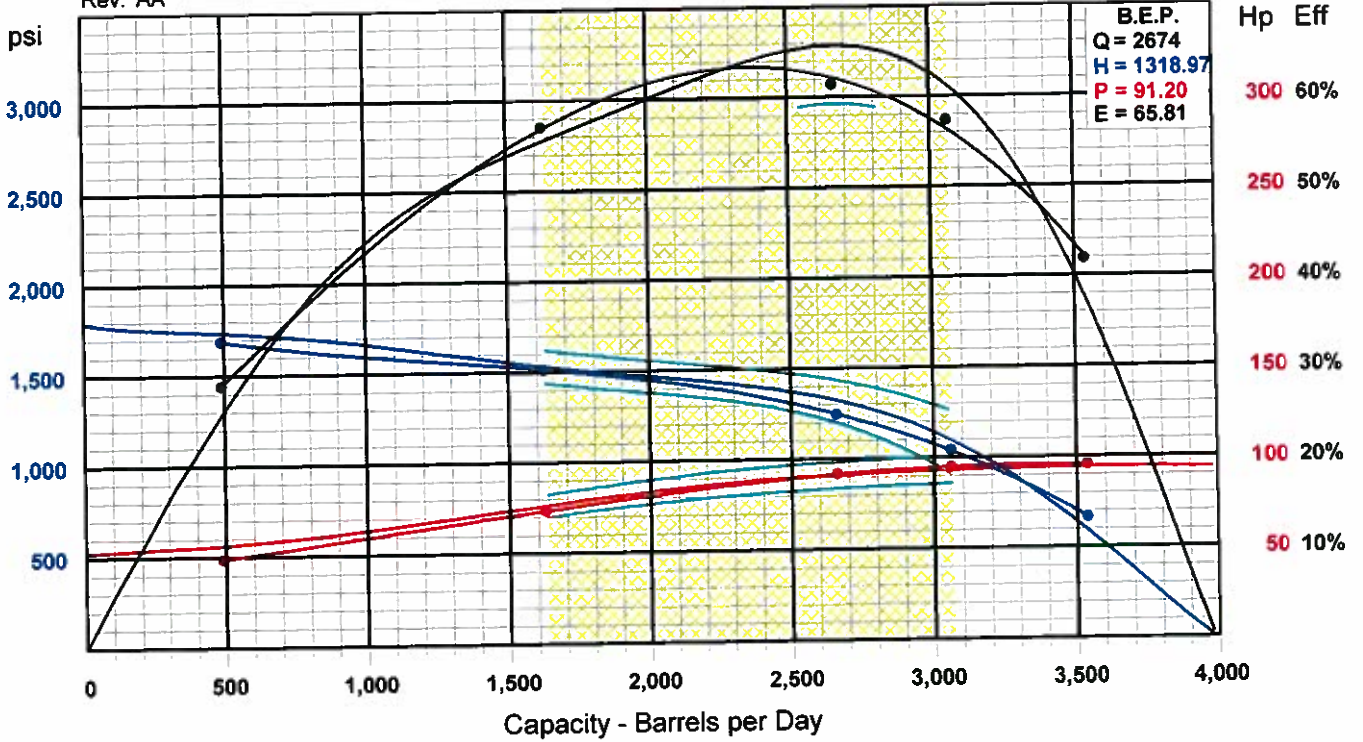
REDA Production Systems

Reda Pump Performance Curve
HS75N
538 Series * - 63 Stage(s) - 3570 RPM - 61 Hz

Log No. NISP12011033103
Serial No. 29E1C55726
March 31, 2011 11:50

Rev. AA

Fluid Specific Gravity 1.00



Schlumberger Artificial Lift Certification of Hydrostatic Testing.

Customer: CANDYNE	Work Order: BFP55726	Test Date: 1-Apr-11
Location: CALGARY	Pump S/N: 29E1C55726	Stage Type: S75N
	Skid S/N	Stage Count: 63STG/60HSG

Per REDA Test Specification TS-5-127, This document certifies that the equipment listed has been Hydrostatically tested and considered satisfactory. As per the Operator, no leaks were detected during the test period.

Comments: PASSED

PLEASE SEE GRAPH
NO VISIBLE LEAKS NOTED

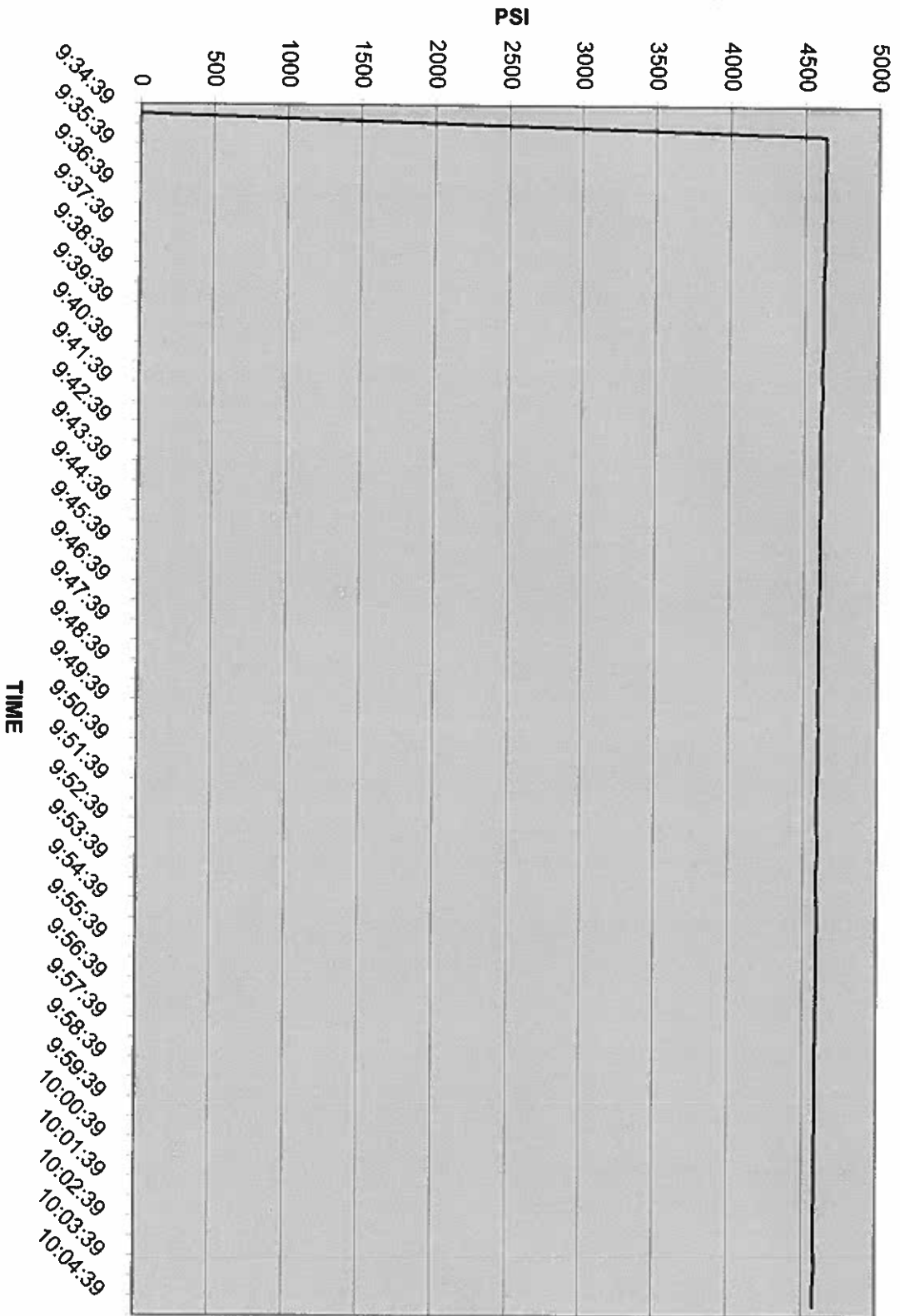
Maximum Allowable Working Pressure (PSI):	Maximum Hydrostatic Test Pressure(PSI):	Hydrostatic Test/Fill Fluid:	Recorded Test Period Duration:
2833	4250	DowFrost 032767	30 Minutes

Certified By:

Print Name: KEVIN DAVIS Title: M.D

Signature:  Date: 1-Apr-11

29E1C55726



— Series 1

Schlumberger Artificial Lift - Nisku Service Center
HORIZONTAL PUMP TEST RESULT

3/31/2011 1:57:59

Working Pressure : 0	Hydrostatic Test Pressure: 0
Work Order Number : BFP 55727	Part Number : 2008012
Log Number : NISP12011033105	Well Site :
Pump Serial Number : 29E1C55727	Thrust Type : CR
Stage Type : HS75N	Bearing Type : ARZ
Number of Stages : 63	Pump Config : CT
Max Recommended Flow: 3060	BEP Flow : 2674
Curve RPM : 3570	Min Recommended Flow : 1632
Avg Water Temperature : 35	Torque Factor : 1.34
PumpStart : 3/31/2011 1:47:31 PM	Test Category : New
	Pump Stop : 3/31/2011 1:56:25 PM
Customer : CANDYNE	Operator Number : KEVIN.G/ KEVIN.D
Comments : 60HSGTzero 0.125	

---values are corrected to 3570 RPM---

	BPD	INLET PSI	OUTLET PSI	TORQUE RAW	PUMP RPM	EFF	BPD	HEAD/ STAGE	HP/ STAGE
Point 1	3494.79	43.74	609.91	134.63	3511	0.377	3553.51	9.35	1.4963
Point 2	3003.26	43.93	996.09	134.02	3512	0.548	3052.86	15.72	1.4888
Point 3	2619.72	43.98	1212.83	131.02	3513	0.600	2662.22	19.29	1.4544
Point 4	1598.22	44.21	1485.63	106.82	3516	0.554	1622.76	23.75	1.1813
Point 5	486.04	44.82	1658.67	70.00	3520	0.290	492.95	26.53	0.7671

TEST DEVIATION FROM CURVE

values are per stage corrected to 3570 RPM

	FLOW BPD	IN RANGE	TEST HEAD	HEAD DEV	HEAD-FL % DEV	TEST HP	HP DEV	HP % CURVE	TEST EFF	EFF DEV	EFF % CURVE
Point 1	3553.51	NO	9.35	0.32	0.4	1.4963	-0.0012	-0.1	37.73	1.31	3.6
Point 2	3052.86	MAX	15.72	-1.82	-3.1	1.4888	0.0093	0.6	54.76	-6.71	-10.9
Point 3	2662.22	BEP	19.29	-1.75	-4.5	1.4544	0.0082	0.6	59.98	-5.83	-8.9
Point 4	1622.76	MIN	23.75	-0.60	-2.1	1.1813	-0.0287	-2.4	55.43	-0.05	-0.1
Point 5	492.95	NO	26.53	-1.07	-3.8	0.7671	-0.1285	-14.3	28.96	3.16	12.2

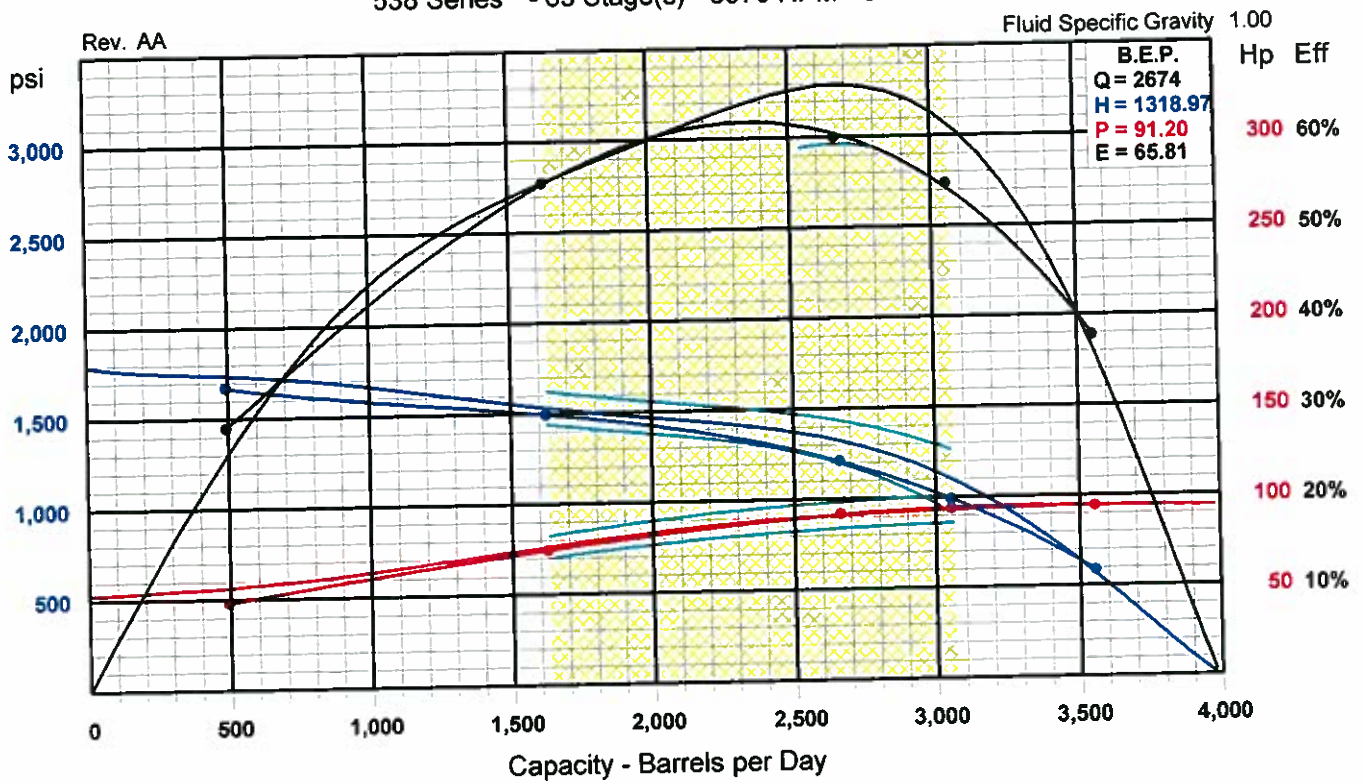
VIBRATION DATA

	Peak Hz	Ampl	Peak Hz	Ampl
	Half Speed Inline		Half Speed Offset	
Top	0.00	0.000	0.00	0.000
Middle	0.00	0.000	0.00	0.000
Bottom	0.00	0.000	0.00	0.000
	Rotating Speed Inline		Rotating Speed Offset	
Top	57.50	0.104	0.00	0.000
Middle	57.50	0.120	0.00	0.000
Bottom	57.50	0.028	0.00	0.000

REDA Production Systems

Reda Pump Performance Curve
HS75N
538 Series * - 63 Stage(s) - 3570 RPM - 61 Hz

Log No. NISP12011033105
Serial No. 29E1C55727
March 31, 2011 13:46



Schlumberger Artificial Lift Certification of Hydrostatic Testing.

