Pump Repair

API RECOMMENDED PRACTICE 697
FIRST EDITION, APRIL 2023



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Introduction

This document can be used for pumps and pump systems to guide the user along a path from perception of a problem through the resolution of the problem. Sections are provided that identify the important aspects of each topic encountered during the resolution of a problem. Topics include:

— inspections performed in the field and repair shop;

— shipping the pump to and from a repair shop;

— modifications and re-rates;

— repair techniques;

— rotor balancing;

— reassembly;

— reinstallation and startup;

— documentation.

Annex B is a high-level flowchart of the pump problem resolution process. The nature of the problem will determine which portions of this document are applicable. The Field and Repair Shop Work Scopes should indicate applicable portions of this practice.

The basic assumption of this practice is that the entire pump (pressure casing, rotor assembly, bearings, and seals) is removed for repair, with the possible exception of BB5 pumps.

Users of this recommended practice should be aware that further or differing recommendations may be needed for individual applications. This recommended practice is not intended to inhibit a vendor from offering, or the purchaser from accepting, alternative equipment or engineering solutions for the individual application. This may be particularly appropriate where there is innovative or developing technology. Where an alternative is offered, the vendor should identify any variations from this recommended practice and provide details.

A bullet (•) at the beginning of a paragraph indicates that either a decision is required or further information should be provided by the owner. This information should be stated in the quotation request or in the order.

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Pump Repair

1 Scope and General Recommendations and Information

1.1 Scope

This recommended practice (RP) covers the minimum recommendations for the inspection and repair of API 610 pumps types OH1 through OH5 and BB1 through BB5. Refer to Annex A for figures and description of pump types.

This document covers the entire process of field inspection, modifications, inspection, upgrades, repair and/or new component manufacturer, reassembly of the pump casing and rotor in the shop, and the reinstallation and start-up of the pump in the field.

Pumps in hydrofluoric acid service may require inspection and repair methods that are beyond the scope of this RP.

Each phase of inspection will determine a work scope. The work scope will become more definitive as the inspection process progresses.

1.2 General Recommendations

1.2.1 The basis of repair recommendations should be to produce a safe reliable pump while:

— returning dimensions required for spare parts interchangeability to the latest design fits and clearances,

— maintaining interchangeability with other units,

— using existing spare parts,

— eliminating errors in manufacturing future spare parts that could be caused by undocumented dimensional changes,

— maintaining its torque transmission capabilities.

NOTE The latest design fits and clearances can be different than originally designed by the original equipment manufacturer (OEM), because rerates and/or upgrades could have been incorporated into the machine design.

1.2.2 Use of previously manufactured components and their acceptance criteria should be mutually agreed upon by all parties involved and documented in the work scope.

1.2.3 The repair shop should assume order responsibility.

1.3 Alternative Procedures

The repair shop or vendor may offer alternative procedures and designs. Any exception to this RP should be clearly stated in the proposal.

1.4 Conflicting Requirements

In case of conflict between this RP and the inquiry, the inquiry should govern. At the time of the order, the order governs.

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1.5 Statutory Requirements

The purchaser and the vendor should determine the measures to be taken to conform with any governmental codes, regulations, ordinances, or rules that are applicable to the equipment, its packaging, and preservation. Equipment installed in the European Economic Area should comply with all applicable European Union Directives.

1.6 Unit Responsibility

The repair shop who has order responsibility should assure that all vendors comply with the requirements of this RP, all referenced standards, and all purchaser requirements.

1.7 Selection of a Repair Shop

1.7.1 General

1.7.1.1 The repair shop should be selected based on the organization's ability to perform anticipated and potential scopes of repair while meeting the expectations of the owner. The review of the repair shop and their capabilities should include items such as:

a) facilities,

b) engineering capability and support,

c) experience repairing similar equipment,

d) manufacturing of replacement components,

e) having a quality system in place, including documentation.

1.7.1.2 Qualification of a repair shop is usually accomplished by having the repair shop complete and submit a qualification survey form (such as the one in API 687). Initial and follow-up audits should be performed by the owner to ensure the repair shop is capable of performing the repair.

1.8 Communication

1.8.1 General

1.8.1.1 The success of a repair depends upon open communication. Communication is important in defining the needs and expectations of the owner to the repair shop and to vendors. Verbal instructions, recommendations, and agreements should be confirmed in writing.

1.8.1.2 The owner, repair shop, and vendors should each have a designated person to coordinate communication.

1.8.1.3 The methods of communication should be defined before any repairs are initiated.

1.8.1.4 All written correspondence should be identified with the following information.

a) The owner's corporate name.

b) The job/project number.

c) The equipment item number and service name.

d) The inquiry or purchase order number.

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e) Any other identification specified in the inquiry or purchase order.

f) The repair shop's identifying proposal number, repair shop order number, serial number, or other reference to identify return correspondence completely.

1.8.1.5 The complexity of a repair will usually determine how many of the following meetings should be planned. After the meetings are held, the meeting minutes should be published by the repair shop and distributed to the attendees or other relevant personnel.

a) A meeting should be held to review the repair scope, timetable, establish points of contact, and assign responsibilities for all parties. The owner's desired service life and uninterrupted operation requirements should be discussed.

b) Follow-up meetings may be necessary if deviations from the initial repair scope are found during the repair process.

c) In the case of rerates, additional meetings such as a pre-award/coordination and design audit may be needed.

1.8.2 Electronic Drawing and Data Transmittal

Appropriate lines of communication, such as electronic drawing and data transmittal, should be used to ensure that all members are kept informed. Examples are:

a) direct electronic links between computer-aided design (CAD) systems,

b) electronic mail including digital photography transmission,

c) video and telephone conferencing.

2 Normative References

2.1 This RP refers to American standards. Other international or national standards may be used as agreed between owner and repair shop provided it can be shown that these other standards meet or exceed the American standards referenced.

2.2 The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API Standard 610, *Centrifugal Pumps for Petroleum, Petrochemical, and Natural Gas Industries*

API Standard 614, *Lubrication, Shaft-sealing and Oil-control Systems and Auxiliaries*

API Standard 670, *Machinery Protection Systems*

API Standard 682, *Pumps—Shaft Sealing Systems for Centrifugal and Rotary Pumps*

API Recommended Practice 686, *Recommended Practice for Machinery Installation and Installation Design*

API Recommended Practice 687, *Special Purpose Rotating Equipment Repair*

AGMA 9002-B04 [1], *Bores and Keyways for Flexible Couplings (Inch Series)*

[1] American Gear Manufacturers Association, 1001 N. Fairfax Street, Suite 500, Alexandria, VA 22314-1587, www.agma.org.

