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Lubrication, Shaft-sealing, and Oil-control Systems and Auxiliaries

API STANDARD 614
SEVENTH EDITION, XXXXXX 202X

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Introduction

API 614 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 API 614 and provide details.

API 614 requires the purchaser to specify certain details and features.

A bullet (●) at the beginning of a section or subsection indicates that either a decision is required or further information is to be provided by the purchaser.

A diamond (◆) at the beginning of a section or subsection indicates that the feature is required for unsparred equipment in critical service.

NOTE Sections and subsections preceded by a diamond (◆) are those features and requirements described as “special purpose” oil systems in previous editions of API 614.

In this International Standard, United States customary units are included in parentheses for information.

Annex A contains a site and utility data sheet and oil system data sheets.

Annex B contains symbols used in piping and instrument diagrams and figures.

Annex C contains piping and instrument diagrams.

Annex D contains contract documents and engineering design data.

Annex E provides guidance on oil filter performance and oil-system cleanliness testing.

Annex F contains international materials specifications.

Annex G provides an explanation of reservoir levels.

Annex H provides guidance on oil drain line sizing.

Annex I contains an inspector's checklist.

Annex J contains a guide to system reliability.

Annex K provides guidance on varnish and electrostatic discharge.

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1 Scope

API 614 covers the minimum requirements for lubrication systems, oil-type shaft-sealing systems, oil-control systems, and auxiliaries, excluding dry gas seal systems and fuel systems. These systems can serve individual equipment such as compressors, gears, pumps, and drivers or complete trains. API 614 does not apply to dry gas seal systems. API 614 does not apply to dry gas seal systems (refer to API 692) or high-pressure oil systems and fuel systems used on gas turbines (refer to API 616).

2 Normative References

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any addenda) applies.

API Standard 520 (all parts), *Sizing, Selection, and Installation of Pressure-relieving Devices*

API Standard 526, *Flanged Steel Pressure-relief Valves*

API Standard 547, *General Purpose Form-wound Squirrel Cage Induction Motors—185 kW (250 hp) through 2240 kW (3000 hp)*

API Recommended Practice 551, *Process Measurement*

API Recommended Practice 578, *Guidelines for a Material Verification Program (MVP) for New and Existing Assets*

API Standard 594, *Check Valves: Flanged, Lug, Wafer, and Butt-welding*

API Standard 600, *Steel Gate Valves—Flanged and Butt-welding Ends, Bolted Bonnets*

API Standard 602, *Gate, Globe, and Check Valves for Sizes DN 100 (NPS 4) and Smaller for the Petroleum and Natural Gas Industries*

API Standard 603, *Corrosion-resistant, Bolted Bonnet Gate Valves—Flanged and Butt-welding Ends*

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

API Standard 611, *General-purpose Steam Turbines for Petroleum, Chemical, and Gas Industry Services*

API Standard 660, *Shell-and-Tube Heat Exchangers*

API Standard 661, *Petroleum, Petrochemical, and Natural Gas Industries—Air-cooled Heat Exchangers*

API Standard 670, *Machinery Protection Systems*

API Standard 676, *Positive Displacement Pumps—Rotary*

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

API Recommended Practice 691, *Risk-based Machinery Management*

API Standard 692, *Dry Gas Sealing Systems for Axial, Centrifugal, and Rotary Screw Compressors and Expanders*

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ANSI B11.19 ¹, *Performance Requirements for Risk Reduction Measures: Safeguarding and Other Means of Reducing Risk*

ANSI/AGMA 9000-D11 ², *Flexible Couplings—Potential Unbalance Classification*

ANSI/AGMA 9002-B04 (R2011), *Bores and Keyways for Flexible Couplings (Inch Series)*

ASME B1.1 ³, *Unified Inch Screw Threads (UN, UNR, and UNJ Thread Forms)*

ASME B1.20.1, *Pipe Threads, General Purpose (Inch)*

ASME B16.1, *Grey Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250*

ASME B16.5, *Pipe Flanges and Flanged Fittings: NPS 1/2 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 B31.3, *Process Piping*

ASME B73.1, *Specification for Horizontal End Suction Centrifugal Pumps for Chemical Process*

ASME B73.2, *Specification for Vertical In-line Centrifugal Pumps for Chemical Process*

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

ASME Boiler and Pressure Vessel Code, Section VIII: *Rules for Construction of Pressure Vessels, Division 1*

ASME Y14.2, *Line Conventions and Lettering*

ASTM A193/A193M ⁴, *Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications*

ASTM A194/A194M, *Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both*

ASTM A240/A240M, *Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications*

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

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*

¹ American National Standards Institute, 1899 L Street, NW, Washington, District of Columbia 20036, <https://ansi.org>.

² American Gear Manufacturers Association, 1001 N. Fairfax Street, Suite 500, Alexandria, Virginia 22314, www.agma.org.

³ American Society of Mechanical Engineers, Two Park Avenue, New York, New York 10016, www.asme.org.

⁴ ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, www.astm.org.

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ASTM D5445-15, Standard Practice for Pictorial Markings for Handling of Goods

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 E709, Standard Guide for Magnetic Particle Testing

ASTM E1003, Standard Practice for Hydrostatic Leak Testing

AWS D1.1/D1.1M⁵, Structural Welding Code—Steel

EN 1092-1⁶, Flanges and their joints—Circular flange for pipes, valves, fittings and accessories, PN designated—Part 1: Steel flanges

EN 1092-2, Flanges and their joints—Circular flange for pipes, valves, fittings and accessories, PN designated—Part 2: Cast iron flanges

EN ISO 3452-1, Non-destructive testing of welds—Penetrant testing—General principles

EN 10675-1, Non-destructive testing of welds—Acceptance levels for radiographic testing—Steel, nickel, titanium and their alloys

EN ISO 11666, Non-destructive testing of welds—Ultrasonic testing—Acceptance levels

EN ISO 17636-1, Non-destructive testing of welds—Radiographic testing—X- and gamma-ray techniques with film

EN ISO 17636-2, Non-destructive testing of welds—Radiographic testing—X- and gamma-ray techniques with digital detectors

EN ISO 17637, Non-destructive testing of welds—Visual testing of fusion-welded joints

EN ISO 17638, Non-destructive testing of welds—Magnetic particle testing

EN ISO 17640, Non-destructive testing of welds—Ultrasonic testing—Techniques, testing levels and assessment

EN ISO 23277, Non-destructive testing of welds—Penetrant testing—Acceptance levels

EN ISO 23278, Non-destructive testing of welds—Magnetic particle testing—Acceptance levels

EN ISO 23279, Non-destructive testing of welds—Ultrasonic testing—Characterization of discontinuities in welds

IEC 60079 (all parts)⁷, Explosive atmospheres

⁵ American Welding Society, 8669 NW 36 Street, # 130, Miami, Florida 33166, www.aws.org.