Customer: CANDYNE	Work Order: BFP55727	Test Date: MAR 31/2011
Location: CALGARY	Pump S/N: 29E1C55727	Stage Type: S75N
	Skid S/N	Stage Count: STG/HSG


Per REDA Test Specification TS-5-127, This document certifies that the equipment listed has been Hydrostatically tested and considered satisfactory. As per the Operator, no leaks were detected during the test period.

Comments: PASSED

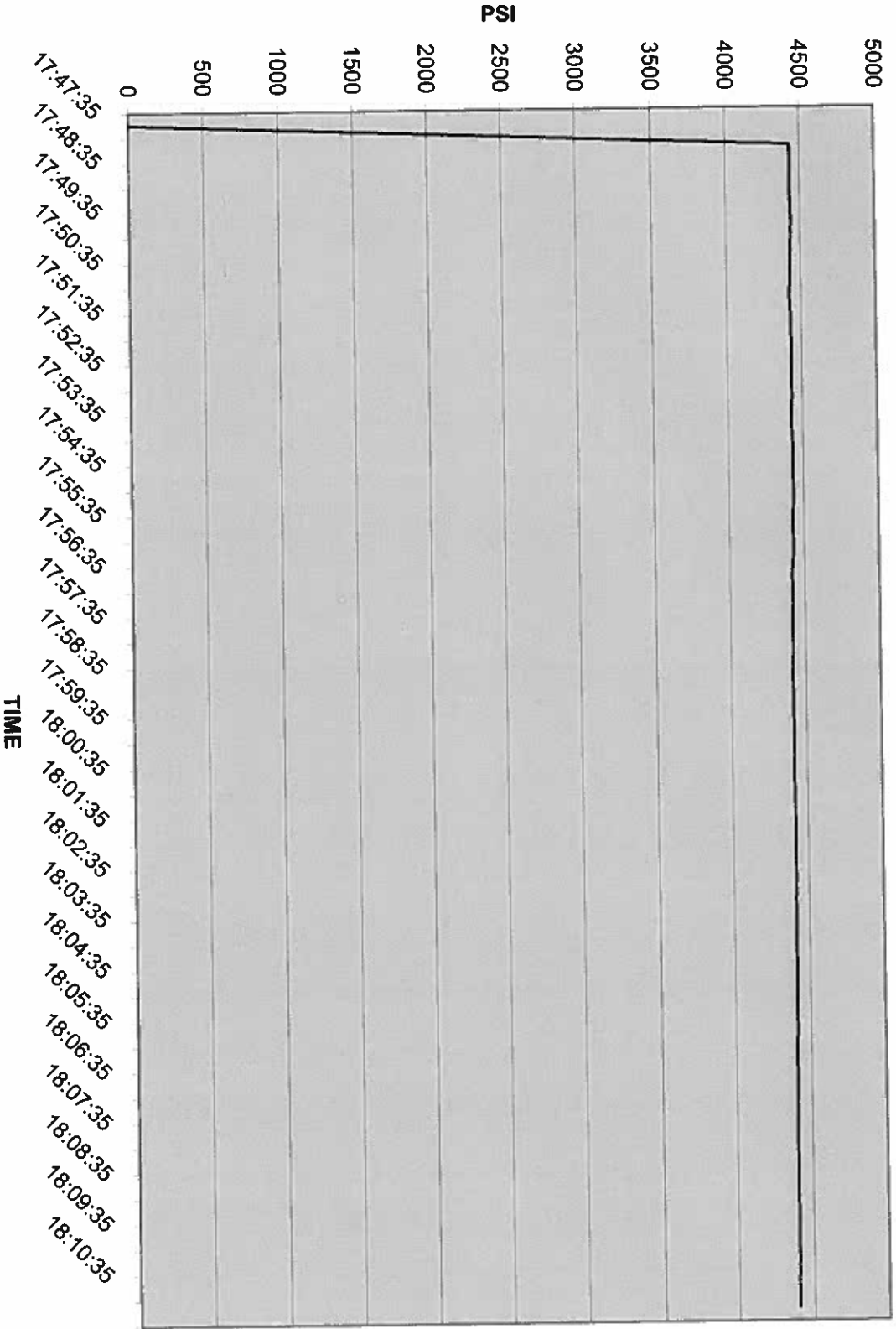
PLEASE SEE GRAPH
NO VISIBLE LEAKS NOTED

Maximum Allowable Working Pressure (PSI):	Maximum Hydrostatic Test Pressure(PSI):	Hydrostatic Test/Fill Fluid:	Recorded Test Period Duration:
2833	4250	DowFrost 032767	30 Minutes

Certified By:

Print Name: RASHMIN SOZA	Title: M.D
Signature: 	Date: MAR 31/2011

29E1C55727



Series 1

Schlumberger Artificial Lift - Nisku Service Center
HORIZONTAL PUMP TEST RESULT

3/31/2011 4:43:02

Working Pressure	: 0	Hydrostatic Test Pressure:	0
Work Order Number	: BFP55728	Part Number	: 2008012
Log Number	: NISP12011033107	Well Site	: CALGARY
Pump Serial Number	: 29E1C55728	Thrust Type	: CR
Stage Type	: HS75N	Bearing Type	: ARZ
Number of Stages	: 63	Pump Config	: CT
Max Recommended Flow:	3060	BEP Flow :	2674
Curve RPM	: 3570	Min Recommended Flow :	1632
Avg Water Temperature	: 36	Torque Factor	: 1.34
PumpStart	: 3/31/2011 4:31:06 PM	Test Category	: New
		Pump Stop	: 3/31/2011 4:41:37 PM
Customer	: CANDYNE	Operator Number	: KEVIN.D/RASHMIN.S
Comments	: 60HSGTzero 0.125		

---values are corrected to 3570 RPM---

	BPD	INLET PSI	OUTLET PSI	TORQUE RAW	PUMP RPM	EFF	BPD	HEAD/ STAGE	HP/ STAGE
Point 1	3463.97	43.84	747.51	136.82	3513	0.457	3520.18	11.61	1.5201
Point 2	2979.23	44.03	1104.25	135.63	3513	0.597	3027.57	17.50	1.5066
Point 3	2625.71	44.07	1291.14	130.68	3513	0.643	2668.32	20.59	1.4514
Point 4	1610.01	44.24	1536.34	103.85	3516	0.595	1634.73	24.60	1.1486
Point 5	478.17	44.64	1724.79	69.61	3520	0.298	484.96	27.65	0.7637

TEST DEVIATION FROM CURVE

values are per stage corrected to 3570 RPM

	FLOW BPD	IN RANGE	TEST HEAD	HEAD DEV	HEAD-FL % DEV	TEST HP	HP DEV	HP % CURVE	TEST EFF	EFF DEV	EFF % CURVE
Point 1	3520.18	NO	11.61	1.89	2.4	1.5201	0.0232	1.5	45.70	6.85	17.6
Point 2	3027.57	MAX	17.50	-0.34	-0.6	1.5066	0.0286	1.9	59.75	-2.34	-3.8
Point 3	2668.32	BEP	20.59	-0.41	-1.1	1.4514	0.0045	0.3	64.31	-1.50	-2.3
Point 4	1634.73	MIN	24.60	0.28	1.0	1.1486	-0.0652	-5.4	59.47	3.84	6.9
Point 5	484.96	NO	27.65	0.04	0.2	0.7637	-0.1307	-14.6	29.83	4.40	17.3

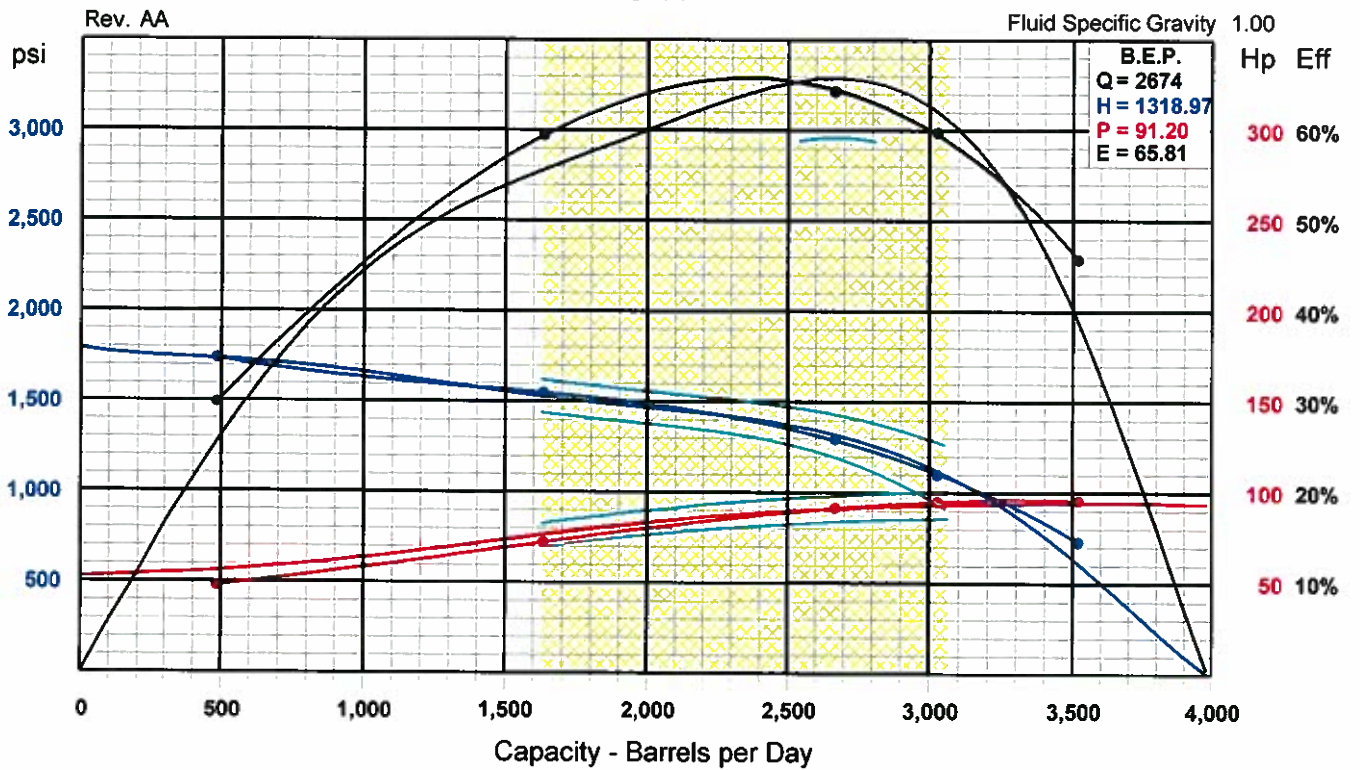
VIBRATION DATA

	Peak Hz	Ampl	Peak Hz	Ampl
	Half Speed Inline		Half Speed Offset	
Top	0.00	0.000	0.00	0.000
Middle	0.00	0.000	0.00	0.000
Bottom	0.00	0.000	0.00	0.000
	Rotating Speed Inline		Rotating Speed Offset	
Top	57.50	0.051	0.00	0.000
Middle	57.50	0.109	0.00	0.000
Bottom	57.50	0.088	0.00	0.000

REDA Production Systems

Reda Pump Performance Curve
HS75N
538 Series * - 63 Stage(s) - 3570 RPM - 61 Hz

Log No. NISP12011033107
Serial No. 29E1C55728
March 31, 2011 16:30



Schlumberger Artificial Lift Certification of Hydrostatic Testing.

Customer: CANDYNE	Work Order: BFP55728	Test Date: 1-Apr-11
Location:	Pump S/N: 29E1C55728	Stage Type: S75N
	Skid S/N	Stage Count: 63STG/60HSSG

Per REDA Test Specification TS-5-127, This document certifies that the equipment listed has been Hydrostatically tested and considered satisfactory. As per the Operator, no leaks were detected during the test period.


Comments: PASSED

PLEASE SEE GRAPH
NO VISIBLE LEAKS NOTED

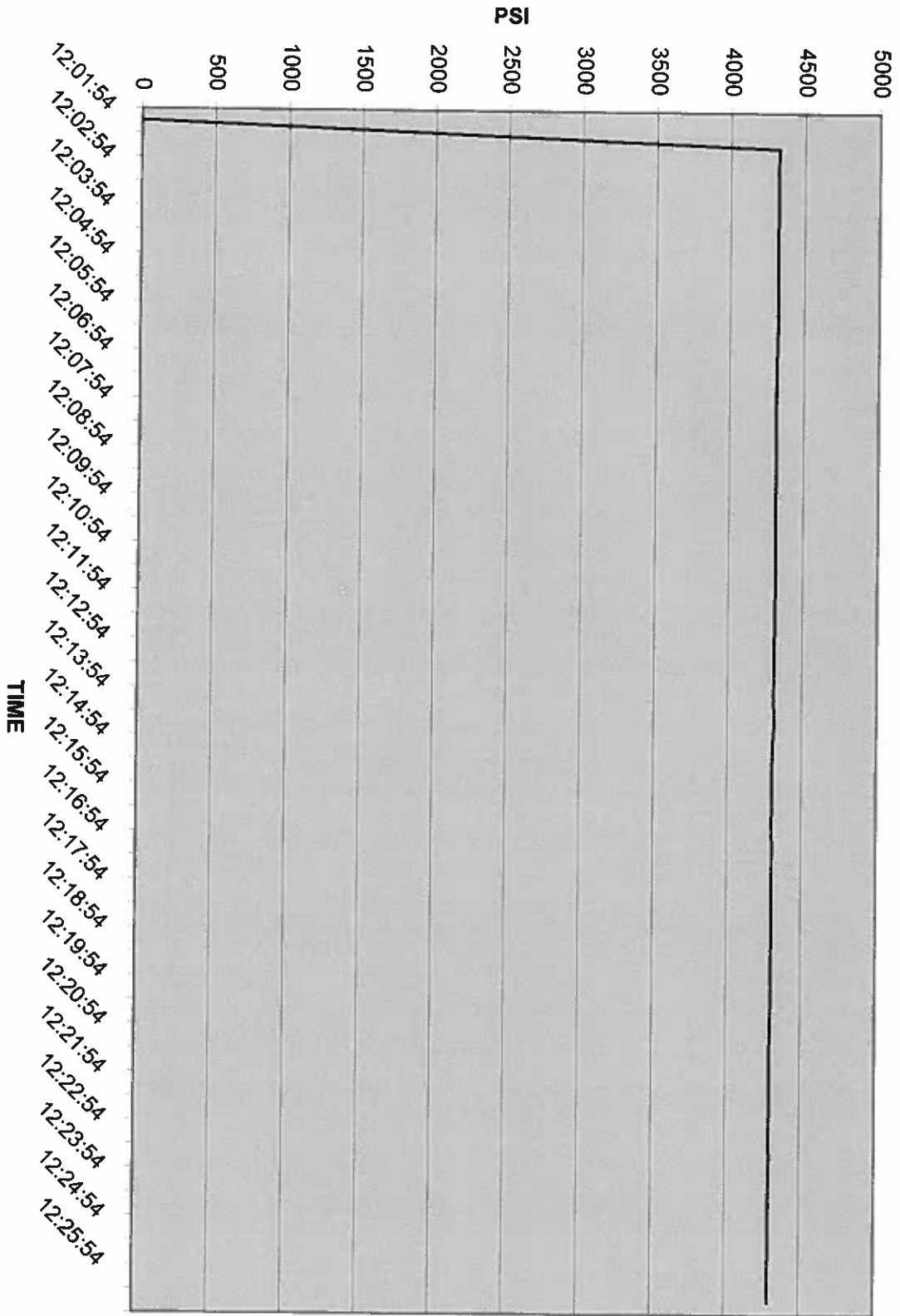
Maximum Allowable Working Pressure (PSI):	Maximum Hydrostatic Test Pressure(PSI):	Hydrostatic Test/Fill Fluid:	Recorded Test Period Duration:
2833	4250	DowFrost 032767	30 Minutes