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ANSI B11.19 [2], *Performance Requirements for Risk Reduction Measures: Safeguarding and Other Means of Reducing Risk*

ANSI/HI 9.1-9.5 [3], *Pumps General Guidelines*

ASME B16.1 [4], *Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250*

ASME B16.5, *Pipe Flanges and Flanged Fittings NPS ½ Through NPS 24 Metric/Inch Standard*

ASME B16.11, *Forged Fittings, Socket-Welding and Threaded*

ASME B16.42, *Ductile Iron Pipe Flanges and Flanged Fittings Classes 150 and 300*

ASME B16.47, *Large Diameter Steel Flanges NPS 26 Through NPS 60 Metric/Inch Standard*

ASME *Boiler and Pressure Vessel Code (BPVC), Section V: Nondestructive Examination*

ASME *Boiler and Pressure Vessel Code (BPVC), Section VIII: Rules for Construction of Pressure Vessels*

ASME *Boiler and Pressure Vessel Code (BPVC), Section IX: Welding, Brazing, and Fusing Qualifications*

ASTM A388/A388M [5], *Standard Practice for Ultrasonic Examination of Steel Forgings*

ASTM A435/A435M, *Standard Specification for Straight-Beam Ultrasonic Examination of Steel Plates*

ASTM A516/A516M, *Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service*

ASTM A577/A577M, *Standard Specification for Ultrasonic Angle-Beam Examination of Steel Plates*

ASTM A578/A578M, *Standard Specification for Straight-Beam Ultrasonic Examination of Rolled Steel Plates for Special Applications*

ASTM A609/A609M, *Standard Practice for Castings, Carbon, Low-Alloy, and Martensitic Stainless Steel, Ultrasonic Examination Thereof*

ASTM B23, *Standard Specification for White Metal Bearing Alloys (Known Commercially as "Babbitt Metal")*

ASTM E94/E94M, *Standard Guide for Radiographic Examination Using Industrial Radiographic Film*

ASTM E165/E165M, *Standard Practice for Liquid Penetrant Testing for General Industry*

ASTM E186, *Standard Reference Radiographs for Heavy-Walled (2 to 4 ½ in. (50.8 to 114 mm)) Steel Castings*

ASTM E280, *Standard Reference Radiographs for Heavy-Walled (4 ½ to 12 in. (114 to 305 mm)) Steel Castings*

ASTM E446, *Standard Reference Radiographs for Steel Castings Up to 2 in. (50.8 mm) in Thickness*

ASTM E709, *Standard Guide for Magnetic Particle Testing*

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2 American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, www.ansi.org.
3 Hydraulic Institute, 300 Interpace Parkway, Bldg. A, 3rd Floor, Parsippany NJ, 07054, www.pumps.org.
4 ASME International, 2 Park Avenue, New York, NY 10016-5990, www.asme.org.
5 ASTM International, PO Box C700, 100 Barr Harbor Drive, West Conshohocken, PA 19428, www.astm.org.

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ASTM E1417/E1417M, *Standard Practice for Liquid Penetrant Testing*

MSS SP-55 [6], *Quality Standard for Steel Castings for Valves, Flanges, Fittings, and Other Piping Components—Visual Method for Evaluation of Surface Irregularities*

SSPC SP 1 [7], *Solvent Cleaning*

SSPC SP 6, *Commercial Blast Cleaning*

3 Terms, Definitions, Acronyms, and Abbreviations

3.1 Terms and Definitions

For the purposes of this document, the following definitions apply.

3.1.1
accuracy
The degree to which the result of a measurement, calculation, or specification conforms to the correct value or a standard.

3.1.2
as found
The condition in which the pump arrives at the repair shop, prior to any repair work.

3.1.3
as repaired
The condition in which the pump leaves the repair shop, after repair work is complete.

3.1.4
axial float
rotor float
Clearance between the rotor and stationary components measured in the direction parallel to the shaft.

3.1.5
axially split
Joint split with the principal face parallel to the shaft centerline.

3.1.6
balance line
Internal or external line used to equalize pressure between higher pressure in the seal chamber (stuffing box) or balance chamber (as found on multistage pumps with balance drums or disks) and the lower pressure at the suction of the pump.

3.1.7
baseplate
Structure used to mount, support, and align machinery and its auxiliary components.

3.1.8
bearing isolator
Mechanical device that isolates a bearing from its environment, so that the bearing is kept properly lubricated and uncontaminated throughout its projected design life.

[6] Manufacturers Standardization Society of the Valve and Fittings Industry, 127 Park Street, NE, Vienna, VA 22180-4602, www.mss-hq.com.
[7] Association for Materials Protection and Performance, 15835 Park Ten Place, Houston, TX 77084, www.ampp.org.

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3.1.9
burnished area
proximity probe target area
Area that has been plastically deformed (polished) by sliding contact with another object, typically a diamond burnishing tool, to minimize electrical and mechanical runout in the location where an eddy current (proximity) vibration probe takes its readings.

3.1.10
cartridge
Assembly of all the parts of the pump except for the casing.

3.1.11
cartridge seal
Completely self-contained mechanical seal unit (including seal faces, flexible elements, seal gland plate, sleeve, and mating ring) that is pre-assembled and preset before installation.

3.1.12
cavitation
The formation of vapor cavities in a liquid.

3.1.13
channel ring
A device in BB3 and BB5 pumps used to separate discharge side of prior stage and the suction of the next stage and diverts/controls flow into eye of the impeller.

3.1.14
clearance fit
The dimensional relationship between assembled parts in which the inner component is smaller than the outer component.

3.1.15
contact verification
transfer contact verification
blue check
An inspection used to characterize the contact pattern and contact percentage between two surfaces.

NOTE 1 The inspection typically uses a soft, uniform paste that is nondrying, non-hardening, remains pliable, and is transferable.

NOTE 2 This is often referred to as a “blue check” because the paste is typically blue although the paste can be in other colors.

3.1.16
distance between shaft ends
DBSE
The axial dimension between two adjacent machinery shaft reference points including any threaded end or in the case of integral flanges, the distance from the mating faces.

NOTE Coupling detail drawings and manufacturers alignment drawings typically identify the DBSE reference points.

3.1.17
element bundle
Assembly of the rotor plus the internal stationary parts of a centrifugal pump.

3.1.18
fretting
Wear process that occurs at the contact area between two materials under load and subject to minute relative motion by vibration or some other force.

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3.1.19
galling
Wearing caused by adhesion between sliding surfaces.

3.1.20
gauss
Unit of measure for residual magnetism or magnetic flux density.

3.1.21
gear wheel
bull gear
The lowest speed rotor of a gear set.

3.1.22
go/no-go gauge
An inspection tool used to check a work piece against its allowed tolerances.

NOTE Its name derives from its use: the gauge has two tests; the check involves the work piece having to pass one test (Go) and fail the other (No Go).

3.1.23
gouge
An indentation, groove, or hole appearing to be scooped out with a chisel or sharp tool.

3.1.24
hydrodynamic bearing
Bearing that uses the principles of hydrodynamic lubrication.

3.1.25
indications
A response or evidence of a discontinuity that requires interpretation to determine its significance.

3.1.26
interference fit
The dimensional relationship between assembled parts in which the inner component is larger than the outer component.

3.1.27
labyrinths (rotating and stationary)
Noncontacting seals that provide a tortuous path to reduce leakage.

3.1.28
matchmark
A mark placed on the adjacent separable parts of a device to aid in the reassembling of the parts.

3.1.29
measurement device graduation
The graduation of a measurement system is the smallest difference between values that can be distinguished.

3.1.30
oil mist lubrication
Lubrication provided by oil mist produced by atomization and transported to the bearing housing, or housings, by compressed air.

3.1.31
oiler
Device used for supplying nonpressurized oil to lubricate pump bearings.

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3.1.32
original equipment manufacturer
OEM
Company that originally designed and manufactured the equipment or component.

3.1.33
owner
Final recipient of the equipment who may delegate another agent as the purchaser of the equipment.

3.1.34
phase-referenced
Measurement of the relative angular location between two points (measurement point and a reference point). The phase angle (measured in degrees or radians) is the difference between the measurement point and a reference point.

NOTE A phase-referenced runout [total indicator runout (TIR)] has two components: (1) the TIR and (2) the angle between the measurement point and the reference point.

3.1.35
positive material identification
PMI
Analysis of a metallic alloy to establish composition by percentage of its constituent elements.