⁶ European Committee for Standardization (CEN), Management Centre, Rue de la Science 23, B - 1040 Brussels, Belgium, <https://www.cen.eu>.

⁷ International Electrotechnical Commission, 3 Rue de Varembé, CH-1211, Geneva 20, Switzerland, www.iec.ch.

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IEC 60529, *Degrees of protection provided by enclosures (IP code)*

IEEE 841⁸, *Premium-Efficiency, Severe-Duty, Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors--Up to and Including 370 kW (500 hp)*

ISA S12.4⁹, *Instrument Purging for Reduction of Hazardous Area Classification*

ISA 18.1, *Annunciator Sequences and Specifications*

ISO 7-1¹⁰, *Pipe threads where pressure-tight joints are made on the threads—Part 1: Dimensions, tolerances and designation*

ISO 6162 (all parts), *Hydraulic fluid power—Flange connections with split or one-piece flange clamps and metric or inch screws*

ISO 10434, *Bolted bonnet steel gate valves for the petroleum, petrochemical and allied industries*

ISO 14120, *Safety of machinery—Guards—General requirements for the design and construction of fixed and movable guards*

ISO 15761, *Steel gate, globe and check valves for sizes DN 100 and smaller, for the petroleum and natural gas industries*

ISO 16889, *Hydraulic fluid power—Filters—Multi-pass method for evaluating filtration performance of a filter element*

ISO 21940-11, *Mechanical vibration—Rotor balancing—Part 11: Procedures and tolerances for rotors with rigid behavior*

ISPM Pub. No. 15¹¹, *Regulation of wood packaging material in international trade*

NFPA 70¹², *National Electrical Code*

NFPA 79, *Electrical Standard for Industrial Machinery*

NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment*

SAE J518 (all parts)¹³, *Hydraulic Flanged Tube, Pipe, and Hose Connections*

⁸ IEEE, 445 Hoes Lane, Piscataway, New Jersey 08854, www.ieee.org.

⁹ International Society of Automation, 67 T.W. Alexander Drive, Research Triangle Park, North Carolina 27709, <https://www.isa.org>.

¹⁰ International Organization for Standardization, Chemin de Blandonnet 8, CP 401 – 1214 Vernier, Geneva, Switzerland, www.iso.org.

¹¹ Food and Agriculture Organization of the United Nations, Viale delle Terme di Caracalla 00153 Rome, Italy, <http://www.fao.org/home/en>.

¹² National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02169, www.nfpa.org.

¹³ SAE International, 400 Commonwealth Drive, Warrendale, Pennsylvania 15096, www.sae.org.

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TEMA ¹⁴, Standards of the Tubular Exchanger Manufacturers Association

3 Terms, Definitions, Acronyms, and Abbreviations

3.1 Terms and Definitions

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

3.1.1

alarm point

Preset value of a measured parameter at which an alarm is activated to warn of a condition that requires corrective action.

3.1.2

block-in time

Period required after the driver is shut down to isolate a piece of equipment, such as a compressor, from its system and to depressurize it.

3.1.3

booster pump

Oil pump that takes suction from the discharge of another pump to provide oil at a higher pressure.

3.1.4

buffer gas

Gas supplied to the process side of a double shaft seal, used to keep process gas away from the seal.

3.1.5

coast-down time

Period required after the driver is shut down for the equipment to come to rest.

3.1.6

components

Machinery and hardware items such as reservoirs, pumps, heat exchangers, filters, valves, and instruments that are part of the system.

3.1.7

console

Total system whose components and controls are packaged as a single unit on a continuous or joined baseplate.

NOTE 1 With a console, the purchaser is required only to make external connections.

NOTE 2 Rundown tanks and seal-oil tanks that are separately mounted, as well as other items such as instrumentation mounted on the equipment, are not part of the console.

¹⁴ Tubular Exchanger Manufacturers Association, 25 North Broadway, Tarrytown, New York 10591, <http://kbcdo.tema.org>.

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3.1.8

continuous-flow transfer valve

Valve that can simultaneously divert both inlet and outlet flows from one component to its installed spare equipment without altering the continuity of full flow through the transfer valve to the equipment.

3.1.9

control oil

Oil required to operate such components as relays, servomotors, and power pistons on the main equipment.

3.1.10

cool-off time

Period during which oil has to be circulated through the equipment to prevent heat damage after the driver is shut down.

3.1.11

diamètre nominal (nominal diameter)

DN

Alphanumeric designation of size for components of a pipework system.

EXAMPLE DN20.

NOTE 1 Adapted from ISO 6708:1995.

NOTE 2 The letters DN are followed by a dimensionless whole number that is indirectly related to the physical size, in millimeters, of the bore or outside diameter of the end connection.

NOTE 3 The number following the letters DN does not represent a measurable value, and it is not appropriate that they be used for calculation purposes except where specified in the relevant standard.

3.1.12

equipment

Main machinery served by the oil system.

3.1.13

fail safe

System or component that causes the equipment to revert to a permanently safe condition (shutdown and/or depressurized) in the event of a component failure or failure of the energy supply to the system.

3.1.14

gauge board

Unenclosed bracket or plate used to support and display gauges and other instruments.

NOTE A gauge board is not a panel. A panel is an enclosure. Refer to 3.1.33 for the definition of a panel.

3.1.15

general-purpose application

Application that is usually spared or is in noncritical service.

3.1.16

local

Mounted on or near the equipment or console.

3.1.17

mission time

Duration of the mission.

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NOTE Mission time begins when the equipment or system is 100 % operational, i.e. equipment or system capability has returned to engineered capability, and the equipment or system is ready for service. The mission time ends when the equipment or system can no longer meet the defined mission objectives.

3.1.18

main oil pump

Oil pump that is normally in operation.

3.1.19

maximum allowable temperature

Maximum continuous temperature for which the manufacturer has designed the equipment (or any part to which the term is referred) when handling the specified fluid at the specified pressure.

3.1.20

maximum allowable working pressure

Maximum continuous pressure for which the manufacturer has designed the console or components when handling the specified fluid at the maximum allowable temperature.

3.1.21

maximum pump discharge pressure (centrifugal type)

Maximum specified suction pressure plus the maximum differential pressure the pump with the finished impeller is able to develop when operating at rated speed with fluid of the specified normal relative density (specific gravity).

3.1.22

maximum sealing pressure

Highest pressure expected at the seals during any specified static or operating conditions and during start-up and shutdown.

3.1.23

mist eliminator

Can reduce oil mist emissions, recover oil, and help prevent oil leaks.

3.1.24

nominal pressure

PN

Numerical designation relating to pressure that is a convenient round number for reference purposes.