Certified By:

Print Name: KEVIN DAVIS Title: M.D

Signature:  Date: 1-Apr-11

29E1C55728



— Series 1

Schlumberger Artificial Lift - Nisku Service Center
HORIZONTAL PUMP TEST RESULT

3/31/2011 2:49:48

Working Pressure	: 0	Hydrostatic Test Pressure:	0
Work Order Number	: BFP55729	Part Number	: 2008012
Log Number	: NISP12011033106	Well Site	:
Pump Serial Number	: 29E1C55729	Thrust Type	: CR
Stage Type	: HS75N	Bearing Type	: ARZ
Number of Stages	: 63	Pump Config	: CT
Max Recommended Flow:	3060	BEP Flow :	2674
Curve RPM	: 3570	Min Recommended Flow :	1632
Avg Water Temperature	: 35	Torque Factor	: 1.34
PumpStart	: 3/31/2011 2:38:46 PM	Test Category	: New
		Pump Stop	: 3/31/2011 2:47:59 PM
Customer	: CANDYNE	Operator Number	: KEVIN.G/ KEVIN.D
Comments	: 60HSGTzero 0.125		

---values are corrected to 3570 RPM---

	BPD	INLET PSI	OUTLET PSI	TORQUE RAW	PUMP RPM	EFF	BPD	HEAD/ STAGE	HP/ STAGE
Point 1	3495.05	43.88	665.04	136.42	3511	0.408	3553.78	10.26	1.5169
Point 2	3005.93	43.99	1035.41	134.23	3512	0.570	3055.57	16.37	1.4913
Point 3	2607.62	44.19	1249.78	130.60	3513	0.618	2649.93	19.90	1.4499
Point 4	1606.28	44.26	1503.86	105.22	3516	0.573	1630.94	24.05	1.1636
Point 5	474.84	44.59	1664.12	70.22	3520	0.283	481.59	26.63	0.7699

TEST DEVIATION FROM CURVE

values are per stage corrected to 3570 RPM

FLOW BPD	IN RANGE	TEST HEAD	HEAD DEV	HEAD-FL % DEV	TEST HP	HP DEV	HP % CURVE	TEST EFF	EFF DEV	EFF % CURVE	
Point 1	3553.78	NO	10.26	1.24	1.5	1.5169	0.0195	1.3	40.85	4.45	12.2
Point 2	3055.57	MAX	16.37	-1.13	-2.0	1.4913	0.0117	0.8	56.98	-4.42	-7.2
Point 3	2649.93	BEP	19.90	-1.22	-3.2	1.4499	0.0052	0.4	61.78	-4.01	-6.1
Point 4	1630.94	MIN	24.05	-0.27	-0.9	1.1636	-0.0490	-4.0	57.28	1.70	3.1
Point 5	481.59	NO	26.63	-0.98	-3.5	0.7699	-0.1239	-13.9	28.30	3.03	12.0

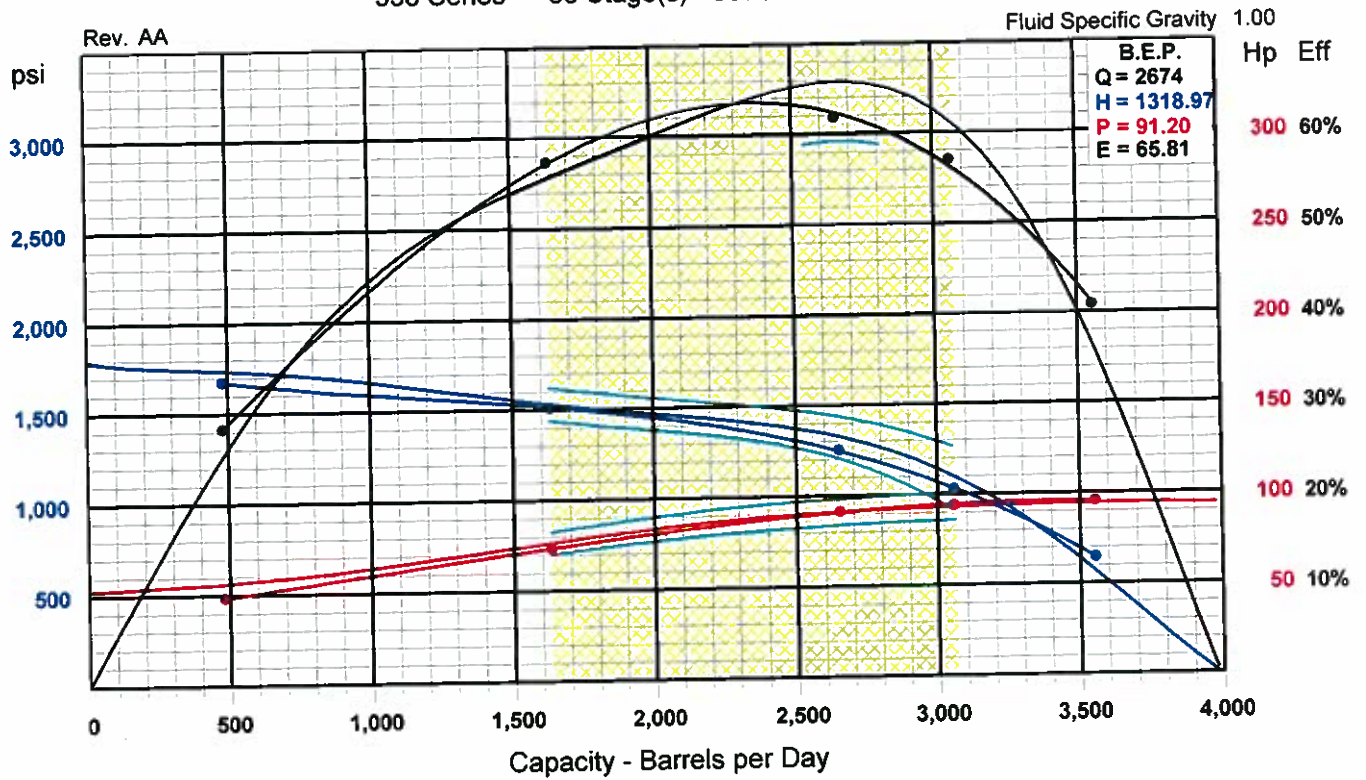
VIBRATION DATA

	Peak Hz	Ampl	Peak Hz	Ampl
	Half Speed Inline		Half Speed Offset	
Top	0.00	0.000	0.00	0.000
Middle	0.00	0.000	0.00	0.000
Bottom	0.00	0.000	0.00	0.000
	Rotating Speed Inline		Rotating Speed Offset	
Top	57.50	0.106	0.00	0.000
Middle	57.50	0.150	0.00	0.000
Bottom	57.50	0.099	0.00	0.000

REDA Production Systems

Reda Pump Performance Curve
HS75N
538 Series * - 63 Stage(s) - 3570 RPM - 61 Hz

Log No. NISP12011033106
Serial No. 29E1C55729
March 31, 2011 14:38



Schlumberger Artificial Lift Certification of Hydrostatic Testing.

Customer: CANDYNE	Work Order: BFP55729	Test Date: MAR 31/2011
Location: CALGARY	Pump S/N: 29E1C55729	Stage Type: S75N
	Skid S/N	Stage Count: 63STG/60HSG


Per REDA Test Specification TS-5-127, This document certifies that the equipment listed has been Hydrostatically tested and considered satisfactory. As per the Operator, no leaks were detected during the test period.

Comments: PASSED

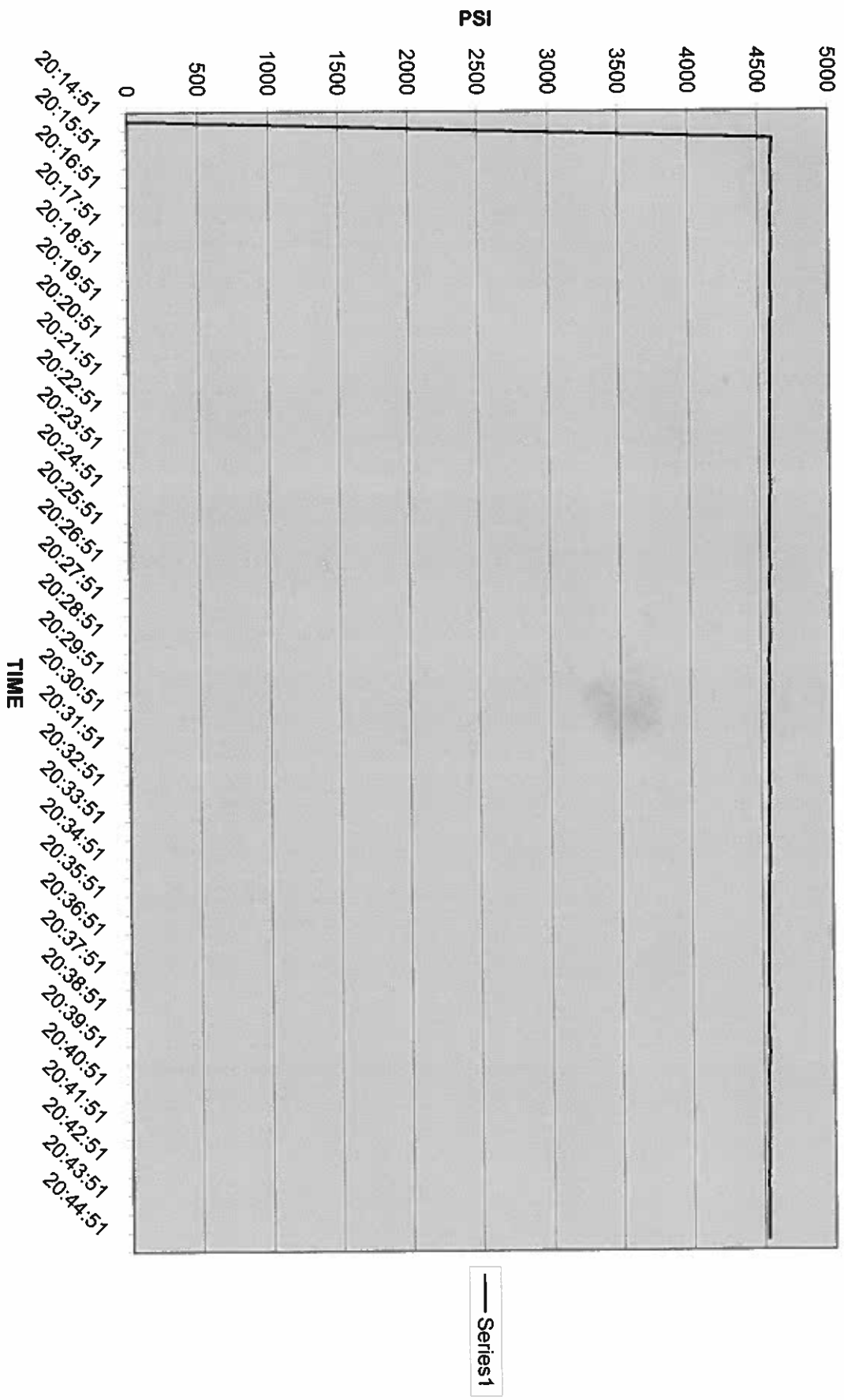
PLEASE SEE GRAPH
NO VISIBLE LEAKS NOTED

Maximum Allowable Working Pressure (PSI):	Maximum Hydrostatic Test Pressure(PSI):	Hydrostatic Test/Fill Fluid:	Recorded Test Period Duration:
2833	4250	DowFrost 032767	30 Minutes

Certified By:

Print Name: KEVIN DAVIS	Title: M.D
Signature: 	Date: MAR 31/2011

29E1C55729



Schlumberger Artificial Lift Certification of Hydrostatic Testing.

Customer: PARAMOUNT	Work Order:	Test Date:	APRIL 1/11
Location:	S/N: 0214-C 9 11-2	Stage Type:	
	Skid S/N	Stage Count:	STG/HSSG

Per REDA Test Specification TS-5-127, This document certifies that the equipment listed has been Hydrostatically tested and considered satisfactory. As per the Operator, no leaks were detected during the test period.

Comments: PASSED DISCHARGE HEAD P.N. 3909032

PLEASE SEE GRAPH
NO VISIBLE LEAKS NOTED

Maximum Allowable Working Pressure (PSI):	Maximum Hydrostatic Test Pressure(PSI):	Hydrostatic Test/Fill Fluid:	Recorded Test Period Duration:
		DowFrost 032767	10 Minutes

Certified By:

Print Name: KEVIN GILLINGHAM	Title: M.D
Signature: <i>Kevin Gillingham</i>	Date: APRIL 1/11

Schlumberger Artificial Lift Certification of Hydrostatic Testing.

Customer: PARAMOUNT	Work Order:	Test Date:	APRIL 1/11
Location:	S/N: 0215-CA11-2	Stage Type:	
	Skid S/N	Stage Count:	STG/HSG

Per REDA Test Specification TS-5-127, This document certifies that the equipment listed has been Hydrostatically tested and considered satisfactory. As per the Operator, no leaks were detected during the test period.