3.1.36
pressure casing
Composite of all stationary pressure-containing parts of the unit, including all nozzles and other attached parts.

3.1.37
radially split
Split with the joint perpendicular to the shaft centerline.

3.1.38
recirculation
Flow reversal at the inlet or discharge tips of impeller vanes.

3.1.39
register fit
A joint that causes two stationary parts, when assembled, to be concentric to each other when fasteners are tightened.

3.1.40
repair shop
Agency that provides unit responsibility for the inspection and repair services. The repair shop may or may not be an owner's shop.

3.1.41
rerate
A change in the operating performance that may or may not require hardware changes.

3.1.42
residual magnetism
Magnetization remaining in a magnetized body no longer under external magnetic influence.

3.1.43
rolling-element bearings
An assembly of mechanical components that utilizes rolling contacts between the rolling elements and race rings to support load while permitting constrained motion of one race ring relative to the other race ring.

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3.1.44
ruptured surface
Surface containing a crack, break, or hole.

3.1.45
scribe
A shallow line used to represent a position of a part to another part for reference.

3.1.46
soft foot
Distortion caused if one or more feet of a machine differ in height from the others (are not in the same plane).

3.1.47
solo test
Operation of the pump driver uncoupled from the pump.

3.1.48
special tool
Tool that is not a commercially available catalogue item.

3.1.49
thermal gaps
Axial gaps between adjacent components on a shaft that allow for thermal expansion and operation above the 1st critical speed.

3.1.50
thread lubricant
Lubrication applied to reduce the loss of torque when tightening due to friction between the external and internal threads.

3.1.51
total indicator reading
total indicated runout
TIR
Difference between the maximum and minimum readings of a dial indicator or similar device, monitoring a face or cylindrical surface during one complete revolution of the monitored surface.

NOTE For a cylindrical surface, the indicated runout implies an eccentricity equal to half the reading. For a flat face, the indicated runout implies an out-of-squareness equal to the reading.

3.1.52
tolerance
Allowable variation in the measured parameter(s).

3.1.53
tooth contact
Interface between gear teeth that transmits the torque from one gear to another gear.

3.1.54
truth band
Locations on the component (such as a shaft) that are used to reference concentricity and or perpendicularity of a repaired location to the original geometric centerline of the component.

3.1.55
upgrade
An improvement in the equipment design, which can increase reliability but does not result in a change in the performance.

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3.1.56
vendor
Agency selected for service support by the repair shop.

NOTE This RP addresses the responsibilities between two parties, defined as the repair shop and the owner. The repair shop can utilize vendors to repair, refurbish, or supply components.

3.1.57
volute
The area of casing that receives the fluid being pumped by the impeller, reducing the fluid's velocity.

3.1.58
water jacketed
Fully enclosed internal chambers or passages through which water can be circulated to aid in cooling.

3.1.59
wiped
Damage that involves the displacement of Babbitt from one location to another location in the bearing.

3.2 Acronyms and Abbreviations

For the purposes of this document, the following acronyms and abbreviations apply.

AUS	austenitic stainless steel
BB	between bearing (type of pump with a number typically following the BB)
BEP	best efficiency point
DBSE	distance between shaft ends
DE	drive end (identifies location of end of equipment)
DOT	United States Department of Transportation
DN	diamètre nominal/nominal diameter/Durchmesser nach Norm
EP	extreme pressure
FPI	fluorescent penetrant inspection
FWS	field work scope
HVLF	high-velocity liquid fuel (type of coating)
HVOF	high-velocity oxygen fuel (type of coating)
ID	inside diameter
L	loose (degree of fit of resulting dimensions)
LH	left-hand
MAWP	maximum allowable working pressure
MIC	microbially induced corrosion

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MT	magnetic particle inspection
MTR	mill test report
NDE	non-drive end (identifies location of end of equipment)
NDT	nondestructive testing
NPS	nominal pipe size
NPSH	net positive suction head
NPSHA	NPSH available
NPSH3	NPSH at 3 % head loss
OD	outside diameter
OEM	original equipment manufacturer
OH	overhung (type of pump with a number typically following the OH)
PdM	predictive maintenance
PH	precipitation hardened
P&ID	process and instrumentation drawing
PM	preventive maintenance
PMI	positive material identification
P-P	peak to peak (amplitude of electrical signal)
PT	liquid penetrant inspection
PTE	pump temperature equalization
PTEP	pump temperature equalization piping
PTFE	polytetrafluoroethylene
PWHT	postweld heat treatment
Ra	arithmetic average of the roughness profile
RMS	root mean square
RO	runout (measurement)
RSWS	repair shop work scope
RT	radiographic inspection
RTD	resistance temperature device

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SG	specific gravity
T	tight (degree of fit of resulting dimensions)
TI	temperature indicator
TIR	total indicator runout
TYP	typical
UN	Unified constant pitch (a thread form)
UNC	Unified National Coarse (a thread form)
UNF	Unified National Fine (a thread form)
UNS	Unified Numbering System (for metal and alloys)
UT	ultrasonic inspection testing
VT	visual inspection testing
WPS	welding procedural specification

4 Inspection of Installed Pump and Removal from Baseplate

4.1 Scope

This section describes the data to be recorded and the recommendations of field inspection of the pump assembly and auxiliaries.

The field inspections and documentation should capture the as-found condition of the equipment, determine the field work scope (FWS), and ensure that key steps or inspections are not overlooked.

The amount of field data and information obtained can be determined by the severity of the pump problem.

Equipment that has already been shut down should have the data and information reviewed prior to any restarting attempts.

4.2 Obtaining Data

4.2.1 Annex C should be utilized to evaluate the perceived problem with the pump.

4.2.2 Equipment information such as datasheet(s), pump performance curve, and equipment and seal system drawings as identified in Annex C should be obtained. The owner should provide this information to the repair shop.

4.2.3 Process conditions, auxiliary systems, and associated components referenced in Annex C should be evaluated.

4.2.4 Review pump nameplate for consistency with information in 4.2.2.

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4.2.5 Observe and document the type of lubrication system. Verify that the lube oil system is functioning correctly and observe its condition. When necessary, obtain a lube oil sample for analysis.

4.2.6 Review the perceived pump problem with people such as operations, maintenance, or others.

4.2.7 Review field data and information with respect to the equipment design data and information to determine possible cause of perceived problem.

4.2.8 Based upon the results from the review performed in 4.2.6, and any current practices or upgrades recommended, prepare an FWS. The FWS may or may not require the pump to be shut down to correct the perceived problem.

4.2.9 Items that do not require the equipment to be shut down should be completed to finish the FWS (equipment is still in operation).

4.3 Preparations for Pump Shutdown

4.3.1 Recommendations when shutting down a pump are as follows.

a) Obtain site approval for shutdown. Follow all procedures.

b) Confirm installed spare train (driver and driven) (if utilized) is satisfactory for operation prior to starting.

c) If problem pump is still in operation, verify the condition of spring piping hangers and supports/locking devices (gags) that would affect the alignment of the piping for the pump prior to shutting down the pump. Determine if they are set according to the latest piping assembly drawings.

d) Review the operating condition of the other equipment to determine if additional work scopes are necessary.

e) Spare pump should be confirmed that it is operating satisfactorily by running it for a minimum of 4 hours.

f) Shut down problem pump and record coast down information, such as vibration, rotor shuttling, time, abrupt stop, noise from the equipment.

g) For steam turbine drivers, consider manually tripping the turbine to verify that the turbine trip valve and system are operating properly.

h) Confirm the pump that was shut down is not rotating backward such as from a leaking check valve. In the event the pump is running backward and driven by an electric motor, do not attempt a restart.

i) To verify that the perceived problem is with the shutdown pump, compare operation and equipment indicators of the spare pump placed in service to the pump removed from service.

j) Obtain an oil sample for analysis if not taken during analysis of lube system as described in 4.2.5.