EXAMPLE PN 100.

NOTE The permissible working pressure associated with a PN designation depends upon materials, design, and working temperature and has to be selected from the pressure/temperature rating tables in corresponding standards.

3.1.25

normal flow

Total amount of fluid required by equipment components such as bearings, seals, couplings, and steady-state controls excluding transient flow for controls or fluid bypassed directly back to the reservoir.

3.1.26

normal operating point

Point at which usual operation is expected and optimum efficiency is desired. This point is usually the point at which the vendor certifies that performance is within the tolerances stated in this standard.

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3.1.27

normally closed

De-energized position of a device (e.g. automatically controlled electric switch or valve) remaining in a closed position during operation unless energized.

NOTE During operation of the equipment, the positions of these devices are not necessarily the same as their on-the-shelf positions.

3.1.28

normally open

De-energized position of a device (e.g. automatically controlled electric switch or valve) remaining in an open position during operation unless energized.

NOTE During operation of the equipment, the positions of these devices are not necessarily the same as their on-the-shelf positions.

3.1.29

NPS

Nominal pipe size (NPS) dimensionless value approximately equal to a diameter in inches.

EXAMPLE NPS $\frac{3}{4}$.

NOTE 1 Refer to ASME B31.3, para. 300.2.

NOTE 2 The letters NPS are followed by a value that is related to an approximate diameter of the bore, in inches, for piping up to and including 12 in. diameter. For piping over 12 in. (NPS 12), the NPS value is the nominal OD.

3.1.30

NPT

American National Standard Pipe Taper thread form designation for pipe threads as per ASME B1.20.1.

EXAMPLE $\frac{3}{4}$ -14 NPT.

NOTE Proper designation is comprised of a number representing NPS followed by the number of threads per inch and the letters NPT representing the thread series.

3.1.31

observed

Inspection or test when the purchaser is notified of the timing of the inspection or test and the inspection or test is performed as scheduled, whether or not the purchaser or his or her representative is present.

3.1.32

owner

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

3.1.33

package

Total system or part of a system, whose components are mounted on a single baseplate.

3.1.34

panel

Enclosure used to mount, display, and protect gauges and other instruments.

NOTE Instruments in a panel can be open or enclosed by the panel (see 3.1.14).

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3.1.35

positive material identification

PMI

Any physical evaluation or test of a material to confirm that the material that has been or will be placed into service is consistent with the selected or specified alloy material designated by the purchaser. These evaluations or tests may provide either qualitative or quantitative information that is sufficient to verify the nominal alloy composition.

3.1.36

pressure control valve

PCV

A valve that regulates the pressure of the flowing medium.

NOTE A backpressure control valve is designed to regulate pressure upstream of the valve inlet, whereas a pressure control valve (PCV) is designed to regulate pressure downstream of valve outlet.

3.1.37

pressure-limiting valve

PLV

Automatic pressure-limiting device for liquid service, which opens in proportion to the increase in pressure over the opening set pressure and automatically closes when the upstream pressure is reduced below the set pressure, and which is actuated by the static pressure upstream of the valve.

NOTE 1 These devices are not necessarily tight shutoff when closed, i.e. they may have a small leakage flow when closed and therefore do not necessarily conform to API 520 or API 526. These devices are intended for liquid service only and are normally used for limiting the discharge pressure of positive-displacement-type oil pumps and the downstream pressure of fail-open oil pressure-regulating valves when necessary.

NOTE 2 Pressure-limiting valves (PLVs) need a flowing test system in order to test. Normally, these valves are, therefore, tested in the system on which they are installed.

3.1.38

pressure safety valve relief valve

PSV

Automatic pressure-relieving device, which opens in proportion to the increase in pressure over the opening set pressure, has a rapid full opening or pop action characteristic, and is actuated by the static pressure upstream of the valve.

NOTE The device automatically closes when the upstream pressure is reduced below the set pressure. These devices are considered to be tight shutoff when closed and are normally used in gas, vapor, or liquid service.

3.1.39

purchaser

Agency that issues the order and specification to the vendor.

NOTE The purchaser can be the owner of the plant in which the equipment is installed or the owner's appointed agent.

3.1.40

remote

Located away from the equipment or the console, typically in a control room.

3.1.41

rundown

Oil capacities associated with operational vs. non-operational states.

NOTE Pertains to oil capacities in reservoirs and overhead tanks.

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3.1.42

self-contained regulator

Regulating valve assembly that utilizes or internally senses the controlling pressure or temperature.

3.1.43

separation gas

Supply of inert gas or air fed into the region between the seal and the shaft bearing.

3.1.44

settling-out pressure

Maximum pressure the system can reach under static conditions.

3.1.45

shaft-driven pump

Oil pump driven by the shaft of one of the main machines served by the oil system.

3.1.46

shutdown

Condition as determined by the equipment user that requires action to stop the equipment.

3.1.47

shutdown set point

Preset value of a measured parameter at which automatic or manual shutdown of the system or equipment is required.

3.1.48

special purpose application

Application for which the equipment is designed for uninterrupted, continuous operation in critical service and for which there is usually no installed spare equipment.

3.1.49

standby pump

Oil pump that is capable, either automatically or manually, of being immediately brought up to operating speed, and that is capable of operating continuously.

3.1.50

standby service

Normally idle piece of equipment that is capable of immediate automatic or manual start-up and continuous operation.

3.1.51

stilling tube

Pipe extending into the reservoir from the connection to below pump suction-loss level to prevent splashing and provide free release of foam and gas.

NOTE 1 A stilling tube is typically used for non-pressurized returns and has an open top or vent holes to equalize to reservoir pressure (refer to Figure C.23).

3.1.52

trip

Automated shutdown to ensure personnel safety (safety critical).

3.1.53

unit responsibility

Obligation for coordinating the documentation, delivery, and technical aspects of all the equipment and all auxiliary systems included in the scope of the order.

NOTE Responsibility for such factors as the power requirements, speed, rotation, general arrangement, couplings, dynamics, noise, lubrication, sealing system, material test reports, instrumentation, piping, and testing of components is included.

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3.1.54

vendor

Manufacturer or manufacturer's agent that sells or supplies the equipment.

NOTE The vendor can be the manufacturer of the equipment or the manufacturer's agent and normally is responsible for service support.

3.1.55

vent gas

Gas leakage that is taken away by the vent system.

3.1.56

vent system

Arrangement of piping and valves used to take gas to a safe location.

3.1.57

witnessed

Inspection or test where the purchaser is notified of the timing of the inspection or test and a hold is placed on the inspection or test until the purchaser or his or her representative is in attendance.