Comments: PASSED DISCHARGE HEAD PN- 3909032

PLEASE SEE GRAPH
NO VISIBLE LEAKS NOTED

Maximum Allowable Working Pressure (PSI):	Maximum Hydrostatic Test Pressure(PSI):	Hydrostatic Test/Fill Fluid:	Recorded Test Period Duration:
		DowFrost 032767	10 Minutes

Certified By:

Print Name: KEVIN GILLINGHAM	Title: M.D
Signature: <i>Kevin Gillingham</i>	Date: APRIL 1/11

Recommended Spare Parts and Servicing Tools

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HORIZONTAL PUMPING SYSTEM RECOMMENDED SPARE PARTS AND SERVICING TOOLS

QUANTITIES RECOMMENDED ARE FOR 1 UNIT(S) FOR 3 YEARS

SPARE PARTS				
ITEM	QTY	DESCRIPTION	P/N	WT/LBS
1.	1	Thrust Chamber Assy, 2 Bearing, G3A (1.18-6B)	100447637	275
2.	1	SEAL: JC, TYPE 2, 1.50 SZ, NON-CART, MONEL, HSN, CF-SP-93410-8	7005564	5
3.	3	KIT, HPS, O-RING SET, HSN, 538/540 SERIES TANDEM	100304355	1
4.	1	Seal: Bearing Isolator, Motor Side	100447640	1
5.	1	Seal: Bearing Isolator, Pump Side	100390497	1
6.	3	Thrust Chamber Oil, 5 gal (ROYAL PURPLE,SYNFILM 46 GT)	100179556	45
7.	3	O-Ring Lubricant	0553420	.3
8.	3	Motor Grease No. 2	1192640	1
9.	3	Teflon Tape, 1/2"	0588855	.06
10.	3	Coupling 1.188 x 1.375	3907128	2
11.				
12.				
13.				
14.				
15.				
16.				
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				

TOOLS				
ITEM	QTY	DESCRIPTION	P/N	SUPPLIER
1.	1	Multimeter: Fluke model #87, True RMS, C/W Holster Test Leads & C25 Case	1048685	SLB
2.	1	Dow Corning – for pump O-Rings	3901207	SLB
3.	1	Straight Edge, 6"	0588236	SLB
4.	1	Screwdriver, 6" Blade)	0588566	SLB
5.	1	¾" Open and Box Wrench (675/862)	0593459	SLB
6.	1	Combination Wrench ½"	0593426	SLB
7.	1	Box End / Open / End Wrench, 9/16" x 5/8" (400/540)	0001164	SLB
8.	1	Wrench: Eklind #812 (3/32" – ¼")	0593491	SLB
9.	1	Macit Wrench Set, 3/16" x 3/8"	0593509	SLB
10.	1	Amp Meter Probe, Current, Clamp on	0856856	SLB
11.	2	Scissor Jack for Gen 2	100040787	SLB
12.	2	Roller Jack for Gen 1	1099878	SLB
13.	1	Feeler Gauge – (motor & pump aligning)	1192582	SLB
14.	1	Crane for TC Removal	100040817	SLB
15.	1	Box End / Open End, 1 ½" x 1 5/8"	1192590	SLB
16.	2	Grease Gun – 1 for Flex Coupling and 1 for motor	1192616	SLB
17.	2	Grease Gun Flex Hose	1192624	SLB
18.	1	Tool Box	1192632	SLB

19.	1	Seal (Non-Cartridge) Installation Tool (Plastic Cylinder)	3954255	SLB
20.	1	Small Pipe Wrench 18"	3901773	SLB
21.	1	Large Pipe Wrench 24"	3901774	SLB
22.	1	Strap Wrench, Medium SW #350-67402	3901775	SLB
23.	1	T-Handle Long Allen Wrench 3/16"	3901779	SLB
24.	1	T-Handle Long Allen Wrench 1/4"	3901780	SLB
25.	1	Crescent Wrench, 10" SW #06-46304	3901781	SLB
26.	1	Crescent Wrench, 15" SW #13-00215	3901782	SLB
27.	1	Pry Bar, 48" WT #6400-0045	3901803	SLB
28.	1	Snap Ring Pliers, Small BI-DIR, SW #13-06784x	3901805	SLB
29.	1	Pliers, Crescent: R220c	0586172	SLB
30.	1	Channel Lock Pliers 10"	3901808	SLB
31.	1	Wire Brush Set Assorted, SW #05-2267	3901817	SLB
32.	1	Rubber Mallet	3901825	SLB
33.	1	Punch & Center 5/16" Set	3901367	SLB
34.	1	8oz. Ball Pein Hammer	3901826	SLB
35.	1	3/8" Drive Ratchet Set	3901840	SLB
36.	1	Alignment Machine (Masterlign by Pruftechnik)	3901956	SLB
37.	1	Vibration	3901959	SLB
38.	1	Lubricant P-80 (used for Oil Seals & John Crane Seal Installation)	3902450	SLB
39.	1	Screw Extractor Set 3/16" - 3/4" 5 pc	3920263	SLB
40.	1	Ball End hex Keys Set 1/16" - 3/16" Standard	3920264	SLB
41.	1	Needle Nose Pliers 6 5/8"	3920265	SLB
42.	1	Thread Tap Index Set 1/4-20NC - 1/2-20NC	3920266	SLB
43.	1	String Line Twisted Nylon Twine	3920267	SLB
44.	1	Bearing Puller Attachment 4 5/8" Max Spread	3920268	SLB
45.	1	Bearing Manual Push-Puller	3920269	SLB
46.	1	Metal File Set 5 pc	3920270	SLB
47.	1	Box End Wrench 12 pt Set (for Metastream Removal)	3920271	SLB
48.	1	Small precision Machinist Square 20 - 1 1/2	3920272	SLB

Installation and Commissioning

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6 Installation and Commissioning

6.1 Operational Checklist

1. Pre-Commissioning:

It is recommended to review the Specific Job Data Books/User Manuals, supplied with this equipment, prior to commissioning the system. Prior to starting a unit up, a thorough inspection of the equipment should be made, noting damaged or missing items.

a. Safety:

- Refer to the Hazard Analysis Risk Control Recommendations.
- Ensure correct Personal Protective Equipment and Tools.

b. Foundation:

- Ensure equipment is properly supported and anchored without distortion.
- Level skid in both planes and shim as required.

c. Piping:

- Verify piping line class ratings are acceptable for the intended equipment/service conditions.
- Ensure proper piping bracing and support spans.
- Minimize pipe strain/forces.
- Ensure adequate vents/drains.
- Note piping routing (parallel/series) and ensure line sizing is adequate for the service. Not intake piping relative to supply source.
- Verify Expansion Joints/Drop Out Spools are connected properly, if supplied.
- Verify eccentric line reduction in intake piping and concentric line increases in discharge piping, where appropriate.
- Verify piping has been hydro tested and cleaned of debris
- Ensure joints are made up correctly. Tighten and loose or leaking connections without over tightening.

- Verify proper valving: Isolation, Check, Throttling, Control, Relief, Strainers, are supplied in the system and are installed correctly and in the proper places.
 - Ensure external hookups are made up: Seal Flush and Barrier Systems (Drains/Vents/Flare/Cooling Coils, etc), Drains, Vents, Instruments, Lube Cooling, etc.
- d. Electrical Instruments:**
- Verify proper grounding.
 - Verify motor rotation, to include lube cooler motors.
 - Pre-Set instrument shutdown set points.
 - Check incoming line voltage, each phase. Also transformed control voltage. Match Switchgear voltage/rating to motor and power.
 - Inspect makeup of all interconnecting electrical runs (Motor/Panel/Switchgear, Coolers, J-Boxes, etc). Pot any leads, where necessary.
 - Megger/Continuity check wiring and instruments. Verify against wiring schematics provided.
 - Verify proper ventilation/heating to prevent overheating/freezing.
 - Inspect Insulated/traced lines or equipment.
 - Pre-Program Variable Speed Drive/Program Logic Controller/Program Controller as necessary.
- e. Lubricants:**
- Ensure the Thrust Chamber and Lube Cooler are filled to the proper levels with the correct grade of lubricants.
- f. Alignment:**
- Align equipment using Laser Tool. Verify against Factory Supplied Data. Record.
 - Ensure pumps are shimmed properly.
- g. Filling/Venting:**
- With discharge and drain valves closed, open inlet valve and flood system. Vent instruments and piping/pump at high points.
 - Verify static pressure measurements against flange and seal ratings, switchgauge set points. Verify ample NPSHA

2. Startup:

- With unit flooded, start Booster pump, if required. Open Discharge valve to 20%. Slowly open discharge valve to the desired discharge pressure.
- Set VSD, if provided, to the desired carrier frequency/operating frequency.
- Troubleshoot as required.

3. Operational:

- Verify Pump is Operating according to the desired and specified design conditions. Record.
- Adjust set points on instruments as required. Record.
- Measure voltage and amp draw. Ensure current trip limits set and within range of the operating conditions and equipment provided. Record.
- Perform baseline vibration reading for entire drive train in both vertical and horizontal axis for all operating frequencies. Record.
- Observe Thrust Chamber Oil Temperature. Record.
- Shutdown unit and perform a Hot alignment. Record.
- Take Digital pictures of the Unit.
- Complete and retain Service Report. Sign and Date.
- Develop Maintenance Schedule with Customer.

6.2 Transport and Handling

General shipping and handling information

Horizontal pumping system (HPS) equipment is normally mounted on a rigid, non-flexible steel welded structure requiring a minimum of supportive packing. The unit can be lifted and moved with a forklift or crane-type equipment. An appropriately sized spreader bar and slings or chains must be used. Lifting eyes are located at each of the four corners of the skid to accommodate lifting.



Warning

Potential Severity: Serious
 Potential Loss: Assets
 Hazard Category: machinery equipment hand tools

Never attempt to lift the assembly from any point other than the lifting eyes on the skid.

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Ground transport

Ground transport via truck requires the use of no fewer than two wooden supports (4-in square by 8-ft long) placed crosswise under the skid and spaced no more than 10 ft apart. Use only straps to secure the unit, with a minimum of two tiedowns per unit. This recommendation also applies when two skids are placed side-by-side for transportation on the same platform. The straps should be placed over the skid at the location of the wooden supports. Never place a strap over the motor, thrust chamber, intake or pump. Engine-driven units may require some disassembly to meet specific clearance requirements. Secure all loose components. Provide protection from road debris.

When loading one unit, always load the motor end toward the truck cab. If loading more than one unit, the units should be staggered opposite of each other.

Ocean transport

HPS units for shipment via ocean transport should be crated or shipped in shipping containers. The client or application engineer will determine the better method.

Air transport

Air transport normally requires palletizing of the assembled skid to allow for ease of loading and unloading. Additionally, weight and balance requirements of some aircraft may require special palletization to permit transport.

6.2.1 **Lifting**

Units can be lifted with a forklift or a crane.

6.2.1.1 **Forklifts**

Ensure the forklift has the capacity to handle the HPS unit. Forklifts are rated for a given load at a distance from the mast. Since HPS units have the load located along the longitudinal axis of the skid, the centerline of the motor is the centerline of the load.

Each HPS unit has the center of gravity marked on the unit. This is the unit balance point and is determined by the manufacturer. If there is packing material or other loose items on the skid, the center of gravity will have moved.

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The forks must straddle the center of gravity. Distance between the forks is important. A small HPS unit can be handled by a forklift with 30– to 36–in between the forks. A full-length skid (46 ft) will require 60–in. or more between the forks.

6.2.1.2 Cranes

Two different lifting configurations are possible when using an appropriate spreader bar and slings or chains. Because the center of gravity is not at the longitudinal center of the unit, in all but a few cases, either the slings or chains are not the same length or the center lifting eye on the spreader bar will not be in the center of the spreader bar. If the spreader bar has a single (or main) lifting eye in the center, then the sling or chain on the motor side will be shorter. The spreader bar must be shorter than the unit. This is done to keep the unit from not being level when lifted. If the unit is not level when lifted, shorten the motor side sling or chain or lengthen the pump side sling or chain. If the spreader bar has the main lifting eye offset and was designed to lift the specific skid, use equal length slings or chains. The units have lifting eyes located at each of the four corners.

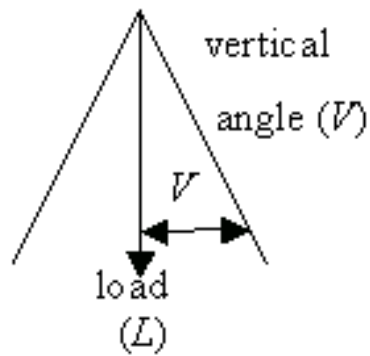
The crane manufacturer's load recommendations must be followed. Be especially careful of low boom angles. Follow all Schlumberger safety procedures, lifting procedures and guidelines.

Because the load on the slings or chains is not the same on each end of the skid, the loads must be calculated and compared to the ratings on the slings or chains. The slings or chains should be inspected before each use. Damaged slings or chains should be repaired or discarded.

6.2.2 Lifting Device Load Calculations

h Hint

A calculator with trigonometric functions is useful for making lifting calculations.



Term	Definition
L	load to be lifted
R	load on the lifting device
C	cosine of the maximum vertical angle

then

$$L=RC$$

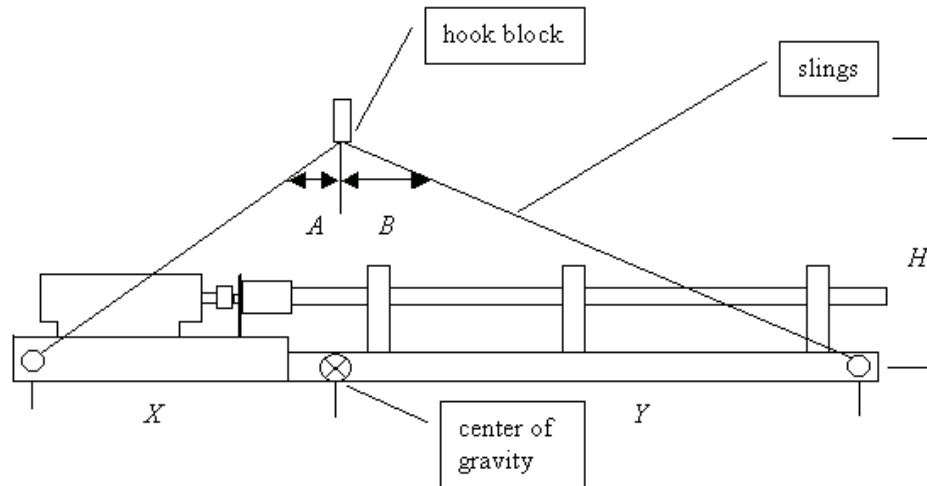
$$R=L\div C$$

Angle	Cosine
15°	0.966
25°	0.906
30°	0.866
35°	0.819
40°	0.766
45°	0.707
50°	0.643
60°	0.500
70°	0.342

When the vertical angle is increased, the load on the sling will be increased by a factor that is the cosine of the vertical angle. If any two terms of the equation are known, the equation can be used to solve for the third term.

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Example

A HPS unit weighs 13,000 lbm and its length is 35 ft. The unit will be lifted with a crane and slings. Determine the strength requirement of the slings and verify the loads. The hook block must remain over the center of gravity.