4.3.2 Follow all site procedures for energy isolation including blinding and plugging. Prior to performing work scope, equipment should be isolated from all energy sources and brought to zero energy.

4.4 Inspections After Shutdown

4.4.1 Perform inspections/corrections from the FWS and 4.2.7 that can be done only if equipment has been shut down and prior to pump removal. These inspections are typically completed after the pump has been shut down and prior to disconnecting pump, auxiliary piping, or removal of pump.

a) Data or information should be obtained for potential upgrades identified in Section 11.

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b) Determine location of any reported leak(s) by performing field pressure test.

c) Identify fasteners associated with leakage of corrosive liquids.

d) Survey the surrounding area and equipment for possible causes of problems affecting equipment in question.

e) Verify the condition of spring piping hangers and supports/locking devices (gags) that would affect the alignment of the piping for the pump prior to draining the pump.

   1) Determine if they are set according to the latest piping assembly drawings.

   2) Determine if the spring piping hanger or support stops/locking devices should be installed prior to disconnecting the pump piping flanges.

   3) For applications that require the spring piping hanger or support/locking device to be removed during piping removal, determine if any additional temporary piping supports are necessary for the remaining piping.

f) Externally corroded or eroded piping on the pump should be inspected further to determine its fitness for service.

g) Obtain and record shaft alignment readings between train (driver and driven) components for reference. The piping and equipment should be close to ambient temperature, so that the information can be compared to the alignment readings obtained after the piping is disconnected and removed.

h) Photograph pump installation with auxiliaries still in place for use during reassembly.

i) Decontaminate piping, pump, bearing housings, and other auxiliary systems per site and governmental regulations.

4.4.2 Review of FWSs

Review the results of the completed FWS and determine if the perceived problem has been resolved or whether further work is recommended. If additional field work is recommended, develop a revised FWS such as FWS rev 01 for the items to be completed in the field. If it is determined that the pump should be removed and sent to a repair shop, then a repair shop work scope (RSWS) should be developed. The FWS should also include any known abnormal condition of the other equipment associated with the pump such as the driver, auxiliary systems, piping, and foundation/baseplate identified in Section 5.

4.4.3 Review of FWS Revisions

Additional FWS revisions may be necessary until the problem has been resolved. If it is determined that the pump should be removed and sent to a repair shop, then an RSWS should be developed.

4.4.4 If root cause “failure” analysis is contemplated for the equipment, preservation of information useful in determining possible causes of wear as well as possible failure mechanisms (forensic evidence) should be considered.

Additional care should be exercised during disassembly and inspection to preserve and document failure modes and mechanisms such as pipe strain, misalignment, or foundation condition.

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4.5 Pump Removal Considerations

4.5.1 Disconnecting Pump Process or Auxiliary Piping

4.5.1.1 Prior to loosening piping flanges at the pump, install the stops for the piping spring hangers and supports if required.

4.5.1.2 Observe and document pipe strain per recommendations of API 686.

Maximum shaft movement in either vertical or horizontal direction after all flanges have been loosened should be no more than 0.002 in. (0.05 mm) in the vertical or horizontal direction.

4.5.1.3 Observe and document piping to pump flange alignment and flange face parallelism per recommendations of API 686. This information should be used for inclusion in the work scope that is developed in 5.9.

4.5.1.4 Obtain the shaft alignment readings between train (driver and driven) components. This information can be compared to historical information and information that was obtained in 4.4.1 prior to the piping being removed. For acceptable alignment procedures and tolerances, refer to API 686.

4.5.1.5 After review of piping and shaft alignment data, determine the need to modify or adjust the process piping.

4.5.1.6 As the auxiliary piping and components such as buffer fluid seal pots, plugs, coolers, cyclone separators, or valves are being disconnected to allow the pump's removal, document their orientation with sketches or photographs. The termination ends should also be tagged with pump number and service connection description and protected in accordance with 4.5.1.7 and 4.5.1.8. Wire any orifice plate to the flange where it was installed.

Plug any oil mist connections. Locate and identify any reclassifiers. Tag and store for reinstallation.

4.5.1.7 Follow all site procedures for piping and tubing terminations, including blinding and plugging, while the pump is removed.

4.5.1.8 Any open flanged connection in the piping or on the pump should be covered with a solid metal cover with a rubber gasket to prevent debris from entering or leaking. Tubing should be plugged with a metal plug.

Molded plastic flange covers or plugs, rags, and towels are not acceptable.

4.5.1.9 Permanent or temporary suction strainers should be inspected and cleaned. Consider if temporary strainer baskets should remain.

4.6 Removing Pump from Baseplate

4.6.1 In order to fully inspect and repair a pump, the entire pump should be sent to the repair shop. However, with a BB5 pump, the outer casing may not always be removed from the baseplate unless there is a problem requiring the removal.

4.6.2 Prior to removing the coupling spacer, observe for matchmarking of the coupling components. If there are no matchmarkings, create such matchmarkings.

a) Remove coupling guard and spacer, observe and document position of hubs on the shaft and the distance between shaft ends (DBSE).

b) Evaluate data by comparing against alignment requirements, general arrangement, and coupling drawings. Revise work scope if necessary.

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NOTE Not all couplings require assembly with matchmarkings; however, the matchmarkings can provide some information that can be beneficial during investigations.

4.6.3 Remove, tag, protect, and document location of externally mounted auxiliary devices such as proximity probes, temperature-indicating devices, and other instrumentation.

4.6.4 To verify a soft foot condition, install a dial indicator to measure the deflection of each pump foot while loosening the respective pump hold-down bolt. Record this information.

Refer to API 686 for soft foot checking procedure and tolerance. Modify work scope if necessary to bring within tolerance.

Perform a soft foot check on any other equipment that can be removed from the base.

4.6.5 When removing the pump from the baseplate, document the location of each hold-down bolt with respect to the pump foot bolt hole. Tag the bolt with the location it was installed.

4.6.6 Equipment hold-down bolts should be checked for bolt undercutting. This information can be used to determine if the holes in the pump feet should be enlarged. In no case should the bolt shank be undercut below the root diameter. Modify the work scope in 5.9 to correct any bolt/hole alignment that will prevent proper pump alignment on reassembly.

4.6.7 If shims or spacers are utilized, they should be tagged and identified for their foot location. Shims should comply with 5.5 and API 686.

4.6.8 Components left in the field should be properly tagged and protected from environmental conditions such as moisture, sand, and dirt.

4.6.9 Clean the area from which the pump was removed.

4.6.10 For on-site locations, decontaminate the pump and or components to comply with site and governmental regulations.

4.6.11 The owner and repair shop may discuss and arrange for cleaning and decontamination by the repair shop and disposal of contaminants.

4.6.11.1 Any pump or component(s) containing hazardous or flammable material that will be transported to an off-site location should be cleaned and decontaminated (some disassembly can be required) to comply with governmental codes, regulations, ordinances, directives, or rules that are applicable.

NOTE 1 The United States Department of Transportation (DOT) regulates hazmat transportation within the territory of the United States.

NOTE 2 Refer also to ANSI/HI 9.1-9.5.

4.6.11.2 Safety datasheets should be included.

4.6.12 Seal any openings of the pump and seal(s) to prevent leakage of product possibly left in the pump or components during transportation. Sealing should be accomplished by using steel plugs and flange covers consisting of a gasket and steel plate.