3.2 Acronyms and Abbreviations

BWG	Birmingham wire gauge
DBSE	distance between shaft ends
DN	nominal diameter
FMEA	failure modes and effects analysis
HA	hand-auto
HMI	human-machine interface
HOA	hand-off-auto
MAWP	maximum allowable working pressure
NDT	nondestructive testing
NPS	nominal pipe size
NPT	national pipe thread (tapered)
P&ID	process (piping) and instrument diagram
PCV	pressure control valve
PLV	pressure-limiting valve
PN	nominal pressure
SDS	safety data sheet
SI	International System of Units
UNC	unified national coarse thread
USC	United States customary
VDDR	vendor drawing and data requirements

NOTE For instrumentation abbreviations, refer to Annex B.

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4 System Configuration (How to Use This Standard to Specify an Oil System)

4.1 The requirements of this standard define a minimum API 614 oil system.

NOTE The system configuration codes are intended for use when no other purchaser requirements are given.

4.2 • Purchaser will select one (or more) of the following methods to specify the oil system, as illustrated in the oil system selection guide (see Figure 1). A purchaser-specified oil system will take precedence over the system configuration codes.

- Specify the configuration option codes from Table 1.
- Require those features described by all paragraphs of this standard preceded by a diamond (◆).

NOTE Sections and subsections preceded by a diamond (◆) are those features and requirements described as “special purpose” oil systems in previous editions of API 614.

- Specify system features and options individually on the oil system data sheet (typical data sheets are included in Annex A).
- Purchaser specification.

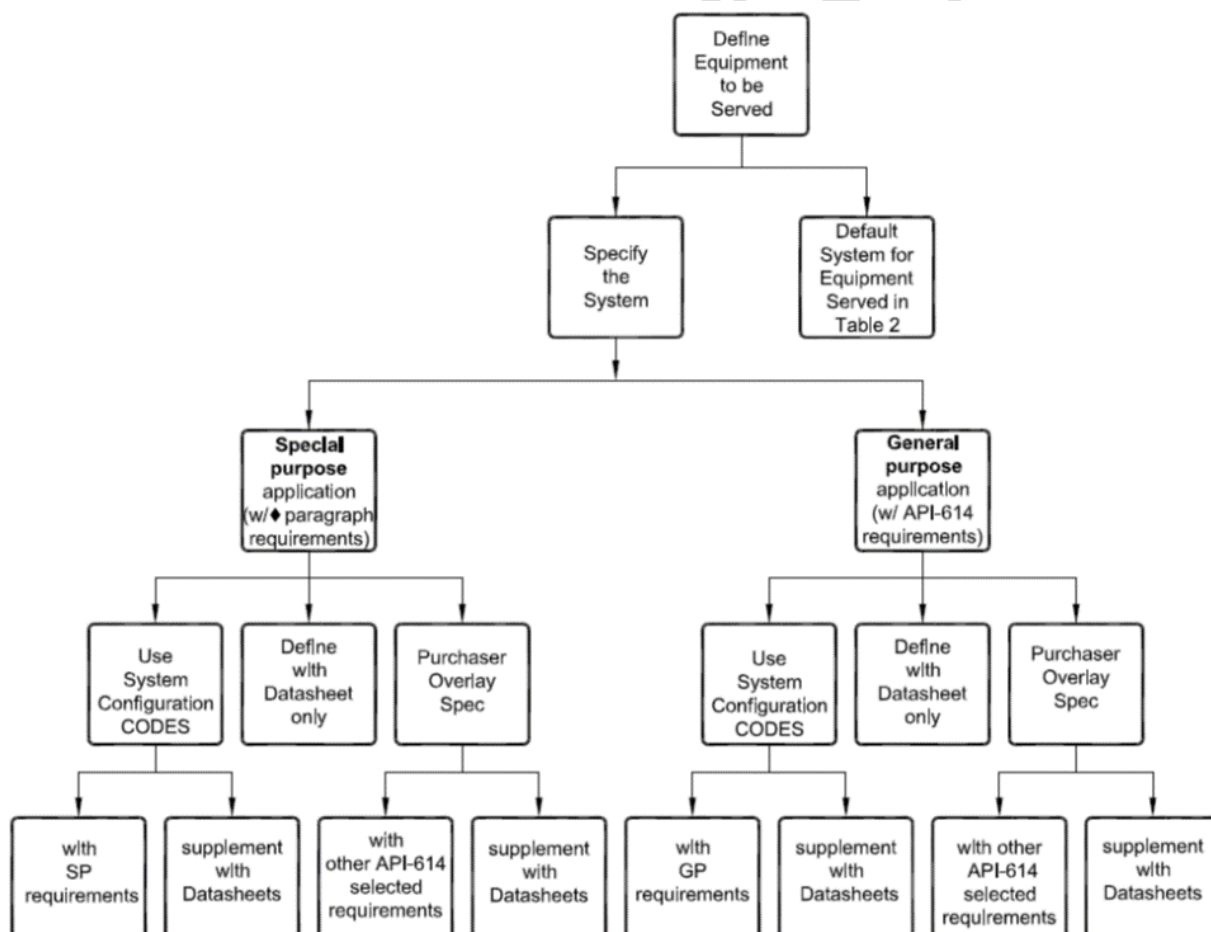


Figure 1—Oil System Selection Guide

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4.3 A bullet (●) at the beginning of a section or subsection indicates that either a decision is required or further information is to be provided by the purchaser. This information should be indicated in the data sheets; otherwise, it should be stated in the quotation request or in the purchase order.

4.4 A diamond (◆) at the beginning of a section or subsection indicates that the feature is required for unspared equipment in critical service.

NOTE Sections and subsections preceded by a diamond (◆) are those features and requirements described as “special purpose” oil systems in previous editions of API 614.

4.5 ● If specified by the purchaser, all sections and subsections preceded by a diamond (◆) shall apply to the oil system.

4.6 Stand-alone lube-oil systems for drivers and gears may be used if the driven machines need a dedicated lube-oil system, or if the driven equipment does not need a lube-oil system.

NOTE Some examples are electric motors driving oil flooded screw compressors or reciprocating compressors and steam turbines driving fans, pumps, or generators.

4.7.1 Oil systems are defined by a coding system that defines the major components supplied (see Table 1).

4.7.2 The user shall choose the applicable code based upon the required minimum reliability targets for the equipment train.

NOTE 1 Many API equipment standards have specified minimum recommended systems within their respective standards.

NOTE 2 Annex K is supplied as a reference to provide guidance on the selection of a system.