Calculate the load on each sling —

$$R=L\div C$$

$$R=(13000\div 4)\div C$$

The weight of the unit is divided by four because there are four slings. The cosine of the angle C should be the larger of the two A or B .

A or B are determined by measuring the distance from the hook to the center of gravity, ensuring that the hook is tight against the slings. The angle A or B is the arc tangent of the distance from the center of gravity divided by the height.

$$A=\arctan(X\div H)$$

$$B=\arctan(Y\div H)$$

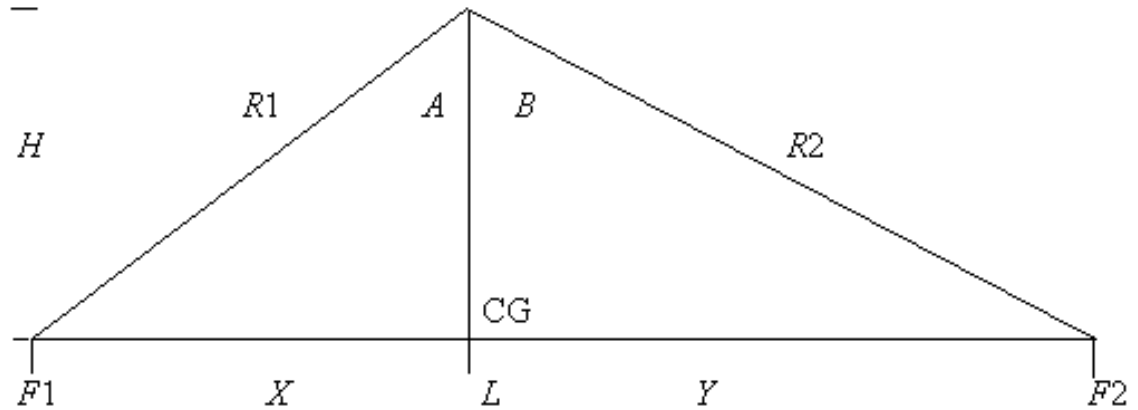
For this example, $X = 13$, $Y = 22$, $H = 15$

$$A=\arctan (13\div 15) = 40.9^\circ$$

$$B=\arctan (22\div 15) = 55.7^\circ$$

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$$F1 = L(y \div [x+y]) = 13000(22 \div [22+13]) = 13000(22/35) = 8171.4 \text{ lbm}$$

$$F2 = L(x \div [x+y]) = 13000(13/35) = 4828.6 \text{ lbm}$$

$$R1 = F1 \div \cosine A = 8171.4 \div 0.756 = 10810.9$$

$$R2 = F2 \div \cosine B = 4828.6 \div 0.564 = 8568.5$$

$R1$ is the greater load so the slings should be sized to lift $R1 \div 2$ (two slings on each end) or $R = 5405$ lbm. The slings should have a minimum rating of 6000 lbm each.

6.3 Site Requirements

The horizontal pumping system (HPS) is shipped fully assembled or in several sections. The HPS unit is built in sections if the overall unit length exceeds shipping limitations. The unit sections are aligned during manufacturing and testing. During the installation procedure, all alignments must be checked.

The installation site should be level with adequate drainage. The client should determine if the unit is set on a concrete pad or on a support system. The support must be adequate to prevent misalignment when the unit is in operation.

Gravel pad

A HPS unit can be set on a gravel pad with no supports, however, this practice is not recommended. It is difficult to level the unit and prevent the unit from being out of alignment. Many units are placed in service with gravel-only support. In these cases, the most important action is to verify the pump is straight and the motor and thrust chamber are aligned.

Steel, wood or concrete supports

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Supports made of steel, wood or concrete can be used. When one of these supports are used, it is important the earth under the supports is compacted and covered with three to four in. of gravel. The skid should be level in both directions on the supports. The base rail of the skid should be shimmed between the rail and the support. The motor end of the skid should have two supports, one located under the mounting bolts at the fan end of the motor and the other support should be located under the motor-to-thrust chamber coupling. Other supports should be equally spaced down the remaining skid no more that 10 ft apart.

Reinforced concrete pad

Field preparation should include a reinforced concrete pad built in accordance with the dimensional HPS drawing, dimensional skid footprint drawing, system weight, and the environmental conditions associated with the installation site. As a general recommendation, the reinforced concrete pad should be rated for 250% of the combined weight of the electric motor or engine and the support skid (250 lbm per foot of length). The pump section of the skid is typically lighter in weight per foot of length than that of the electric motor or engine. The skid should be level in both directions on the pad. The base rail of the skid should be shimmed between the rail and the pad. Do not allow the bottom rail to be unsupported for a length more than 10 ft under the pump and 5 ft under the motor section.

Clearance instructions

The skid clearance for operation should be a minimum of three ft in all directions from the system pump/motor axis except for electric and mechanical connections. The overhead clearance should allow for use of a forklift or winch system to aid in equipment removal and replacement.

Refer to the motor or engine manufacturer's recommendation for ventilation clearances to prevent excessive temperature rise. All system enclosures or buildings should allow for natural convection air circulation at rates that do not allow for excessive temperature rises that may affect motor/engine, starter, and thrust chamber life. Ambient air temperatures greater than 104 degF (40 degC) require special components and design considerations to prevent reduced motor/engine, starter and thrust chamber life.

Clearances mentioned in this section are provided as a general guide and may be superseded by requirements based on class or division rating of a specific system's site location. Local codes, specifications or regulations in the state or country may apply.

6.4 Piping Connections

Proper connection of suction and discharge piping to the horizontal pumping system (HPS) unit is very important. The care used when making fit-ups will affect the equipment runlife and may prevent leaks.

Allowable loads (nozzle loading)

Nozzle loading is defined as the forces and moments induced on the pump flange by the connecting piping. Proper piping configurations will eliminate misalignment between the pump and the driver and may prevent flange leaks.

Factors that determine the forces and moments are:

- weight of the connection piping
- amount of thermal growth
- misalignment of the mating pipe flanges

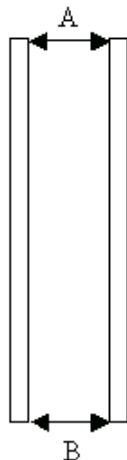
The pipe weight should be supported by a pipe support located a short distance from the companion flange and extending to the pump intake flange. The pipe support should be adjustable so that the companion flange and pump intake flange can be accurately aligned.

The maximum operating temperature for HPS units is 200 degF (93 degC). The units are limited to this temperature to prevent thermal growth from becoming a problem. HPS units can be operated at higher temperatures if certified by the Product Center.

Flange alignment is very important. The ASME piping code B31.3 (1996) states “Any distortion of piping to bring it into alignment for joint assembly which introduces a detrimental strain in equipment or piping components is prohibited.” In the case for HPS units, before installing bolts, flange faces should be aligned to the design plane within 0.0625 in/ft (1 mm/200 mm) measured across any diameter (see [Figure 6-1](#)). Flange bolt holes should be aligned within 0.125 in. (3 mm) maximum offset (see [Figure 6-2](#)).

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A – B less than or equal to 0.0625 in./ft
of flange width

Figure 6-1: Allowable flange alignment

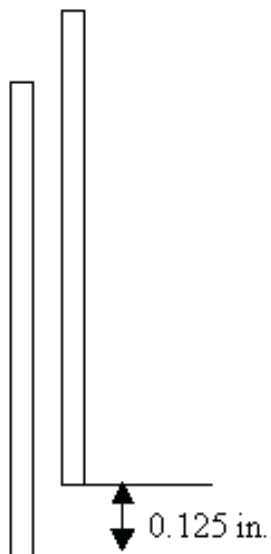


Figure 6-2: Maximum offset for bolthole alignment

Bolting should conform to the following guidelines.

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- When assembling flanged joints, the gasket should be uniformly compressed to the proper design loading.
- Caution should be used when assembling flanged joints where the flanges have widely differing mechanical properties. Tightening to a predetermined torque is recommended.
- Bolts should extend completely through the nuts with at least one complete thread showing beyond the nut.

The practice of “loose bolting” should be used; if the flanges are parallel and aligned so that the bolts can be inserted by hand with force, then the flanges are aligned properly. Tighten the bolts or nuts using an alternating pattern (see [Figure 6-3](#)).

**Note**

Flanges should be inspected for damage prior to assembly. A scratch or gouge on the flange face may cause a leak. Replace damaged flanges.

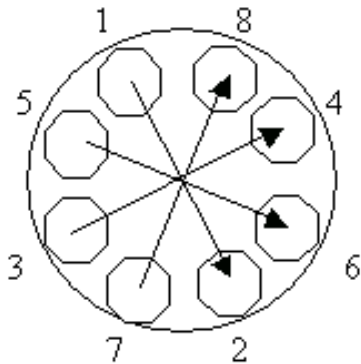


Figure 6-3: Flange bolt tightening sequence

6.5 Commissioning

Safety

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- Verify that all components of the discharge piping have a pressure rating greater than the discharge pressure of the HPS.
- Be aware of high-pressure fluid hazards such as leaks, splits and high-pressure hoses.
- Operate valves slowly and smoothly.
- Be aware of fluid contamination hazards.
- Wear appropriate personal protective equipment.

**Note**

Ensure the equipment is electrically grounded.

**Note**

Ensure that lockout/tagout procedures are reviewed with all personnel and are followed.

**Danger**

Potential Severity: Catastrophic
Potential Loss: Personnel
Hazard Category: human

Lockout/tagout procedures must be followed any time work is performed on the HPS, but risk of catastrophic injury is extremely high if the unit is started with a shaft locked down.

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**Note**

During installation or commissioning, the HPS unit should never be run dry. The bearing system in the pumps and the shaft seals require fluid for cooling. Running the unit without fluid, even for a short period of time, can cause premature bearing or seal failure.

Introduction

Qualified personnel are essential during start-up. Obvious faults may go unnoticed if personnel are unfamiliar with the equipment. The first task of the commissioning team is to check the HPS installation. Centrifugal pumps can seize at start up due to incorrect start-up procedures.

Commissioning Fluid

The pump may be commissioned on water if the regular product is not available, however, this can result in damage to the unit if the commissioning conditions are very different from the design datasheet conditions.

Risk of Upthrust Damage on Large-Volume Pumps

Upthrust damage can occur in compression-style pumps if a booster pump is used and has sufficient flow to cause the pump to rotate while the piping system is being charged. The damage occurs when liquid flow through the pump pushes the impellers towards the discharge end of the pump. If the pump is turning, the contact between the impeller and the upthrust pad on the diffuser will cause severe wear.

Preventing Thrust Damage at Startup

Allow only sufficient liquid to flow through the pump to remove any air. If the piping design requires high booster pump flow, the HPS shaft should be locked down.

**Note**

Ensure the motor panel is locked out and the clamp is removed prior to starting.

Starting the HPS Unit

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- 1 Close the suction and discharge valves.
- 2 If a time-delay relay is installed in the low-discharge-pressure circuit, set the pressure switches. (Follow procedure below.) Otherwise, set the pressure shutdown switches after the unit is stabilized and running.
- 3 Perform all required pre-start checks.
- 4 Slowly open the suction valve to full-open position and observe the suction pressure gauge.
- 5 Fill the pump. When initially filling the pump, it is likely that air will become entrained in the pump. The air must be evacuated before starting the HPS unit. This can be accomplished by filling the pump with fluid and then opening the small bleeder valve on the top of the pump case at the discharge end. Close the valve as soon as the airflow through the bleeder valve has stopped. If the HPS unit is not equipped with the bleeder valve, evacuate the air by loosening the pressure shutdown switch hydraulic hose connection on the pump case at the discharge end. Tighten the switch hose connection as soon as the airflow has stopped.
- 6 Perform a conditional inspection and verify that the unit is ready to start.
- 7 Partially open the discharge valve. Twenty percent of full open is recommended as a starting point.
- 8 Position yourself to carefully observe the direction of rotation (clockwise when looking from the back of the motor towards the pump).
- 9 Start the unit. If the rotation direction is not correct, shut off and reverse two of the motor leads at the starter. If the rotation direction is correct, go to the next step.

***i* Note**

Electric motors over 200 horsepower (150 kW) may have starting limitations. The motor manufacturer may limit the number of starts in a given time period and/or require a certain amount of time between starts. If a motor has starting limitations, the limitations will be listed on the motor data plate. Review the motor data plate prior to starting the motor.

- 10 Monitor the suction and discharge pressures (and the inrush amperage and voltage if possible).
- 11 Slowly open the discharge valve as the pump pressure builds (attempt to maintain design pressure).

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- 12 Verify actual flow and pressure compared to the design datasheet as the system fills and stabilizes.
- 13 Adjust the pressure shutdown switches and perform a vibration analysis and a hot alignment procedure in accordance with the following procedures.

Pressure Shutdown Switch Adjustments

- 1 Allow the HPS unit to run and stabilize at the desired flow and pressure
- 2 Set both pressure shutdown switches. There are high and low limits for each switch. If a time-delay relay is installed in the low-discharge-pressure switch circuit the switches should be set prior to starting the unit. There are at two factors to consider when choosing the high and low limits for the pressure switches.
 - Safety and environmental concerns must be considered. A pressure increase above system maximum allowable operating pressure (MAWP) because of blocked or shut-in piping can be hazardous. A pressure decrease due to leaking or failed piping or system processes can cause pump or seal damage. Thus, the high and low pressure limits should be set slightly above and slightly below the normal system operating pressures.
 - Protection of the HPS unit and its components must be considered. For example, operating the pump beyond its recommended operating discharge pressure range can cause equipment damage. The pump curve supplied with each HPS unit shows that particular pump's recommended high- and low-flow limits. The curve in the databook is for a specific fluid specific gravity and pump speed. Changes in either will result in the shutdown switches being improperly set. The limits are shown as two dark vertical lines on the pump curve. Thus, the two points at which these two dark vertical lines cross the line representing the head produced by the pump are the appropriate low- and high-flow pressure limits for the pump. These two pressure points, read on the left scale of the pump curve, should be used as the limit points when setting up the discharge pressure switch (with regard to equipment protection).
 - The suction pressure switch high limit should be set at a point that is 10% to 20% less than the pressure rating of the suction flange and/or the HPS intake jacket. The switch low limit point should be set at the minimum pump NPSHR. The pump should never be run dry; this can cause immediate failure of the pump.

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Vibration Analysis

Vibration measurements should be taken with either a Vibrotip, a CSI 1900 or similar equipment while the HPS unit is operating. Out-of-specification vibrations should be identified and repaired.

Set the vibration switch when all vibration measurements are in specification.

1. With the unit running, the sensitivity knob on the vibration shutdown switch should be slowly adjusted to increase the sensitivity until the switch activates and the motor stops running.