4.6.13 Pumps should be properly rigged and lifted to avoid damage. See API 686 for rigging and lifting information. Pumps should be lifted so as not to distort or stress the bearing housing(s) or shaft. Reference manufacturer’s recommendation on proper lifting.

4.6.14 Keep all personnel from working under the lift and keep them a safe distance away until the machinery is secured in place on its transport.

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4.7 BB5 Inner Bundle Removal

4.7.1 Remove inner bundle in accordance with pump manufacturer's requirement. Special tools can be required.

4.7.2 Once the inner bundle assembly has been removed, visually inspect as follows:

a) overall condition of the outside of the bundle;

b) gasketed surfaces and condition of any gaskets;

c) signs of leakage;

d) the face(s) in contact with the pump case should be inspected for erosion;

e) document any deposits and obtain samples for analysis;

f) record barrel dimensions as needed.

4.8 Discussion of Work Scope with Repair Shop

The owner should discuss with the repair shop information such as the following.

a) Why the pump was sent in for repair and any time constraints for the repair.

b) Brief history of the pump's service record since its last repair. Any changes incorporated by previous repairs, such as changes of material, dimensions, or operating parameters, should be provided.

c) Description of the conditions in which the pump is operating. It is important to identify the presence of any corrosives such as H_2S, chlorides, abrasives, or any other chemical or substance that is important for consideration.

d) General documentation related to the pump obtained in 4.2 such as the pump materials, the use of any coatings, datasheet, previous repair records, general arrangement drawings, and pump assembly drawings.

e) The extent to which the repair shop will be involved in root cause analysis and expectations for evidence preservation and documentation.

f) Any required hold or witness points.

4.9 Transportation recommendations from equipment field location to the repair shop are identified in Section 7.

5 Field Inspections (Following Pump Removal from Baseplate)

5.1 General

5.1.1 Inspections in 5.2 through 5.9 should be performed in addition to the FWS including revisions in Section 4.

5.1.1.1 Inspections should be documented with test reports, photographs, and forms as needed.

5.1.1.2 Results of these inspections should be evaluated and the work scope revised as necessary.

5.1.1.3 Take samples of any residues and deposits for analysis.

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5.1.2 Consider performing preventive maintenance (PM) or predictive maintenance (PdM) activities on the driver, gearbox, coupling, and auxiliary systems as applicable.

5.1.3 All lifting devices, tooling, and measurement tooling should meet current certification and calibration requirements. See API 686 for rigging and lifting information.

5.1.4 Clean equipment prior to inspections to remove dirt, rust, and other foreign material using a procedure appropriate for the component.

5.1.4.1 Protect all critical areas during cleaning.

5.1.4.2 Abrasive cleaning methods for some components can leave residue that could damage equipment and should not be used.

5.1.4.3 Nondestructive testing (NDT) may require additional cleaning as identified in Annex A1.1 of ASTM E165/E165M.

5.1.4.4 Once the equipment or components have been cleaned, inspected, and repaired as necessary, store and protect these items so they are ready for use once the pump has been repaired and installed. Auxiliary components should be tagged and placed in containers to keep the items grouped together.

5.2 Pump Driver

5.2.1 If the driver is not removed, the electric motor or steam turbine driver should have a solo run in accordance with API 686 to determine if any additional work is necessary. Follow site safety procedures to safely operate the driver for the solo test run. It may be necessary to install the coupling guard for this test run.

For hydrodynamic bearing motors, the shaft should be fully extended and apply a background layout fluid onto the shaft for scribing.

a) With motor power off, and with motor shaft fully extended, use a scribe to mark the layout fluid while turning the shaft by hand. Apply axial load to keep the shaft extended during the scribing.

b) Push shaft fully in the other direction and scribe again.

c) These two scribe marks give a visual indication of the extreme positions of the shaft.

d) If it can be done safely, with the motor running during the solo test, scribe the running position that should be approximately in the center of the two other scribe marks. The running position is typically termed the magnetic center.

   NOTE The position of the rotor during the solo test can be influenced by the operation of any cooling fan(s) installed on the motor, motor electrical characteristics, or motor levelness.

e) These scribe marks can be helpful during assembly and initial operation to verify the motor is not running at one extreme of the axial float and for the setting of the coupling. Operation of the driver may require some or all the auxiliary systems to be placed in operation.

5.2.2 Unless the gearbox is suspected to have a problem, it is not recommended to include the gearbox in the solo test. If the gearbox is operated without driven equipment, consult the gear manufacturer for operation of the gear in an unloaded condition.

5.2.3 Take driver and gearbox (if applicable) coupling hub runout readings. Readings should be taken on each coupling hub rim on the machined surface perpendicular to the centerline of rotation. Readings should also be taken on the face of each coupling hub machined surface as far as practical from the shaft center of rotation. When taking the face runout reading for each hub, verify that the shaft does not axially change position by using a second indicator on that shaft end. Installed coupling hubs should have 0.002 in. (0.05 mm) or less TIR. This limitation applies to the coupling rim and to the coupling face.

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Special-purpose equipment coupling hub runout requirements often will be more restrictive.

5.3 Gearbox

5.3.1 Clean the gearbox exterior before removing the inspection cover or upper case half.

5.3.2 Visually inspect the gear teeth for signs of pitting, tooth distress, tooth breakage, or corrosion.

5.3.3 Record the gear backlash. Visually inspect gear contact pattern through the inspection cover. Rotate the gear elements and inspect all the gear teeth for any abnormalities. Document the results with written notes and/or photos.

5.3.4 If the gear contact pattern is not discernible, a gear contact check can be performed. The gear contact is verified by applying a thin coating of color transfer material (such as Prussian blue) at three locations 120° apart to four or more teeth of the dry degreased gear wheel. Layout dye should not be used for this contact check. The coated teeth should be rotated through the mesh with a moderate drag torque applied in a direction that will cause the teeth to contact on the normally loaded faces. The contact verification pattern transfer should show evidence of contact distributed across each helix.

The results of the contact check should be preserved by lifting the contact verification pattern from a tooth by applying and peeling off a strip of clear adhesive tape and then applying the tape to an annotated sheet of white paper.

Typically, the contact verification check should show a minimum of 80 % contact across the tooth length.

5.3.5 For future contact check, clean and coat a minimum of five teeth across the full face of each helix at four locations equally spaced around the gear wheel and two locations equally spaced around the pinion with hard layout lacquer. The actual operating contact pattern can be observed later by visual inspection testing (VT) after some operating time.

5.3.6 If accessible, check oil spray nozzles for damage along with oil spray pattern on gears to ensure oil spray direction is properly aligned with teeth.

5.3.7 Special-purpose gear repairs should be in accordance with API 687.

5.4 Coupling Components

5.4.1 Coupling components such as hubs, shaft nuts, keys, spacers, disc packs, or bolts should be inspected per 10.6.3.

5.4.2 Grease lubricated couplings should be inspected for grease condition such as lack of grease, grease separation, and hardened grease.

5.4.3 Inspect exposed shaft guards for integrity and safety. Corrections can be completed by replacing per 5.8.

5.4.4 If the coupling guard is not a spark-resistant guard, consider upgrading to a spark-resistant guard per 11.8.2.

NOTE Many users consider pure aluminum and aluminum alloys with a maximum content of 2 % magnesium or 0.2 % copper, all copper, and copper-based alloys (e.g. brass, bronze) to be spark resistant. However, local standards, such as EN 13463-1, might not allow aluminum or nonmetallic materials within potentially explosive atmospheres.