Table 1—Oil System Standard Configuration Options

Equipment	Additional Features	Additional Note	Code
Basic module: Lube-oil system only			LO
Basic module: Lube- and control-oil system			LCO
Basic module: Lube- and seal-oil system			LSO
Basic module: Lube-, control-, and seal-oil system			LCSO
Pump and driver configuration: Shaft-driven main pump only	Rotary pumps		PRS00
	Centrifugal pumps		PCS00
Pump and driver configuration: AC motor-driven main pump only	Rotary pumps		PRA00
	Centrifugal pumps		PCA00
Pump and driver configuration: — Shaft-driven main pump — AC motor-driven auxiliary pump	Rotary pumps		PRSA0
	Centrifugal pumps		PCSA0
Pump and driver configuration: — AC motor-driven main pump — AC motor-driven auxiliary pump	Rotary pumps		PRAA0
	Centrifugal pumps		PCAA0
	Rotary pumps		PRTA0

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Equipment	Additional Features	Additional Note	Code
Pump and driver configuration: — Steam turbine-driven main pump — AC motor-driven auxiliary pump	Centrifugal pumps		PCTA0
Pump and driver configuration: — AC motor-driven main pump — AC motor-driven auxiliary pump — AC motor-driven emergency oil pump	Rotary pumps		PRAAA
	Centrifugal pumps		PCAAA
Pump and driver configuration: — Steam turbine-driven main pump — AC motor-driven auxiliary pump — AC motor-driven emergency oil pump	Rotary pumps		PRTAA
	Centrifugal pumps		PCTAA
Pump and driver configuration: — AC motor-driven main pump — AC motor-driven auxiliary pump — DC motor-driven emergency oil pump	Rotary pumps		PRAAD
	Centrifugal pumps		PCAAD
Pump and driver configuration: — Steam turbine-driven main pump — AC motor-driven auxiliary pump — DC motor-driven emergency oil pump	Rotary pumps		PRTAD
	Centrifugal pumps		PCTAD

Table 1—Oil System Standard Configuration Options (*continued*)

Equipment	Additional Features	Additional Note	Code
Reservoir part of equipment		e.g. gear case or reciprocating compressor crank case	R0
External reservoir		Includes standalone reservoirs and those that are either installed or integrated into the driven equipment baseplate	R1
No reservoir heater included			H0
Reservoir heater, electric			HE
Reservoir heater, steam			HS
Components mounted on main equipment baseplate			BP0
Stand-alone console, reservoir mounted components		No separate baseplate; applies to consoles that are installed in (drop in type) or integrated in the main equipment baseplate, typically used for an offshore application.	BP1
Stand-alone console with full baseplate			BP2
Shell-and-tube heat exchanger, single			CS1
Shell-and-tube heat exchanger, duplex			CS2
Plate-and-frame heat exchanger, single			CP1

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Plate-and-frame heat exchanger, duplex			CP2
Air-cooled heat exchanger, single fan			CA1
Air-cooled heat exchanger, 2 x 100 % fans			CA2
Air-cooled heat exchanger, 3 x 50 % fans			CA3
Filter, single			F1
Filter, duplex			F2
Filter, duplex (normal) and filter, single (emergency)			F3
No accumulator			A0
Accumulator, lube oil only			AL
Accumulator, control oil only			AC
Accumulator, lube and control oil separate			ALC
Combined PLV/PCV		If air-cooled heat exchangers are used, or oil pressure is not above water cooling pressure; not applicable to centrifugal pumps.	PV0
Separate PCV – (backpressure regulator / control valve)	w/o block-and-bypass	If air-cooled heat exchangers are used or oil pressure is not above water cooling pressure; not applicable to centrifugal pumps.	PV1
	w block-and-bypass		PV1B
Lube-oil PCV downstream of filter (separate pressure-reducing valve)	w/o block-and-bypass	Allows oil pressure to be above cooling water pressures, if other measures (i.e., orifices at bearing housings) are not employed.	PV2
	w block-and-bypass		PV2B

Table 1—Oil System Standard Configuration Options *(continued)*

Equipment	Additional Features	Additional Note	Code
No thermostatic valve/temperature control valve			TV0
Thermostatic valve	w/o block-and-bypass		TV1
	w block-and-bypass		TV1B
Temperature control valve, two-way, pneumatic operated	w/o block-and-bypass		TV2
	w block-and-bypass		TV2B
Temperature control valve, three-way, pneumatic operated	w/o block-and-bypass		TV3
	w block-and-bypass		TV3B
No lube-oil rundown (overhead) tank			OT0

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Lube-oil rundown (overhead) tank, atmospheric			OTA
Lube-oil rundown (overhead) tank, pressurized			OTP

EXAMPLE System designation: LO-PCAA0-R1-HE-BP2-CS2-F2-A0-PV1-TV3B-OT0.

LO	lube-oil system only;
PCAA0	AC motor-driven main pump (centrifugal) and AC motor-driven auxiliary pump (centrifugal);
R1	external reservoir;
HE	reservoir heater, electric;
BP2	stand-alone console, with full baseplate;
CS2	shell-and-tube heat exchanger, duplex;
F2	filter, duplex;
A0	no accumulator;
PV1	separate PCV (w/o block-and-bypass);
TV3B	temperature control valve, three-way, pneumatic operated (with block-and-bypass);
OT0	no lube-oil overhead (rundown) tank.

NOTE A table that allows quick selection of a system designation code, using pull-down menus, is included with the electronic version of Annex A, sections A.2 and A.3.

4.8 • The purchaser and the vendor shall agree upon an acceptable system before the order is released.

5 General Requirements

5.1 Unit Responsibility

The vendor shall assume unit responsibility for all equipment and all auxiliary systems included in the scope of the order placed on the vendor or sub-vendors.

5.2 Dimensions and Units

5.2.1 Drawings, documentation and maintenance dimensions, units of measurement for instrumentation shall be in the International System of Units (SI) or United States customary (USC) units.

5.2.2 Use of an SI data sheet indicates that SI units shall be used.

5.2.3 Use of an USC data sheet indicates that USC units shall be used.

NOTE Dedicated data sheets for SI units and for USC units are provided in Annex A, section A.2 and A.3.

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5.3 Statutory Requirements

5.3.1 The purchaser and the vendor shall determine the measures to be taken to comply with any governmental codes, regulations, ordinances, directives, or rules that are applicable to the equipment, its packaging, and any preservatives used.

5.3.2 Equipment installed in the European Economic Area shall comply with all applicable European Union directives.

5.4 Document Hierarchy

5.4.1 The hierarchy of documents shall be specified in the purchase order.

N

5.4.2 Requirements of this standard apply in the following order of precedence:

- 1) API 614 data sheet;
- 2) other oil system data sheet;
- 3) configuration code for the specified driven equipment;
- 4) purchaser's specification;
- 5) this standard.

6 Design

6.1 System Design

6.1.1 The term "design" shall apply solely to parameters or features of the equipment supplied by the manufacturer. The term "design" should not be used in the purchaser's inquiry or specifications because it can create confusion in understanding the order.

EXAMPLES Design power, design pressure, design temperature, design speed.