***i* Note**

On a large unit with a motor that has a limited number of starts per hour [usually two] the vibration switch wiring is jumpered closed in the junction box and then the wires are disconnected at the switch. This allows the pump to run while the switch is being adjusted.

-
2. Adjust the vibration switch back 1/8 turn in the opposite direction. The vibration switch is manually reset and is now operational.

***i* Note**

If the wiring was disconnected to make the adjustment, first connect the wires at the switch and then remove the jumper. If the vibration switch activates and stops the motor, decrease the sensitivity another 1/8 turn.

-
3. Recheck the vibration level using a meter. If the vibration has increased since the first reading determine the cause and repair.
 4. Allow the unit to operate for one hour.
 5. Record the thrust chamber 'hot run' oil temperature. This will establish a baseline temperature for future reference.

Hot Alignment Procedure

Shut down the HPS after one hour and perform a hot alignment procedure. The hot alignment procedure typically reduces vibration dramatically in the new installation. This revised baseline figure will also allow a benchmark value to be used in the future to verify alignment accuracy, and present a tangible servicing benefit to the client. Perform another vibration analysis after the hot alignment is performed.

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6.6 Vibration

The vibration standard for testing submersible pumps is American Petroleum Institute (API) 11S 8. This standard relates to pumping units designed for and used in downhole environments. All Artificial Lift pumps are tested for vibration during the post-assembly performance test per the API standard. Horizontal pumping systems (HPS) use a submersible pump in a surface mounted, horizontal configuration with a conventional foot mounted driver. Consequently, the vibration dynamics of the system are different than a pump used in a submersible system. The following content discusses various aspects of vibration for horizontal pumping systems and the limits necessary for acceptable equipment runlife.

Vibration Theory

Any mechanical system that possesses mass and elasticity is capable of relative motion. If this motion repeats itself after a given time period it is known as vibration. Vibration in rotating machinery is caused by unequal forces acting around a centerline. The forces can be caused by

- unbalance
- poor alignment
- electrical forces in the motor
- hydraulic forces from the pumped fluid.

Structure and Foundation Considerations

The type of structure that any rotating machine is mounted on will influence the vibration level. For example, vibration data from a given flow and backpressure on a 23–stage M520A with a 500 HP TEFC motor mounted on a Model 88 skid will be different, but similar to, vibration data for the same pump and motor mounted on a Model HD skid. This is because the skids are designed differently. The configuration of the steel member makes a difference in the way the skid responds to the relative motion of the moving parts and the fluid flowing through the pump. This means that the vibration data recorded at the test facility may not be comparable to the vibration data observed at the field site. This lack of repeatability makes comparisons difficult.

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Generally the more rigid the mounting structure and the more secure the HPS unit is attached, the lower the magnitude of the measured vibration will be. It can be suggested that the HPS skid should be bolted or welded to the foundation to minimize vibration if the vibration is being enhanced by resonance, however, this is only true if the skid anchoring does not induce any misalignment of the components. This misalignment includes

- pump straightness
- pump-to-intake jacket fit up
- thrust chamber to motor alignment
- soft foot in the motor
- piping loads on the intake and discharge nozzle.

The foundation structure should be rigid to minimize the resonance effect of the pump assembly. A concrete pad with the top surface flat to 1/16 in is best. The pad should be larger than the outside dimensions of the skid and from 4 to 12 in thick. The thickness required is proportional to the motor size.

The converse of a concrete pad is a steel deck mounted on a flexible substructure. An example of a flexible structure is a deck on an offshore platform. If other rotating equipment is operating on the same deck, vibrations from the other equipment may affect the HPS vibration level. For reference purposes, vibration data from other rotating equipment should be recorded without the HPS unit running.

Vibration Measurement

The type of vibration monitoring of any rotating equipment depends on the desired result. Two specific equipment types are recommended for horizontal pumping systems; one gives the magnitude of the vibration at a given frequency, i.e. 1.5 mils (or 0.278 in/sec) at 3550 rev/min, the other gives a single number based on a weighted average.

If vibration testing is performed to diagnose the cause of the vibration, a spectrum analysis is used to locate and diagnose unwanted vibration. The spectrum analysis is a display of the magnitude of vibration in mils (1 mil = 0.001 in) or in/sec at various frequencies. The output is typically rendered as a graph with magnitude on the vertical axis and frequency on the horizontal axis. The frequency range is from zero to several times the actual speed of the equipment. This is the best data for troubleshooting and repair determination.

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A simpler and less costly type of monitoring is better suited for trend analysis in the field environment. International Standards Organization (ISO) Standard 10816–1 is a non-frequency based standard that provides appropriate trend analysis and acceptance criteria. (The predecessor to ISO 10816–1 is ISO 2372, Mechanical vibration of machines with operating speeds from 10 to 200 rev/s - Basis for specifying evaluation standards.)

The location of vibration points should be the same for all units except multiple pump units. Data should be taken in the vertical plane only. This reduces the effect of reduced stiffness in the horizontal plane. The figure below shows typical vibration test points on a HPS unit. The points shown in [Figure 6-4](#) are the head, base and middle of each pump, the front and rear thrust chamber bearings and the front and rear motor bearings.

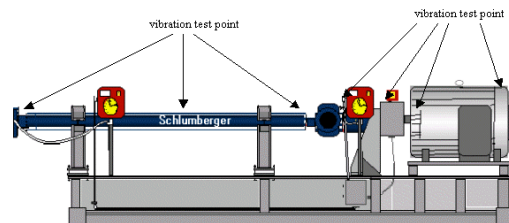


Figure 6-4: Typical vibration test points on a HPS unit

Recommended vibration measurement instruments are either a CSI-1900 or a Prüftechnik AG Vibrotip. Both are available from Artificial Lift Production Systems. The CSI-1900 measures the vibration magnitude at a given frequency. The Vibrotip measures vibration severity. Since both types of measurements are acceptable, the choice should be based on instrument availability and desired testing result.

Vibration Magnitude

The maximum allowable vibration for an electric motor driven unit is shown in [Figure 6-5](#). The graph plots displacement in mils as a function of the shaft speed. [Figure 6-5](#) is used only with a vibration meter such as the CSI-1900 that measures displacement at a given frequency.

To convert the reading in mils to in/sec the following equation can be used

$$V_{\text{Peak}} = 52.3DF \times 10^{-6} \text{ or } D = V_{\text{Peak}} / 52.3F \times 10^{-6}$$

where

Term	Definition
V_{Peak}	vibration velocity, in/sec

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D	peak to peak displacement, mils (1 mil = 0.001 in)
F	frequency, cycles/min



Note

$$V_{\text{rms}} = V_{\text{peak to peak}} \times 0.707$$

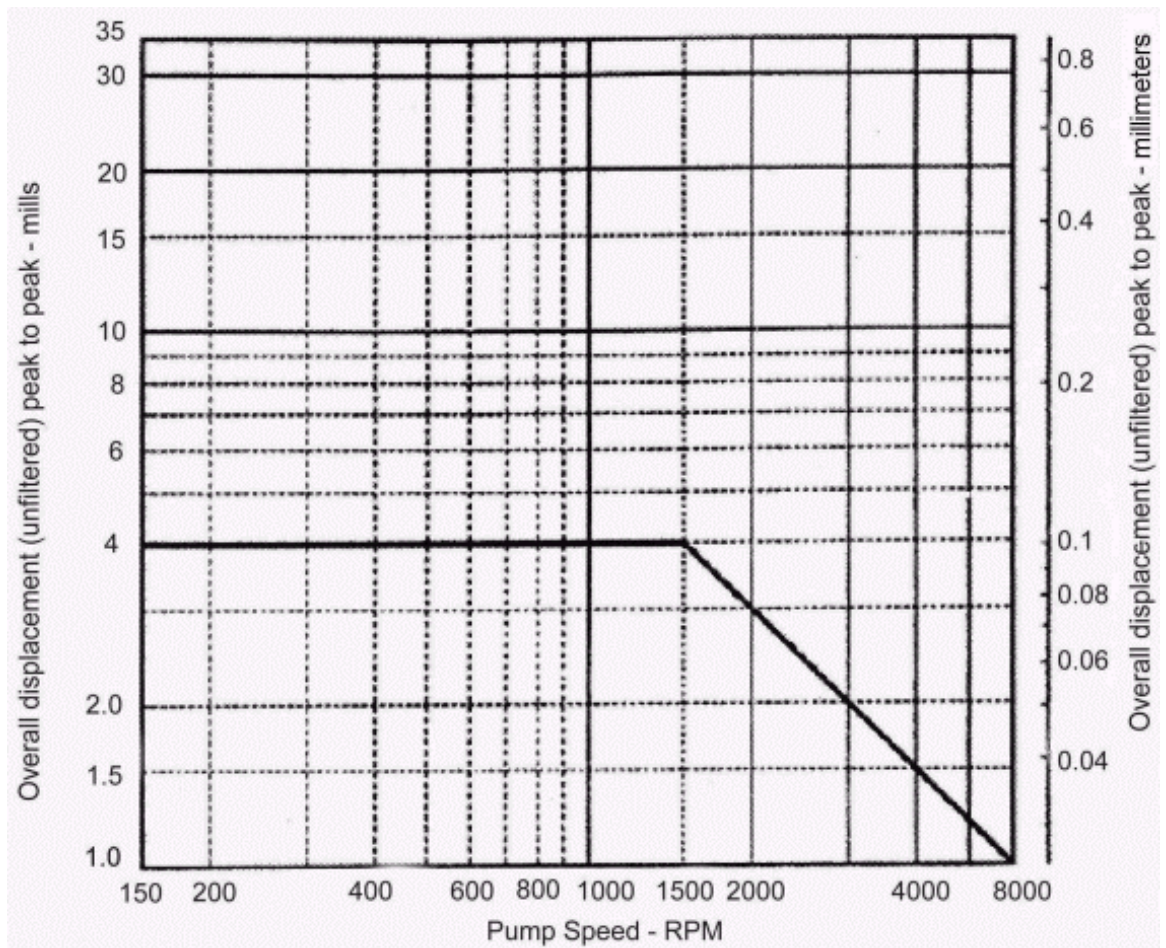


Figure 6-5: Maximum allowable electric motor vibration limits

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eg Example

The CSI-1900 measurement is 0.15 in/sec (peak to peak) at 3570 rev/min. Does this meet specification?

$$D = V_{\text{Peak}} / 52.3F \times 10^{-6}$$

$$D = (0.15) / (52.3)(3570) \times 10^{-6}$$

$$D = 0.8$$

From the figure above, the maximum displacement allowed is 1.6 mils, therefore, the vibration is approximately half of the allowable.

The maximum allowable vibration level for an engine-driven unit is greater than an electric motor driven unit. Caterpillar has established a standard of four mils for a bare engine and five mils for a generator set. Since the gearbox used on an engine-driven unit is similar to a generator, the five mil limit is the maximum allowable vibration limit for the engine portion of the unit. It is very important that the vibration from the engine does not affect the vibration readings on the pump skid. This is dependent on the engine and the pump skid foundation. For example, a concrete pad will not transmit the same amount of vibration as a suspended structure. A steel building or platform deck are examples of a suspended structure. The recommended method is to measure the vibration at the specified locations on the pump skid with the engine running at the rated speed with the driveline disconnected. The readings represent the 'background' vibration level. If the measured vibration magnitude exceeds one-third of the recommended limit, it may then be necessary to reduce the magnitude of the background vibration. Many solutions exist and the best approach may be a combination of several options. Contact InTouch for engineering assistance.

Vibration Severity

Another method of vibration measurement measures vibration severity. The concept of vibration severity is explained in detail in the ISO 10861-1 document. Vibration severity is defined as the maximum broad-band magnitude value measured under agreed machine support and operating conditions. The Prüftechnik AG Vibrotip meter measures vibration severity. The maximum allowable vibration for HPS units as measured by the Vibrotip is:

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Term	Definition
electric drive	0.4 in/sec peak or 0.28 in/sec rms
engine drive	0.5 in/sec peak or 0.35 in/sec rms

The same problem with vibration from other sources also applies to the Vibrotip. If the base that the HPS is mounted on experiences vibration before the HPS motor is started, then the true vibration level for the HPS will be the difference between the non-running and the running measurement.



Tip

Vibration measuring is the second most important element of preventive maintenance (after proper lubrication). The vibration level must be within acceptable limits. A change in vibration level over time (trend analysis) is important. Trend analysis allows for the maintenance of rotating equipment to minimize operating costs and maximize run life.

6.7 HPS Storage

A horizontal pumping system (HPS) should be considered in storage when the unit has been delivered to the jobsite but has not been installed or the unit has been installed but fluid has not been pumped.

The HPS should be decommissioned if it will not be installed and operated within 14 days after arrival.

6.7.1 Preventive Maintenance

Protect the unit from temperature extremes. Heat and UV radiation can damage the paint and rubber components. If the unit was designed to operate inside a building then it should be covered if stored outside. The pump and seal will be damaged by cold weather. Do not expose the unit to freezing temperatures. The fluid used to preserve the pump and intake section freezes at -4°F (-20°C).

Water can be trapped behind the stages in the pump and in the seal flush. This water will freeze and damage the pump at freezing temperatures.

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6.7.2 Motor and Pump

Do not remove the cover from the intake or discharge flange. Do not drain any liquid from the pump or intake. The liquid shipped inside the pump will protect the pump and seal.

Rotate the motor and the pump 10 revolutions weekly. If the motor, thrust chamber/pump assembly or the combination will not turn determine the cause and repair. Failure to rotate the equipment will result in early equipment failure.

6.7.2.1 Ball Bearing Motors

On units with ball bearing motors, the coupling is shipped connected to the thrust chamber. The motor and thrust chamber/pump can be turned as one unit. The motor and thrust chamber/pump combination will turn easily; in many cases the unit will turn by hand. If required, a strap wrench can be used to turn the motor and thrust chamber/pump and will prevent damage to the coupling.

6.7.2.2 Sleeve Bearing Motors

Motors with sleeve bearings are shipped with the coupling disconnected and the motor shaft blocked in place. The oil reservoir for each bearing has been drained. The motor shaft should be unblocked and oil reservoirs filled with turbine oil. The correct viscosity of the oil will be on a dataplate on the motor. Do not connect the coupling. The motor will have to be aligned and the coupling will be in the way. Sleeve-bearing motors are hard to rotate. A large strap wrench is recommended for rotating the motor.

6.7.3 Thrust Chamber

The thrust chamber is shipped with the proper amount of lubricant. Periodic rotation of the thrust section will retard oxidation.

Maintenance

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7 Maintenance

7.1 Lubrication Maintenance Summary

Lubrication requirements for the motor and thrust chamber are shown in [Table 7-1](#). A lubrication chart for standard systems is shown in [Table 7-2](#). A lubrication chart for flush-plan systems is shown in [Table 7-3](#).