5.5 Baseplates

5.5.1 The pump baseplate should be cleaned for inspection. The baseplate drains should be functional.

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5.5.2 The baseplate should be visually inspected to identify any problems such as corrosion, weld joint failure, or other deterioration.

5.5.3 If stepped or tapered equipment shims were used, check the level of the mounting pads. Equipment mounting pads should be per API 686.

5.5.4 Shims and spacers, if any, should be cleaned and checked for flatness.

5.5.4.1 Shim(s) and spacers should be evaluated for reuse. Existing shims that are not austenitic stainless steel should not be cleaned or reused.

5.5.4.2 Shims should be per API 686.

5.5.4.3 Shim thickness and location should be documented.

5.5.4.4 Evaluate the thickness of the shim packs under each foot of the pump and driver to determine if machining of the baseplate mounting surface is necessary to eliminate or to provide for shims. If multiple shims were installed under the pump feet, consider replacing with a single piece spacer.

5.5.4.5 Multiple shims for drivers that exceed the requirements in API 686 can be minimized by including a spacer in addition to the allowable shims.

5.5.5 Mounting pads should be cleaned and free from rust, burrs, etc.

5.5.6 The threads of holes and fasteners should be visually inspected for gross defects. This VT should be made without magnification and is intended to detect such gross defects as missing or incomplete threads, defective thread profile, torn or ruptured surfaces, yielding, cracks, and bent fasteners. Record any damage found during the inspection. If cupping of washers has occurred, consider replacing the washer with hardened washers per ASTM F436/F436M.

5.5.7 Mounting pads should be protected with an appropriate preservative, including reinstalling the equipment's mounting bolts with a preservative.

5.5.8 Pedestal dowel pin holes, if present, should be brushed cleaned and free from any burrs, rust, or debris. Lightly cleaning with a handheld tapered reamer can also help.

5.5.9 The baseplate should be checked for grout voids by doing "ring test" on the top of the baseplate. Map findings.

5.6 Foundation

5.6.1 The foundation should be cleaned and inspected to locate any problems such as cracked or loose concrete or grout.

5.6.2 Baseplate anchor bolts should be visually inspected. Loose or sheared anchor bolts or nuts should be evaluated for corrective action.

5.6.3 Inspect for foundation settlement such as by:

a) cracks in the foundation or grout,

b) out of level baseplate,

c) corrosion of the baseplate,

d) piping misalignment.

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5.7 Auxiliary Systems

5.7.1 General

5.7.1.1 Piping/Tubing

5.7.1.1.1 Piping should be visually inspected for:

a) thread damage,

b) pitting,

c) gouges,

d) wear,

e) cracking,

f) cleanliness,

g) joint upgrade opportunities such as in 11.5.4.2.

If piping is damaged in a way that would affect the integrity, the damaged components should be replaced and hydrostatically tested.

5.7.1.1.2 Tubing should be visually inspected for:

a) missing fitting components,

b) incorrectly compressed components,

c) thread damage of fittings,

d) pitting,

e) gouges,

f) wear,

g) cracking,

h) cleanliness,

i) kinks.

If tubing is damaged in a way that would affect the integrity, the damaged components should be replaced.

5.7.1.1.3 Inspect auxiliary piping connections to the pump pressure casing. Pipe nipples should not be more than 6 in. (152 mm) long and should be a minimum of Schedule 160 seamless for sizes NPS 1 (DN 25) and smaller and a minimum of Schedule 80 for NPS 1 1/2 (DN 40) and larger. Specific piping specifications for the application should be reviewed to determine if a heavier schedule for the piping components is necessary.

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5.7.1.1.4 Inspect auxiliary piping connections for gusseting for integrity and potential upgrade such as noted in 11.5.4.8 and Figure 1.

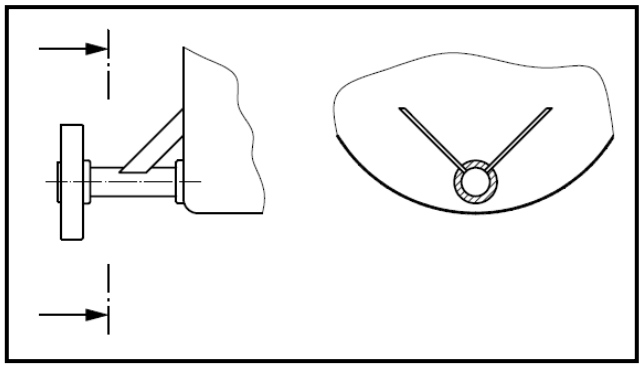


Figure 1—Typical Gusset Design

5.7.1.2 Orifices

5.7.1.2.1 Check for wear or blockage. There should be free flow through the orifice(s). Visually inspect and measure each orifice diameter. The inlet edge of the bore should be sharp, free of burrs, and not worn. The bore inside diameter (ID) should be square and not tapered. Replace as necessary.

For some high-pressure applications, the orifice(s) can be a multipass (series of orifice disks circumferentially offset in one assembly) orifice. Refer to Figure 2.

Metering orifices can have a beveled edge and the orientation of this beveled edge is critical. The beveled edge should face downstream.

Square edge orifices are the most common, but other edge geometries can be employed; therefore, verify the design prior to replacing the orifice.

Compare the results of the measurements to the orifice style and dimension per the documented recommendations.

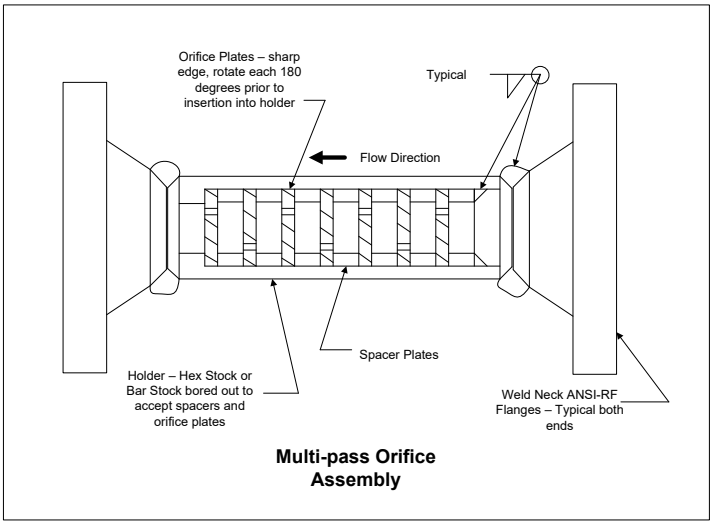


Figure 2—Multipass Orifice Assembly

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5.7.1.2.2 For threaded and drilled orifices manufactured from bar stock, inspect the threads and orifice size.

5.7.1.2.3 All orifices, if used, should have the bore size and identification number attached to an austenitic stainless steel tag, etched on the bar stock, or for plate orifices with a tab, have the information etched on the tab.

5.7.1.3 Steam Traps

5.7.1.3.1 Visually inspect any steam traps for damage or other problems. Repair or replace as necessary.

5.7.1.3.2 Steam traps can be ultrasonically tested to determine if they are properly functioning. The steam trap should be in service for the testing.

5.7.1.4 Instrumentation

The set points, calibration, and functionality of instrumentation should be checked and verified. It is also good to inspect wiring for loose or corroded connections, kinks, pinches around sharp corners, cracked, cut or abraded insulation, burn marks, and other integrity issues.

5.7.1.5 Valves

Valves that are defective should be repaired or replaced.