6.1.2 ● The purchaser shall specify the period of uninterrupted continuous operation.

6.1.2.1 Shutting down the equipment to perform required maintenance or inspection during the specified uninterrupted operation period is not acceptable.

6.1.3 ● Only equipment that is field proven, as defined by the purchaser, is acceptable.

NOTE Purchasers can use their engineering judgment in determining what equipment is field proven. API RP 691 can provide guidance.

6.1.3.1 ● If specified, the vendor shall provide the documentation to demonstrate that all equipment and auxiliaries proposed qualify as field proven.

6.1.3.2 In the event no such equipment is available, the vendor shall submit an explanation of how their proposed equipment can be considered field proven.

NOTE A possible method of qualifying can be that all components comprising the assembled machine satisfy the field-proven definition.

6.1.4 Vendor shall advise in the proposal any component designed for finite life.

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NOTE Annex K is available as a guide for system reliability goals.

6.1.5 Equipment shall be designed for installation in accordance with API 686.

6.1.6 • The equipment, including all auxiliaries, shall be suitable for operation under the environmental conditions specified. These conditions shall include whether the installation is indoors (heated or unheated) or outdoors (with or without a roof), maximum and minimum temperatures, humidity, and dusty or corrosive conditions.

6.1.7 All pressurized equipment and components including piping, piping components, pressure vessels, valves, pumps, instruments, and other components shall have pressure-temperature ratings no less than the maximum allowable working pressure (MAWP)-temperature rating of the system circuit of which they are a part.

NOTE Oil systems consist of different sections that operate at different pressures. For example, booster or control-oil systems can have higher pressure ratings, whereas oil reservoir can have a lower pressure rating.

6.1.7.1 Positive displacement pump discharge circuits shall be rated to at least the associated PLV set point value.

6.1.7.2 Centrifugal pump discharge circuits shall be rated to at least the maximum pump discharge pressure corresponding to the pump discharge pressure at shutoff (zero flow). For centrifugal pumps with variable speed drivers, the maximum pressure at shutoff shall be determined from the maximum speed condition possible. For steam turbine-driven centrifugal pumps, this corresponds to the steam turbine over speed trip setting.

6.1.7.3 Cooling water circuits shall be rated to the cooling water supply system MAWP.

6.1.7.4 Compressible fluid circuits (steam, air, nitrogen, utility and process gas) shall be rated to at least the associated relief valve set point values.

NOTE For utility or process gas exposed circuits, the relief valves are generally located in the utility or process systems outside of the main equipment scope.

6.1.8 The equipment, including all auxiliaries, shall be suitable for operation using the utility stream conditions specified.

NOTE The Site and Utility Data Sheet is shown in Annex A.1.

6.1.9 Any maintenance item with a mass more than 25 kg (50 lb) shall be provided with lifting devices or similar dedicated fixed lifting point(s).

6.1.10 Threaded holes for removed lifting devices (such as eyebolts, hoist rings,) shall be permanently marked with the correct bolt size to be used. If this marking is impractical, bolt size information shall be clearly indicated in the instruction manual.

6.1.11 Spare and replacement parts shall meet all the criteria of the furnished system.

6.1.12 • Control of the sound pressure level of all equipment furnished shall be a joint effort of the purchaser and the vendor having responsibility.

6.1.12.1 • The equipment furnished by the vendor shall conform to the maximum allowable sound pressure level specified.

6.1.12.2 In order to determine compliance, the vendor shall provide both maximum sound pressure and sound power level data per octave band for the equipment.

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6.1.13 • Purchaser shall specify any special provisions for insulation or heat tracing.

6.1.14 Nameplates

6.1.14.1 A nameplate shall be securely attached to the panel or skid at a readily visible location on the equipment and on any major piece of auxiliary equipment.

6.1.14.2 Nameplates shall be of austenitic stainless steel. Attachment pins shall be of the same material. Welding to attach the nameplate to the panel or skid is not permitted.

6.1.14.3 The following data shall be clearly stamped or engraved on the nameplate:

- a) vendor's name,
- b) serial number,
- c) date of manufacture,
- d) MAWP(s) and allowable temperature(s),
- e) purchaser item number or other reference,
- f) test pressure(s),
- g) weight.

6.2 System Selection

6.2.1 The purchaser shall define the scope of supply, level of quality, brand of components, site plan and elevations of the console orientation, space available for the console, and other requirements. Annex A is intended to assist in this definition.

NOTE Typical data sheets for oil systems are in Annex A, sections A.2 and A.3. Typical piping and instrument diagrams for oil systems are in Annex C. Typical inspector checklists for oil systems are in Annex I.

6.2.2 If components are spared, the design shall allow for maintenance clearances and dismantling clearances as well as transfer between and shutdown of the main or standby, redundant components of the system for maintenance without interrupting the operation of the system or the equipment the system serves.

6.2.3 Each equipment train shall be supplied with a dedicated oil system.

NOTE If equipment trains share a common oil system, damage due to cross-contamination potentially affects all equipment served. Block valves in supply lines for maintenance reasons have the potential to be accidentally closed.

6.2.4 Unless otherwise specified, all machines in the equipment train (such as a compressor, a gear, and a motor) shall be served by the common oil system.

NOTE 1 Gas turbines sometimes require separate, dedicated lubrication systems.

NOTE 2 Some electric drivers do not require forced feed lubrication.

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6.2.5 The oil system supplied shall be capable of supplying specified quantities of clean, filtered oil at the specified temperature and pressure for start-up and all operating conditions of the serviced rotating equipment.

6.2.6 Seal-oil systems shall be designed to serve the full range of equipment operating conditions specified. These conditions may include, but are not limited to, the following:

- a) settling-out pressures;
- b) process relief-valve settings;
- c) shop test and field run-ins;
- d) process start-up or any other idling condition specified, with the system in total automatic control and with the shaft end seal at atmospheric pressure;
- e) account for interconnecting piping distances and elevation differences between the location of the oil system and served equipment.

6.2.7 ● The supplier with unit responsibility shall specify the equipment's normal operating point and alternate operating points, including transients.

6.2.8 ● The purchaser shall specify whether the seal-oil and lube-oil systems are to be separate or combined.

6.2.9 ● Where oil is supplied from a common system to two or more machines (such as a compressor, a gear, and a motor), the oil's characteristics shall be specified by the supplier with unit responsibility on the basis of agreement with all vendors supplying equipment served by the common oil system.

NOTE Site conditions with extreme variations, such as desert or arctic applications, can also require special oil grade viscosity and increased oil supply temperatures.

6.2.10 Materials and component selection of elastomers, including O-rings, bladders, actuator diaphragms, and internal coatings, shall be compatible with the specified oil(s).