Table 7-1: Lubrication requirements for the motor, and thrust chamber

Component	Lubrication intervals
motor	Lubricate every three months for 24 hr/day service. Use grease (p/n 1192640) or as recommended in the motor section maintenance sheet.
thrust chamber	Use only recommended oil (Royal Purple, p/n 100179556). Change the oil every six months of continuous service.

Table 7-2: Lubrication chart for standard systems

	Thrust Chamber Lube Oil	O-Ring Lubricant ¹	Motor Grease	Test Fluid
Part Number	100179556	3901207	1192640	1014778
Technical Specification	Royal Purple Synfilm 46 GT	D-22	C-152	D-89
Quantity for First Fill	none	none	none	none
Quantity for Maintenance	4 qt (change)	none for routine maintenance	as required	test and ship only
Estimated Annual Average Consumption	12 qt	none (only needed for equipment change out)		test and ship only
Quantity to be Stocked	30 gal	2, 5.3-oz tubes	6, 14-oz tubes	test and ship only
Shelf Life	4+ Years	5 years	2+ years	years

¹ This o-ring lubricant (Dow Corning No. 55) is not recommended for use as a lubricant on silicone o-rings and John Crane seals.

Table 7-3: Lubrication chart for flush-plan systems

	Thrust Chamber Lube Oil	Barrier Fluid	O-ring Lubricant ¹	Motor Grease	Test Fluid
Part Number	100179556	7003973	3901207	1192640	1014778
Technical Specification	Royal Purple Synfilm 46 GT	synthetic lubricant	D-22	C-152	D-89
Quantity for First Fill	none	none	none	none	none
Quantity for Maintenance	6.5 qt (change)	as required	none for routine maintenance	as required	test and Ship Only
Estimated Annual Average Consumption	13 qt	5 gal	none (only needed for equipment change out)		test and ship Only
Quantity to be Stocked	30 gal	15 gal	2, 5.3-oz tubes	6, 14-oz tubes	test and ship only
Shelf Life	4+ years	2+ years	5 years	2+ years	years

¹ This o-ring lubricant (Dow Corning No. 55) is not recommended for use as a lubricant on silicone o-rings and John Crane seals.

7.2

Recommended Maintenance Schedules



Note

The HPS unit should be running while performing Task 1, Task 2 and Task 3. The HPS unit should shut down and locked out for the remaining tasks.

Task	Task Description	Daily	Monthly	Quarterly	Semiannual
1	While the HPS unit is operating, listen and feel for changes in sound and vibration level.				
2	Perform vibration and alignment checks.	N/A	N/A		
3	Verify the shutdown setting has not been changed and instruments are functioning.				
4	Inspect suction and discharge connections for leaks.				
5	Inspect the thrust chamber for leaks.				
6	Inspect the mechanical seal for leaks.				

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Task	Task Description	Daily	Monthly	Quarterly	Semiannual
7	If the HPS unit is equipped with a thrust chamber cooling system, inspect the cooling system for leaks and clean the radiator.				
8	Check the thrust chamber or thrust chamber cooling system oil level.				
9	If the HPS unit is equipped with electric motor bearings that are lubricated with oil, change the oil.				
10	Inspect the skid for damage due to external forces.				
11	Inspect the HPS unit for cleanliness, especially the electric motor fins, thrust chamber and mechanical seal.				
12	If the electric motor bearings are lubricated with grease, lubricate the bearings in accordance with motor manufacturer recommendations.	N/A			
13	If the HPS unit runs on an intermittent basis and the unit does not have a thrust chamber cooling system, change the thrust chamber oil.	N/A	N/A		
14	Change the thrust chamber oil regardless of accessories.	N/A	N/A	N/A	
15	If the HPS unit is equipped with a lubricated coupling, inspect the coupling for grease leaks.	N/A	N/A		
N/A — not applicable					

7.3 HPS Field Service Report

Table 7-4: Client and Date of Report

Client:	Date:
---------	-------

Table 7-5: General Information

Service report No.		Field	
Field sales order No.		Well No.	

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Lead representative		Country	
Second representative		Lease	
CSO number		State	
Client PO		Client Representative	

Table 7-6: Pump Data

Stage type		Shaft size	
Series		Metallurgy	
Construction/thrust		Discharge flange	
	Section 1 (intake end)	Section 2	Section 3
Housing size			
Number of stages			
SLB part number			
Serial number			
In-service date			

Table 7-7: Motor Data

Manufacturer		Enclosure	
HP rating		RPM	
Nameplate voltage		Nameplate amperage	
Frame		SLB part number	
Model number		In-service date	
Running voltage		Starter/controller	

Table 7-8: Engine-Driven Units

Engine manufacturer		Engine model number	
Engine serial number		HP/KW rating	
Engine operating speed		Fuel type	

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Speed increaser manf.		Speed increaser model	
Speed increaser s/n		Input/output ratio	

Table 7-9: Thrust Chamber and Intake Assembly

Model		Metallurgy	
Series		SLB part number	
Serial number		Intake pressure rating	
Intake pressure (actual)		Flange size and type	
Flange part number		In-service date (TC)	
TC/motor coupling type			

Table 7-10: Shutdown Switches

Settings	Found at		Left at		Operational
	High	Low	High	Low	
Intake					
Discharge					
Vibration					

Table 7-11: Observed Operating Parameters

Discharge pressure		Discharge rate		Cycling	
Cycles in 24 hr.		Pumping fluid		Fluid S.G.	
Fluid temperature		Sand, scale, H ₂ S, CO ₂ , other			

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Table 7-12: Motor Maintenance Check List

Motor	Service performed	Condition
Motor bearings lubricated		
Air intake ports cleaned		
Motor properly grounded		
Comments		

Table 7-13: Thrust Chamber Maintenance Checklist

Thrust chamber	Service performed	Condition
Oil changed		
Retainer seal (motor side) checked		
Retainer seal (intake side) checked		
Shaft seal (intake) checked		
Weep hole drain port cleaned		
Sight glass cleaned		
Comments		

Table 7-14: Metastream Spacer Coupling Maintenance Checklist

Metastream Spacer coupling	Service performed	Condition
Inspect hub and spacer for wear		
Check coupling alignment		
Comments		

Table 7-15: General Operation Checklist

General operation	Service performed	Condition
Check skid/mounting bolts		
Hi/Lo discharge pressure switch		

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General operation	Service performed	Condition
Hi/Lo intake pressure switch		
Vibration switch		
Operating parameters checked		
Additional service or repair required/recommended		

Table 7-16: Vibration Measurements

Location	30 Hz amplitude	60 Hz amplitude	120 Hz amplitude
Intake vertical			
Intake horizontal			
Mid-pump vert. (I/D)			
Mid-pump horz. (I/D)			
Discharge vertical			
Discharge horizontal			
Motor vert. bearing			
Motor horz. bearing			

7.4 Decommissioning Procedures

7.4.1 Short-Term Decommissioning Procedures

The following decommissioning procedures should be performed for horizontal pump systems that will be idle for more than 14 days but less than 4 months.

1. Perform necessary lock-out/tag-out procedures before beginning any work.
2. Close intake and discharge valves.
3. Drain fluid from the pump.

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4. Flush the pump with clean fluid. (Water if the pumped fluid was water based and diesel if the pumped fluid was oil based.)
5. Fill the pump with preservation fluid. (Glycol if the pumped fluid was water based and diesel if the pumped fluid was oil based.)
6. Check the oil level in the thrust chamber. Replenish as necessary.
7. Ensure the motor bearings are adequately lubricated.
8. Remove the motor-to-thrust chamber coupling guard so that the motor and pump can be periodically rotated.
9. Using a strap wrench on the motor shaft, rotate the pump and motor 10 revolutions once a week.
10. Check the pump preservation fluid level on a weekly basis and replenish as necessary.

7.4.2 Long-Term Decommissioning Procedures

The following decommissioning procedures should be performed for horizontal pump systems that will be idle for more than four months.

1. Perform necessary lock-out/tag-out procedures before beginning any work.
2. Close intake and discharge valves.
3. Drain fluid from the pump.
4. Flush the pump with clean fluid. (Water if the pumped fluid was water based and diesel if the pumped fluid was oil based.)
5. Fill the pump with preservation fluid. (Glycol, if the pumped fluid was water based and diesel if the pumped fluid was oil based.)
6. Fill the thrust chamber completely full of oil. Oil should be visible in the fill spout. This action will prevent condensation in the thrust chamber. If the HPS is equipped with a heat exchanger or remote mounted tank, close the valve in the return line from the thrust chamber.
7. Ensure the motor bearings are adequately lubricated.
8. Remove the motor-to-thrust chamber coupling guard so the motor and pump can be periodically rotated.
9. Using a strap wrench on the motor shaft, rotate the pump and motor 10 revolutions once a week.

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10. Remove the motor drain plugs on a monthly basis and verify that the drains are open and functioning properly.

7.5 Recommissioning Procedures

The following recommissioning procedures should be performed for horizontal pump systems that have been decommissioned and are being prepared for return to service.



Note

If the HPS has been moved or relocated, a complete commissioning procedure should be performed including a motor-to-thrust chamber coupling alignment and a pump-to-intake alignment.

1. Change the thrust chamber oil. If a cooling system is installed, the reservoir should be cleaned and the filter replaced.
2. Using a strap wrench around the motor shaft, rotate the pump and motor through 10 revolutions.
3. Change the motor bearings oil or grease the motor bearings.
4. Inspect the motor-to-thrust chamber coupling. If the coupling is a Falk greased coupling, clean and lubricate the coupling. Disc couplings do not require lubrication but should be cleaned if required.
5. Replace the motor-to-thrust chamber coupling guard.
6. During prolonged shutdown periods the inlet pressures may have increased. Ensure that the HPS inlet maximum pressure limit will not be exceeded.
7. Slowly open the intake valve to charge the system with fluid. On units with cartridge seals, slightly open the seal flush lines to expel any air and to verify fluid flow. The seals will fail on start-up if the seal flush is not working. If a unit has been idle for six months or more, remove the seals and send them to the seal manufacturer for cleaning and inspection.
8. Open and flush all lines to pressure switches and transducers. Close lines.
9. Verify that all instruments are operational and are properly set.

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10. If any guards and safety equipment have been removed, ensure they have been reinstalled.
11. Ensure that the HPS is compliant with all electrical, mechanical and process parameters and settings of the design.
12. Remove all lock-out/tag-out items and restart the HPS in accordance with start-up procedures.

Troubleshooting

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8 Troubleshooting

8.1 Troubleshooting Basics

Much of the work performed by technicians involves the maintenance and repair of equipment and systems. Technicians must have a good knowledge of what is commonly referred to as troubleshooting to maintain the equipment and systems at peak performance.

Troubleshooting is the ability to determine the cause of a problem and then correct it. Troubleshooting covers a wide range of problems from simple jobs such as changing oil in a thrust chamber to finding a short circuit or tracing out defects in a complex pumping system. The basic principles used are the same in all cases. Troubleshooting requires a thorough knowledge of electrical theory, hydraulic theory and mechanical theory combined with a systematic and methodical approach to find a diagnose the problem. Troubleshooting also requires the use of appropriate test equipment.

The following general principles and tips will help define the troubleshooting process.

Think Before Acting

Thoroughly study the problem and then ask the following questions.

- Were there any warning signs preceding the trouble?
- Has any previous repair and maintenance work been done?
- If the circuit, component or system is still operational, is it safe to continue operation before further testing?

Answers to these questions can usually be obtained by:

- questioning the owner or operator of the equipment
- taking time to think the problem through
- looking for additional symptoms
- consulting troubleshooting charts
- checking the simplest things first
- referring to repair and maintenance records

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- checking with calibrated instruments
- double-checking all conclusions before beginning any repair on the equipment or circuit components.

**Note**

Always check the easiest and obvious things first. Following this simple rule will save time and trouble.

The source of many problems can be traced not to one component alone but to the relationship of one component to another. For example, a tripped circuit breaker can be reset to restart the unit, but what caused the circuit breaker to trip? It could have been caused by a vibrating energized conductor momentarily coming into contact with ground, a loose connection causing overheating or any number of causes. Often, electrically-operated equipment is completely disassembled in search of the cause of a certain complaint and all evidence is destroyed during the disassembly process. Check to be certain an easy solution to the problem has not been overlooked.

Find and Correct the Problem

After an electrical or mechanical failure has been isolated, be sure to correct the cause so the same failure will not be repeated. Further investigation may reveal other faulty components.

Although troubleshooting charts and procedures will help in diagnosing problems, they can never be complete. There are many variations and solutions for a given problem.

8.2 Troubleshooting Electric Motors and Starters

Electric motors use the principle of electromagnetic induction. An induction motor has a stationary part (stator) with windings connected to the power supply and a rotating part (rotor) that contains coils or bars. The stator and rotor are not electrically connected. The magnetic field produced in the stator windings induces a voltage in the rotor coils or bars.

When an electric motor malfunctions, the stator windings are usually defective and will require repair or replacement. Stator problems can usually be traced to one or more of the following causes:

- worn bearings
- moisture

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- overloading
- operating in a single-phase mode
- poor insulation.

Dust and dirt are usually contributing factors. Some types of dust are highly conductive and materially contribute to insulation breakdown. The effect of dust on the motor temperature (through restriction of ventilation) is another reason for keeping the motor clean by periodically blowing it out with compressed air or washing out the fins. The compressed air must be dry and delivered at low pressure to prevent insulation damage.

One of the worst enemies of motor insulation is moisture, therefore, the motor insulation must be kept as dry as possible. If a motor must be operated in a damp location, the windings should receive a special moisture-resistant treatment.

The winding life depends on keeping it in its original condition as long as possible. In a new machine, the winding is snug in the slots and the insulation is fresh and flexible. This condition is best maintained by periodic cleaning, followed by varnish and oven treatments. After the insulation dries out, it loses flexibility and the mechanical stresses caused by starting and plugging as well as the natural stresses in operation under load will tend to cause the coils to short circuit. Failures from the coil to ground will usually be at the point where the coil leaves the slot. The effects of periodic varnish and oven treatments properly carried out so as to fill all air spaces caused by drying and shrinkage of the insulation will maintain a solid winding and will also provide an effective seal against moisture.

Starters

Starters provide an electrical connection to the motor. A typical starter consists of a manual disconnect that isolates the incoming power from the rest of the equipment, a contactor that is energized by a control circuit, a control power transformer that reduces incoming line voltage to a low voltage of 110 VAC or 220 VAC and a control circuit.

[Table 8-1](#) provides troubleshooting information for electric motors and starters.