5.7.1.6 Sight Glasses

Any sight glass should be checked for cracks, gasket damage, function, and replaced as necessary. Removable sight glasses should be removed and cleaned. Weld-pad-type sight glasses should be disassembled and cleaned. New gasketing should be used for reassembly.

5.7.1.7 Cleanliness

5.7.1.7.1 All components should be cleaned, inspected, tested, operation verified, and replaced, as applicable.

5.7.1.7.2 Clean the area upon completion of all inspections.

5.7.1.8 Equipment Installation

5.7.1.8.1 Verify that the equipment that is/was installed on the baseplate, mounting plate, or plates had mounting bolts and alignment devices that are/were centered.

5.7.1.8.2 If bolt bound situations had previously occurred, determine whether corrections are necessary and how the corrections should be completed.

5.7.1.8.3 Review the condition of any washers used and whether hardened washers should be used for the reinstallation.

5.7.1.9 Auxiliary Components

5.7.1.9.1 Review auxiliary systems for proper installation and sufficient instrumentation such as pressure or temperature measuring devices.

5.7.1.9.2 Review any component openings to determine if blinds or solid pipe plugs need to be installed.

5.7.1.9.3 Review any components for recommended vents and drains.

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5.7.2 Seal System

5.7.2.1 Auxiliary Seal System

Auxiliary seal system components can include:

a) heat exchangers,

b) reservoirs,

c) cyclone separators,

d) strainers,

e) accumulators,

f) filters,

g) flow indicator,

h) instrumentation.

5.7.2.1.1 Auxiliary system and components should be drained of all fluids for complete inspection of the components.

a) Auxiliary components should be cleaned or replaced.

b) Remove any piping or tubing to allow for cleaning and inspection.

c) Any internal coils should be removed, where possible, cleaned, and inspected.

d) Cover any open ends to prevent contamination per 4.5.1.8.

e) If the reservoir has a bottom flange, it should be removed to allow complete cleaning.

5.7.2.1.2 Cooling coils (removable or non-removable) should have the outside of the coils cleaned, typically with high-pressure water, and the inside of the coils cleaned by flushing with a cleaning solution.

5.7.2.1.3 Auxiliary components, including flanges and fittings, should be visually inspected for deterioration or pitting. Any dents, scratches, or gouges should be investigated to verify that the integrity of the component has not been jeopardized. Pitting damage should be measured, and the remaining thickness should be reviewed to verify that the component continues to meet the datasheet and nameplate design information. Nameplates per 10.7.5 should be provided.

a) The connections and flange faces should be visually inspected. Refer to Annex U for allowable flange face surface imperfections.

b) Vessels should be inspected in accordance with site regulations.

5.7.2.1.4 If repairs are made to the auxiliary component, the component should be hydrostatically tested per 12.4.12.

5.7.2.2 Accumulators

5.7.2.2.1 With the accumulator out of service, verify the pressure of the bladder and compare to the specified pre-charge set pressure.

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5.7.2.2.2 If the bladder has the correct pressure, the component should be considered OK.

5.7.2.2.3 If the bladder does not have the correct pressure, verification should be done to determine if the bladder leaks or has other problems that will not maintain the pressure.

Replace bladder or component as necessary.

5.7.2.3 Filters

Seal filter elements(s) or filter should be cleaned or replaced.

5.7.2.4 Air-cooled Exchangers

Clean coils or fins and straighten bent fins as needed. For exchangers with motor driven fans, remove fan assembly, clean, and check for loose or damaged components and that the motor turns freely.

5.7.3 Lube Oil System

5.7.3.1 Lube Oil Reservoir

5.7.3.1.1 Lube oil systems may not need to be drained if the lube oil analysis indicates the oil is acceptable. If lube oil system is drained, components should be drained of all fluids for complete inspection of the components. Clean and inspect oil drain lines and reservoir. After cleaning and inspection, cover any open ends per 4.5.1.8 to prevent contamination. Any heaters should be de-energized and locked out prior to draining reservoir. Clean components in a manner that removes all contaminants and foreign material. Lint-free device should be used in the cleaning process.

5.7.3.1.2 Remove, clean, inspect for damage, and replace as applicable: inspection covers, vent breathers, relief and check valves, and pump suction strainers.

5.7.3.1.3 Clean, inspect, and test heater.

5.7.3.2 Lube Oil Heat Exchangers

5.7.3.2.1 Exchangers should be cleaned or replaced. Remove any piping or tubing to allow for cleaning and inspection. Cover any open ends to prevent contamination.

5.7.3.2.2 Exchangers should be visually inspected for deterioration or pitting including tube sheets, internal tubing, flanges, anodes, and fittings.

a) Any dents, scratches, or gouges should be investigated to verify that the integrity of the component has not been jeopardized.

b) Pitting damage should be measured, and the remaining thickness should be reviewed to verify that the component continues to meet the nameplate's design information.

c) The connections and flange faces should be visually inspected. Refer to Annex U for allowable flange face surface imperfections.

d) Vessels should be inspected in accordance with site or regulations.

5.7.3.2.3 The higher pressure side of the exchanger should be hydrostatically tested per 12.4.12.

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5.7.3.3 Lube Oil Accumulators/Pulsation Dampeners

With the accumulator/pulsation dampener out of service, verify the pressure of the bladder and compare to the specified pre-charge set pressure.

a) If the bladder has the correct pressure, the component should be OK.

b) If the bladder does not have the correct pressure, verification should be done to determine if the bladder leaks or has other problems that will not maintain the pressure.

Replace bladder or component as necessary.

5.7.3.4 Lube oil filter housings should be completely drained and elements replaced.

5.7.3.5 Lube Oil Air-cooled Exchangers

Clean coils or fins and straighten bent fins as needed. For exchangers with motor driven fans, remove fan assembly if necessary, clean, and check for loose components and that the motor turns freely.

5.7.3.6 Lube oil pumps should be cleaned along with the suction screen, driver, and coupling. Confirm free rotation of the pump.

5.7.4 Oil Mist System

5.7.4.1 Oil mist reclassifier(s) should be visually inspected for plugging or damage and should be cleaned.

5.7.4.2 Verify that each reclassifer is the proper size. Maintain the oil mist reclassifer in the correct location and orientation.

5.7.4.3 Oil mist manifold should be drained and checked for broken or cracked sight glass.

5.7.4.4 Clean the oil mist manifold, sight glass, and collection bottle.

5.7.4.5 Drain oil accumulators.

5.7.4.6 Inspect tubing and replace if damaged even slightly.

5.7.5 Cooling Water System

Cooling water system components should be cleaned, inspected, and replaced as necessary. If fouled, remove a sample for possible analysis.

5.7.6 Electrical and Instrumentation

5.7.6.1 Verify that all electrical components, instrumentation, and electrical isolation components are identified, function properly, and are in good condition.

5.7.6.2 Verify all ground wiring is properly connected, functioning, and is included for all equipment

5.8 Guards for Exposed Shaft Areas

5.8.1 Verify that the guard(s) for exposed shaft areas meet ANSI B11.19 and API 610. If a guard is not included, review 11.8.2.

5.8.2 Visually inspect the guard(s) for:

a) structural integrity,

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b) indications of rubbing or contact that indicate it has been deformed or distorted,

c) discoloration of nonmetallic components,

d) fastener condition,

e) spark-resistant material construction.

5.9 Work Scopes and Revised Work Scopes

Additional FWS revisions may be necessary until the problem has been resolved. If it is determined that the pump should be removed and sent to a repair shop, then an RSWS should be developed.