6.2.11 Recirculated bypass oil shall originate upstream of the filters to minimize the potential for generation of static electricity (or a static charge) that can result when filtered oil bypasses the equipment and is recycled directly to the reservoir.

6.2.12 The arrangement of the equipment, including piping and auxiliaries, shall be developed jointly by the purchaser and the vendor.

6.2.13 The arrangement shall provide adequate clearance areas and safe access for operation and maintenance.

6.2.14 ● The purchaser shall provide minimum requirements for clearance around and access to components (especially clearance around and access to heat exchangers, filters, and hand valves).

6.2.15 The radius reach for operations access to components shall be less than or equal to 510 mm (20 in.).

6.2.16 Pumps, filters, strainers, heat exchangers, traps, valves, and all other components that retain oil under pressure and are external to the reservoir shall be made of steel.

NOTE Iron materials are susceptible to failure upon rapid quench cooling during a fire and may not be repairable.

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6.2.17 • All austenitic stainless steel materials of the oil system shall be 316 grade.

NOTE Some applications, such as coastal or offshore installations, benefit from the improved corrosion resistance of 316 over 304 stainless steel.

6.2.18 Valved vents, drains, and piping shall be furnished to permit draining, cleaning, and refilling of idle components while the equipment is in operation.

6.2.19 The design shall provide for fill and drain passages and connections that are sized and oriented such that servicing can be performed without spilling and does not require special equipment.

6.2.20 • Purchaser shall specify the isolation and maintenance philosophy including the use and location of double block and bleed, car-sealed, or other valves for isolating a component and how they are arranged.

NOTE Double block valves are normally provided where there is safety or environmental issues associated with the reliability of a single block valve.

6.2.21 The console shall perform on the test stand and on its permanent foundation within the specified acceptance criteria, per 9.3.

6.2.22 After installation, the performance of the oil system, including piping, console, and associated auxiliaries, shall be the joint responsibility of the purchaser and the vendor who has unit responsibility for the equipment train served.

NOTE Certain auxiliaries, such as overhead seal-oil tanks, rundown tanks, or interconnecting piping might not be installed on test.

6.2.23 • The vendor shall advise the purchaser of, and both parties shall agree upon, any special provisions that are necessary to ensure that an adequate supply of backup lube or seal oil or both is maintained in the event of complete failure of the primary lube- or seal-oil supply system. These provisions may include emergency pumps, accumulators, rundown tanks, and special arrangements for equipment safety and protection when the equipment decelerates.

6.2.23.1 Provisions shall be adequate for coast-down time, cool-off time, and block-in time, as applicable.

6.2.23.2 The purchaser shall specify any required block-in time.

6.2.24 Block valves that interrupt the oil flow to the equipment shall not be installed in oil supply lines downstream of the filters unless the block valves are part of a component block and bypass arrangement.

6.2.25 If components that can require later removal for maintenance are installed using screwed connections, the connecting piping shall be provided with flanges such that the component can be removed without requiring cutting pipe or major disassembly of the unit.

6.2.26 • A dynamic simulation shall be performed for the oil system.

6.2.26.1 The purchaser shall define the scope of the study and any verification testing requirements.

6.2.26.2 The scope of the simulation shall at a minimum include operating modes and transient conditions, such as pump change over, valve transfer, filter transfer, hydraulic governor transient, start-up, shutdown, and settle out.

6.3 Pressure Design Code

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6.3.1 ● The pressure vessel design shall be in accordance with Section VIII of ASME *Boiler and Pressure Vessel Code (BPVC)* or other purchaser-specified pressure design code.

6.3.2 Pressure components shall comply with the pressure design code and any specified supplementary requirements.

NOTE CEN/TR 14549 provides additional guidance on meeting European Pressure Equipment Directive 2014/68/EU (PED) for locations where European directives might be applicable.

6.3.3 ● Vessels shall be code stamped as indicated on the data sheet.

NOTE 1 Code stamping might not be applicable for pressure design codes other than ASME, but some local jurisdictions require a code stamp for reduced volume components, such as seal-oil drain traps, heat exchangers, or filters, that would not otherwise be covered.

NOTE 3 Code stamping could result in additional inspection because of code requirements.

6.3.4 ● The piping design shall be in accordance with ASME B31.3 or other purchaser-specified piping design code.

6.3.5 ● Piping shall comply with the piping design code and any specified supplementary requirements.

6.4 Welding

6.4.1 Welding and inspection of piping and pressure-containing parts, as well as any dissimilar-metal welds and weld repairs, shall be performed and inspected per procedures qualified in accordance with the pressure design code specified in 6.3 or the piping system design code as specified in 6.3.4.

6.4.2 ● In addition to the requirements of 6.4 and the applicable piping code, the purchaser may specify that additional radiography, magnetic particle inspection, or liquid penetrant inspection of specific welds on equipment and/or piping is required.

NOTE 1 ASME B31.3 and ISO 15649 already include a level of nondestructive testing (NDT) inspection for piping.

NOTE 2 Pipe used on hazardous service (e.g. process fluids high-pressure duties) might warrant additional inspection activities.

6.4.3 All welding other than that covered by the pressure design code or the piping systems design code such as welding on baseplates, non-pressure ducting, lagging and control panels shall be in accordance with structural welding standards such as AWS D1.1/D1.1M, unless otherwise specified.

6.5 Baseplates

6.5.1 Where the major components (pumps, filters, heat exchangers, and reservoir) are mounted on, or within, a baseplate, they shall be directly supported by full-depth structural steel cross-members.

NOTE 1 Decking is not sufficiently rigid to support major components.

NOTE 2 Auxiliary systems are sometimes integrated into the main equipment baseplate(s).

6.5.2 ● ♦ If specified, the oil system shall be designed as a single fabricated steel console with all system components and related valves and manifolds mounted on a common baseplate.

NOTE A single fabricated steel console with all system components and related valves and manifolds mounted on the baseplate refers to the practice of locating all oil system components together on one common baseplate. This is

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opposed to having some components mounted remotely, such as having, for example, separate pump skids, separate heat exchanger skids, or separate valve skids.

6.5.2.1 Baseplate may be fabricated in multiple sections if agreed by the purchaser and the vendor. Multiple-section baseplates shall have machined and doweled mating surfaces that shall be bolted together to ensure accurate field reassembly.

6.5.2.2 All joints, including deck plate to structural members, shall be continuously seal-welded on both sides to prevent crevice corrosion. Stitch welding, top or bottom, is unacceptable.

NOTE The intent is to avoid leaving crevices that could lead to corrosion, rather than to describe the manufacturing process.

6.5.3 Console baseplates shall extend under all mounted components to contain and drain any leakage.

6.5.3.1 Console baseplates, mounted components, and decking shall be arranged and installed to ensure complete drainage of liquids.