Table 8-1: Troubleshooting electric motors and starters

Symptom	Remedy
The starter does not engage.	<ol style="list-style-type: none"> <li data-bbox="792 348 1295 380">1. Verify that the main disconnect is energized. <li data-bbox="792 394 1511 684">2. Determine if the control power transformer has output power. Verify that the instrument loop has voltage at both terminals. If voltage is missing at one terminal, a part of the safety circuit is not closed. The wiring diagram for the skid will have to be used to troubleshoot the instruments. Determine which instrument has the open contact and adjust the switch or repair the wiring. The low-discharge-pressure switch will be tripped because the unit is not running. A time-delay relay can be used to bypass the low-discharge-pressure switch or the switch can be adjusted to get the unit running. Reset the switch after the pump is running. <li data-bbox="792 699 1516 785">3. Determine if the start push button is functional. Determine if there is voltage at the power terminals of start push button. Verify the starter push button is mechanically functional. <li data-bbox="792 800 1252 831">4. Determine if the start relay is energizing. <li data-bbox="792 846 1503 932">5. Determine if the starter energizing coil is functional. If the coil is energizing, the starter may have mechanical defects and should be repaired by a starter repair facility.

Symptom	Remedy
The starter energizes but the motor does not make any noise or attempt to rotate.	<ol style="list-style-type: none"> 1. Tag out and lock out the main disconnect to the starter. 2. Verify that the motor power cables are connected to the starter. 3. Open the motor main input power junction box and verify that the motor leads are connected to the correct power cables from the starter.
The starter energizes and the motor makes noise or attempts to rotate.	<ol style="list-style-type: none"> 1. Tag out and lock out the starter. 2. Attempt to rotate the motor and pump by hand. 3. If the pump and motor freely rotate, verify that the motor power leads are connected. If the leads are properly connected, perform a megger test on the motor and leads at the starter. If the resistance is low, disconnect the motor leads and power leads and perform separate megger tests. Replace defective power leads or repair or replace the motor. 4. If the pump and motor do not freely rotate, uncouple the motor from the thrust chamber. <ul style="list-style-type: none"> • If the thrust chamber and pump freely rotate but the motor does not, remove the fan cover and check the fan for binding. If the fan is not binding, the motor is defective. Repair or replace the motor. • If the motor rotates but the thrust chamber and pump do not freely rotate, disconnect the pump from the skid intake. Pull the pump far enough away from the intake to remove the coupling between the thrust chamber and the pump. Attempt to rotate the pump by hand. If the pump will not rotate, replace the pump. Attempt to rotate the thrust chamber. If the thrust chamber will not rotate, replace the thrust chamber.

8.3 Troubleshooting Thrust Chamber Vibrations

The thrust chamber is located between the motor and the pump intake. Its main function is to absorb the thrust loads generated by the pump. Fluid migration into the thrust chamber is prevented by a mechanical seal located on the suction side of the thrust chamber subassembly. Thrust chambers are subject to regular preventive maintenance.

[Table 8-2](#) provides troubleshooting information for thrust chamber vibrations.

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Table 8-2: Troubleshooting Thrust Chamber Vibrations

Symptom	Remedy
<p>The thrust chamber vibration exceeds limits. Vibration is high at the motor coupling bearing.</p>	<ol style="list-style-type: none"> 1. Compare the vibration measurement to the motor vibration measurement at the motor output shaft bearing. 2. If the motor vibration measurement in the same orientation is equal or close to equal, perform a complete alignment on the motor. Soft foot must be checked and corrected if present. 3. If the thrust chamber vibration is higher than the motor vibration, shut the unit down and disassemble the coupling. 4. Rotate the thrust chamber by hand. If roughness in bearings is felt, replace the thrust chamber. 5. If roughness in the bearings is not felt, check the thrust chamber endplay. The maximum endplay is 0.015 in. Replace the thrust chamber if the endplay exceeds 0.015 in.
<p>The thrust chamber vibration exceeds limits. Vibration is high at the pump end bearing.</p>	<ol style="list-style-type: none"> 1. Compare the measurements in the vertical and horizontal planes. <p>If the vertical vibration measurement is acceptable and the horizontal vibration measurement exceeds the limit, check the horizontal vibration on the intake adaptor and the pump. If the measurements are close to the same, the problem is probably flow-induced vibration.</p> <p>Flow-induced vibration only occurs in the horizontal plane. (The intake adapter, the pump end bearing on the thrust chamber and the base of the pump before the first clamp are common locations for measuring flow-induced vibrations).</p> 2. If the vertical and the horizontal measurements are equal, then the thrust chamber endplay should be measured. On Gen2-series skids, the thrust chamber and mechanical seal are removed as an assembly. 3. Check the endplay in the thrust chamber. The maximum endplay is 0.015 in. Replace the thrust chamber if the endplay exceeds 0.015 in.

8.4 Troubleshooting Thrust Chamber Overheating (The HPS Unit Has a Thrust Chamber Cooling and Filtration System)

The thrust chamber is located between the motor and the pump intake. Its main function is to absorb the thrust loads generated by the pump. Fluid migration into the thrust chamber is prevented by a mechanical seal located on the suction side of the thrust chamber subassembly. Thrust chambers are subject to regular preventive maintenance.

[Table 8-3](#) provides troubleshooting information for thrust chamber overheating problems on HPS units with a thrust chamber cooling and filtration system.

Table 8-3: Troubleshooting Thrust Chamber Overheating Problems on HPS Units With a Thrust Chamber Cooling and Filtration System

Symptom	Remedy
The thrust chamber is overheating.	<p>Check the oil level. Add oil if necessary.</p> <p>Verify the temperature measurement. If the measurement is taken with an infrared thermometer, the oil temperature should also be measured with an immersion thermometer. The maximum oil temperature is 180 degF (82 degC).</p>

Symptom	Remedy
The oil temperature exceeds the maximum limit.	<p>Check for oil contamination. If the oil is contaminated, change the oil and filter and allow the thrust chamber to operate with clean oil until the temperature has stabilized.</p> <p>Determine if the cooling system pump is operating. If the pump is not operating, refer to <i>The cooling system pump is not running</i>.</p> <p>Check the cooler fins for debris.</p> <p>Verify that the fan is circulating air.</p> <p>Verify the pump is circulating oil. Measure the temperature of the oil at the thrust chamber discharge. Measure the temperature of the oil at the oil cooler discharge. The temperature of the oil leaving the cooler should be less than the temperature of the oil leaving the thrust chamber. If the temperatures are similar, the oil may not be flowing. If the oil is not flowing, verify the coupling between the cooling system pump and motor is operational. If the pump is running but oil is not flowing, replace the pump.</p>
The cooling system pump is not running.	<p>Verify there is power at the motor leads. Connection 4 and connection 5 on the wiring diagram are the motor leads on a 120 volt system.</p> <p>If there is no power, troubleshoot the cooling system motor starter.</p> <p>If there is power at the motor leads, shut down the cooling system motor and lock it out. (The thrust chamber will retain enough oil to operate for up to an hour without damage. After an hour without oil circulation, the thrust chamber may overheat, therefore, shutdown the HPS pump motor. On cooling systems with pressure/flow interlocks to the main HPS pump motor the interlocks will have to be bypassed.) Disconnect the coupling between the motor and pump by loosening the setscrew on the motor shaft and moving the motor back from pump. Leave the motor leads connected. After the coupling is removed, attempt to start the motor. If the motor does not start, replace the motor. Also, turn the pump by hand. If the pump will not turn smoothly, replace the pump.</p>

8.5 Troubleshooting Thrust Chamber Overheating (The HPS Unit Does Not Have a Thrust Chamber Cooling and Filtration System.)

The thrust chamber is located between the motor and the pump intake. Its main function is to absorb the thrust loads generated by the pump. Fluid migration into the thrust chamber is prevented by a mechanical seal located on the suction side of the thrust chamber subassembly. Thrust chambers are subject to regular preventive maintenance.

[Table 8-4](#) provides troubleshooting information for thrust chamber overheating problems on HPS units without a thrust chamber cooling and filtration system.

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Table 8-4: Troubleshooting Thrust Chamber Overheating Problems On HPS Units Without a Thrust Chamber Cooling and Filtration System.

Symptom	Remedy
<p>The thrust chamber is overheating.</p> <hr/> <p>i Note Also refer to <i>Special Conditions</i> below.</p>	<p>Verify the temperature measurement. If the measurement is taken with an infrared instrument, the oil temperature should also be measured with an immersion thermometer. The maximum oil temperature for systems containing Royal Purple Synfilm 48 GT is 180 degF (82 degC).</p>
<p>The oil temperature exceeds the maximum limit.</p>	<p>Check for oil contamination. If the oil is contaminated, change the oil and filter and allow the thrust chamber to operate with clean oil until the temperature has stabilized. If the oil temperature still exceeds the limit, replace the thrust chamber.</p> <p>If the thrust chamber is noisy, check for high vibration levels. Replace the thrust chamber if vibration levels exceed the maximum limits.</p> <hr/> <p>i Note If the thrust chamber is replaced, it should be replaced by a duplicate unless the pump service has changed. The problem may be that the original thrust chamber was an LT or single-thrust-bearing model. If the operating conditions are not the same as the original design, then a three-bearing thrust chamber may be required.</p>
<hr/> <p>i Note Special Conditions:</p> <p>An oil cooler may be required if the thrust chamber does not have an oil cooler and has a history of running hot.</p> <p>If the client has substituted another oil for the recommended oil, the substituted oil may be the cause of high oil temperatures. Royal Purple Synfilm 48 GT belongs to a class of synthetic oils with a PAO base. Any oil that does not have a PAO base may not cool properly. The HPS thrust chamber is designed to operate at higher temperatures in the thrust chamber (bearing section) than most pumps. The thrust chamber oil must withstand the higher temperatures. The PAO-base synthetic oils will withstand the higher temperatures. Synthetic oil is also used to prevent water contamination on units that start and stop frequently. A warranty claim on a thrust chamber that has been operated with non-recommended oil will not be honored.</p>	

8.6 Troubleshooting Instruments

Instruments are the control devices for HPS units. The instruments perform two basic functions.

- Interface to a pump control device.
- Instruments have a safety shutdown mechanism in case of a system malfunction. Low suction or discharge pressure, vibration or high component temperatures are a several of the parameters that can be monitored.

Table 8-5 provides troubleshooting information for instruments.

Table 8-5: Troubleshooting a Motor Starter That Does Not Engage. Before using the following table, first determine if the instrument loop has voltage on both terminals.

Symptom	Remedy
The instrument loop does not have power on both terminals.	Determine if the control power transformer has voltage at the output terminals. If there is no power at the output terminals, determine if there is input power. If there is no input power, repair as required.
The control power transformer has output power.	<p><i>This procedure applies to skids with pressure, temperature and vibration switches.</i> Determine if the instrument loop has voltage at both terminals. If voltage is missing at one terminal, a part of the safety circuit is not closed. The wiring diagram for the skid should be used to troubleshoot the instruments. Determine which instrument has the open contact and adjust the switch, repair wiring or replace the switch.</p> <p>The low-discharge-pressure switch will be tripped because the unit is not running. A time-delay relay can be used to bypass the low-discharge-pressure switch or the switch can be adjusted until it makes to get the pump running. Adjust the low-discharge-pressure switch after the pump is running.</p>
The control power transformer has output power.	<p><i>This procedure applies to skids with pressure, temperature and vibration transducers.</i> The control power transformer power loop to the start relay is routed through a relay operated by the transducer reader. This device is normally a programmable logic controller.</p> <p>The programmable logic controller is programmed before the skid is shipped. The programmable logic controller set points can be adjusted by field personnel. The programmable logic controller is code protected. The code is in the skid operations manual that was shipped with the skid. For all units with transducers, the operations manual must be available to start and troubleshoot the unit.</p>

8.7 Troubleshooting Gearbox Noise

Gearbox noise is sometimes difficult to diagnose without sophisticated vibration measurement tools.

A high-pitch “whine” is usually noise from a deteriorating gear. The whine is generated by the tooth meshing frequency. For example, an input gear with 30 teeth running at 1800 rev/min has a meshing frequency of 900 Hz. This compares to a shaft rotation frequency of 30 Hz ($1800 \div 60$).

Bearings rotate at input shaft speed or some increasing or decreasing multiple thereof. The rotational frequency of the shaft is several orders of magnitude below the gear mesh frequency, therefore, the noise produced by bearings that are failing is closer to a “growl” or a frequency much lower than gear mesh frequency. In advanced stages of failure, the bearings may slide, producing a screeching noise. Failing bearings usually generate excessive heat; look for hot spots on the gearbox.

Pinpointing gearbox noise is difficult, especially on systems without torsionally tuned couplings. Noise transfers via shafts and other rigid members and often sounds as though it is coming from a gearbox when it may actually be transmitted there from another source. A “listening rod” may be helpful to locate the noise.

8.8 Troubleshooting Gearbox Overheating

The most frequent cause of overheating is oil level; either too little or too much. Too little oil can result in reduced or no delivery or to moving parts causing high friction and heat. Too much oil increases agitation by gears, bearings and other moving parts, generating excess heat.

Do not add more oil than necessary. Oil levels are determined experimentally at the factory. If there are special circumstances such as pitch, roll or jerky motion, contact [InTouchSupport](#) for technical assistance.

8.9 Troubleshooting Gearbox Vibration

Vibration can generally be divided into two categories, linear and torsional.

8.9.1 Linear Vibration

Linear vibration is the most familiar. This is the shaking and movement of equipment that is easily felt and heard. As a rule, linear vibrations are related to a mechanical problem such as imbalance or misalignment. Linear vibration can also be a result of advanced gear or bearing wear. Typically, linear vibrations worsen as speeds increase. Automobile tire imbalance is an example of linear vibration. As speed increases, the vibration increases in both frequency and amplitude; the faster the tire turns the worse the imbalance becomes.

The damage from linear vibration is usually not surprising. For example, a severely out-of-balance pulley can easily cause a shaft bearing to fail.

8.9.2 Torsional Vibration

Torsional vibrations are difficult to identify because they often cannot be felt. Torsional vibrations usually exist only at certain speed and load conditions and often "come and go" with speed changes. Torsional vibrations exist to some extent in all rotating systems but are not normally a problem unless the system is driven or "excited" by a frequency source that is at or near the natural frequency of the system (resonance). Systems operating at resonance can generate forces equal to several times the expected forces.

Torsional analysis can predict the speeds at which a system may become resonant allowing designers to redesign the system and use various components such as torsional couplings and mass dampeners. Torsional analysis is typically performed by the system packager or a torsional coupling manufacturer.

Torsional vibrations generally cause unexpected damage. For example, a gear may wear or break shortly after being placed in service or a shaft may break unexpectedly even though it is oversized. When there seems to be no explanation for component failures - consider torsional vibrations.

One particularly alarming torsional condition is full reversing in which applied torque actually passes back and forth through zero. If a gearbox is subjected to a full reversing torque, a severe rattle can occur as the gear teeth load and unload. The noise generated by this action can be quite loud. Keep in mind that the gearbox may not be causing the noise. The problem is that a severe torsional condition exists; not a defective gearbox.

If torsional or linear vibrations are suspected as a possible problem, contact InTouchSupport for technical assistance.

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