6 Field Repair

6.1 General

This section covers repairs made to the items left in the field after the pump has been removed for repairs. This section does not cover any pump repair or process piping repair.

6.2 Work Scopes

The work scope developed in 5.9 from field inspections should be completed. ASME *Code* items should be repaired per the code.

6.3 Foundation

6.3.1 The baseplate can be removed to correct broken or loose baseplate anchor bolts or foundation settlement.

6.3.2 Damaged concrete should be removed to sound aggregate and replaced.

6.3.3 Re-grouting and leveling should be per API 686.

6.4 Grouting

6.4.1 Cracked, broken, or loose grout should be repaired by chipping out the damaged grout and replacing per API 686 with epoxy grout—or other grout materials as approved. Small cracks can be filled with grout or epoxy to prevent further deterioration.

6.4.2 Void areas under the top deck plate that are located around equipment supports should be drilled and filled with fluid epoxy grout in accordance with the methods in API 686.

6.5 Baseplates

6.5.1 Tapped holes for equipment hold-down bolts should be cleaned and “chased” for ease of installation. Bolts should be wire brushed and threads “chased,” cleaned, and protected until reuse. Chasing taps should be used to prevent oversizing threads. Recheck for any raised burrs after thread chasing.

6.5.2 Holes for pump hold-down bolts should be per 12.4.10.4.

6.5.3 Equipment mounting pads that are out of level can be repaired by machining per API 686.

6.5.3.1 Mounting pads should be protected with an appropriate preservative.

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6.5.3.2 If mounting pads have provision for taper pin dowels, the holes should be cleaned by hand turning a taper pin reamer lightly in the hole.

6.5.4 Damaged metal portion of the baseplate can be repaired by welding using the appropriate procedures for the material being welded. Repairs to equipment mounting pads should have an engineering review to verify that the integrity of the baseplate is sufficient. Caution should be taken when welding on the baseplate to prevent affecting grout to base plate bond, distortion of mounting pads, and damage to other equipment from stray currents.

6.6 Pump Driver

Details for the repairs of the driver are not included within this RP.

6.7 Gearbox

Gearbox repairs should be per API 687.

6.8 Coupling and Exposed Shaft Guards

6.8.1 Couplings should be inspected per 10.6.3.

6.8.1.1 Disc packs on general-purpose metal flexible-disk-style couplings should be replaced if damaged and the coupling rebalanced if necessary.

6.8.1.2 During coupling removal and disassembly, keep the disc pack in the same orientation/position in relation to the hub and spacer. Do not separate disc packs that will be reused.

6.8.1.3 Consider sending these couplings to the owner's selected coupling vendor for refurbishment. Other general-purpose couplings are generally not repaired.

6.8.1.4 Special-purpose couplings should be repaired by a coupling vendor selected by the owner that can maintain the integrity of the coupling per API 687.

6.8.2 Refer to 11.8.2, ANSI B11.19, and API 610 for guidance on replacement or repair of shaft guards.

6.9 Auxiliary Systems

Auxiliary system repairs are described in 5.7.

6.10 Electrical Grounding

Electrical grounding systems should be repaired by correcting the grounding lugs or wiring. Typically, these items are replaced.

6.11 Piping Strain

Piping strain correction should be in accordance with API 686.

7 Shipment of Equipment or Components to or from Repair Shop

7.1 Preparation for Shipment

7.1.1 The repair shop or owner has the authority to reject any shipment not in compliance with their rules and regulations.

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7.1.2 Consult with the repair shop for:

a) shipping container or skid requirements,

b) communications when shipping is initiated,

c) photographs,

d) liquid draining,

e) preservation,

f) warning tags,

g) necessary tooling or fixtures,

h) hold points established before shipping,

i) identification of the length of shipping or storage time,

j) additional cleaning/decontamination.

7.1.3 Shipping containers or skids should be per 7.3.

7.1.4 All shipments not in containers should have a canvas tarp to avoid miscellaneous damage by foreign objects and moisture.

7.1.5 Preservation should be applied to the equipment and/or components to prevent damage during shipping and possible storage. Safety datasheet information should be provided for the preservative.

7.1.6 The pump or component(s) should be adequately supported and restrained to prevent movement during shipment. Block the shaft to prevent axial movement.

7.1.7 Rotors being returned for repair should be adequately preserved to prevent any damage or environmental deterioration (see API 686). Each proximity probe target area (burnished areas) of the shaft should be protected during disassembly with material such as non-adhesive vinyl tape. Each area should further be easily identified such as with a brightly colored wrapping indicating a probe area and “PROBE AREA, DO NOT CUT” wording. The rotor should be supported per the recommendations of 7.3.

7.1.8 Verify that all openings of the pump and seal(s) have been sealed using flange covers and metal plugs.

7.1.9 Verify that decontamination and/or draining has been completed.

7.1.10 The repair shop should provide unique identification number(s) to allow tracking of all owner components at that shop.

7.1.11 The owner should identify all components with a common unique job-related number, such as a purchase order or requisition number.

7.1.11.1 Material(s) shipped separately should be identified with securely affixed, corrosion-resistant metal tags indicating the unique number.

7.1.11.2 Crated equipment should be shipped with duplicate packing lists, one inside and one outside of the shipping container. The packing list should have the unique number and describe each item in the crate.

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7.2 Shipment

7.2.1 General

7.2.1.1 The equipment and/or components should be tagged with the owner's description. Equipment inside enclosed shipping containers should also have tagging attached to the equipment.

7.2.1.2 Any pump or component(s) containing hazardous or flammable material should be cleaned and decontaminated (some disassembly can be necessary) in accordance with applicable governmental codes, regulations, ordinances, directives, or rules prior to being transported to an off-site location. Safety datasheets should be included. A repair shop may require owner certification that the pump has been sufficiently cleaned of all hazardous materials. The owner should communicate with the repair shop of the possibility of trapped liquids or gases that can result in either a safety situation or that can be affected by the use of flame torches to facilitate disassembly. Consideration should be given to differences with regulations and languages of the shipping and receiving locations.

The owner and repair shop may discuss and arrange for cleaning and decontamination at the repair shop.

NOTE 1 The DOT regulates hazmat transportation within the territory of the United States.

NOTE 2 Refer also to ANSI/HI 9.1-9.5.

Consider requirements for other countries that may be used for shipping or receiving.

The repair shop has the authority to reject any shipment not in compliance with their rules and regulations.

7.2.1.3 The vehicle, the type of vehicle, and method of securing the equipment should be adequate for the load being transported.

7.2.1.4 Hold-down methods should not damage the equipment.

7.2.1.5 Tooling and fixtures for lifting, disassembly, and assembly should be provided, if requested by the repair shop.

7.2.2 Transporting to or from an on-site repair shop should be done per the recommendations of the site.

7.2.3 Transport to or from Off-Site Repair Shop

7.2.3.1 The shipping location should document what is included with the shipment. Attach a copy of this document to the equipment and another copy to the outside of any shipping container. Transmit a copy to the repair shop upon departure of the shipment to the repair shop.

7.2.3.2 Take photographs for documentation of the equipment as loaded onto the vehicle.

7.3 Shipping Containers/Skids

7.3.1 Shipping containers/skids should be adequate to perform the intended service of support, protection, handling, and the length of shipping and storage time.

7.3.2 Hold-down methods should not damage the equipment.

● **7.3.3** If specified, the containers should have a dual purpose of shipping and storage.

7.3.4 Labeling to include as a minimum (depending if the shipment is from the owner or the repair shop):

a) owner name, location, address, phone contact;

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