6.5.3.2 Single-piece package console baseplates shall have a sloped gutter type drain around the circumference of the base deck.

6.5.3.3 One or more tapped drain connections at least DN 50 (NPS 2) shall be located to affect complete drainage.

NOTE NPS 2 drain connections are sometimes impractical for smaller system baseplates.

6.5.4 ● If specified, nonskid metal decking covering all walk and work areas shall be provided on the top of the baseplate.

NOTE 1 Nonskid surfaces can be obtained by nonskid coatings, diamond plate, or grating over the metal decking.

NOTE 2 Decking might not be required if the grout pour is used to create a walking surface.

6.5.5 ● If specified, decking shall be sloped.

NOTE Minor puddling of fluid can occur with flat decking.

6.5.6 The console baseplate shall be provided with lifting attachments for at least a four-point lift.

6.5.6.1 Lifting attachments on the console baseplate or equipment shall be designed using a maximum allowable dynamic stress of one-third of the specified minimum yield strength of the material.

6.5.6.2 The console baseplate shall be designed so that after the reservoir, components and all piping mounted on it are drained of oil, the package can be lifted without disassembling, permanently distorting or otherwise damaging either the baseplate or any component mounted on it.

NOTE 1 Spreader bars can be required for large baseplates.

NOTE 2 equipment with integrated reservoirs can be designed for shipment with oil in the reservoir.

6.5.6.3 ● The lifting lugs or trunnions that are attached by welding shall be 100 % NDE tested in accordance with the applicable code as specified in 9.2.1.5.

6.5.6.3.1 Lifting lugs shall be designed in accordance with standards, such as ASME BTH-1 or AISC 325.

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6.5.6.3.2 Lifting lug design calculations shall be provided for owner's review.

6.5.6.4 console baseplates shall be designed for lifting with all equipment mounted.

NOTE In some cases, it can be more practical to design the baseplate to remove heavy equipment prior to lifting.

6.5.6.5 Removable lugs or commercially available specialty products such as pivot type hoisting rings may be provided only with purchaser approval.

6.5.6.6 ● commercially available lifting attachments shall be furnished with material and load test certifications traceable to an internationally recognized standard and attested by an independently accredited third-party agency or organization.

6.5.7 ● If specified, all console baseplates shall be provided with at least one opening or hole in each bulkhead section through which grout can be poured and vented, per requirements of 6.5.7.1 through 6.5.7.6.

6.5.7.1 Each opening shall have a clear area of no less than 125 cm² (20 in.²) and no dimension less than 75 mm (3 in.).

6.5.7.2 Each opening shall permit filling and venting of the entire cavity with grout under the console baseplate without creating air pockets.

6.5.7.3 Each hole into which the grout is poured shall be accessible: no component or piping shall be required to be removed and no tripping hazards in walk and work areas shall be created.

6.5.7.4 Vent holes at least 13 mm (1/2 in.) in diameter shall be provided at the highest point and located to vent the entire cavity for each bulkhead compartment.

6.5.7.5 Each grout hole shall also be provided with steel raised-lip edge (curbing) 13 mm (1/2 in.) high to prevent accumulated oil or water from entering the grout, and if located in an area where liquids could impinge on the exposed grout, metallic covers with a minimum thickness of 3 mm (1/8 in.) shall be provided.

NOTE The 13 mm (1/2 in.) curb or raised-lip edge required for grout holes is not considered a tripping hazard.

6.5.7.6 Vent holes shall be provided without raised-lip edge.

6.5.8 ● If epoxy grout is specified, the vendor shall precoat all the grouting surfaces of the mounting plates with a catalyzed epoxy primer applied to degreased white metal.

6.5.8.1 The epoxy primer shall be compatible with epoxy grout.

6.5.8.2 The vendor shall submit instructions for field preparation of the epoxy primer to the purchaser.

6.5.9 The bottom of the baseplate between structural members shall be open.

6.5.10 If the baseplate is installed on a concrete foundation, accessibility for grouting under all load-carrying structural members shall be provided.

6.5.11 The underside mounting surfaces of the baseplate shall be in one plane to permit use of a single-level foundation.

6.5.12 If multi-section baseplates are provided, the mounting pads shall be in one plane after the baseplate sections are doweled and bolted together.

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6.5.13 ● If specified, the console baseplate shall be designed for column mounting (i.e. of sufficient rigidity to be supported at specified points) without continuous grouting under structural members.

6.5.14 Leveling screws shall be provided in the proximity of each hold-down bolt.

6.5.15 ● ♦ Leveling measurement locations shall be labeled and numbered on a drawing to ensure consistency in leveling from the vendor shop during fabrication to setting and leveling in the field. The vendor shall provide a chart or diagram with the location numbers and level measurement readings recorded at each location in the shop during fabrication.

6.6 Oil Reservoirs

6.6.1 General

6.6.1.1 Reservoirs shall be rigid enough to prevent sagging and vibration.

6.6.1.2 Components bolted to the reservoir shall be mounted on pads; no bolt holes shall extend into the reservoir.

6.6.1.3 If reinforcing ribs are required, they shall be installed externally or designed to eliminate the possibility of deposit accumulation if installed internally.

NOTE 1 Some equipment types can have integral oil reservoirs within the crankcase or casing.

NOTE 2 For special features, see 6.6.13.

6.6.1.4 ● If specified, the reservoir shall be supplied to conform with the over pressurization rating resulting from process shaft seal or nitrogen purge pressurization control failure, as indicated on the data sheet.

6.6.1.5 ● If specified, the reservoir shall be supplied to conform with the negative pressure rating resulting from use of an extraction type oil mist eliminator, as indicated on the data sheet. See 6.6.5.7 and 6.6.5.8.

6.6.1.6 Reservoirs shall be sealed to prevent dirt and water from entering.

6.6.1.7 Top-surface openings shall be raised at least 25 mm (1 in.).

6.6.1.8 Top-surface openings shall have a gasket.

6.6.1.9 ● ♦ If specified, pumps, heat exchangers, or filters shall not be mounted on top of the reservoir.

NOTE This can be impractical for offshore or other installations where available space is limited.

6.6.1.10 The reservoir top shall be provided with a drain rim or gutter and one or more drain connections if:

- a) pumps, heat exchangers, or filters are mounted on top of the reservoir, and
- b) the reservoir is not installed on a base plate with gutter.

NOTE For installations on an existing equipment base, a drain rim or gutter on the reservoir might not be required.

6.6.1.11 ● ♦ The tops of reservoirs shall slope at least 10 mm/m ($\frac{1}{8}$ in./ft).

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NOTE It might not be possible to implement this requirement for reservoirs integrated with the main equipment baseplate.

6.6.2 Oil Connections and Internal Piping

6.6.2.1 All return oil flow connections and baffles shall be located such that the return oil streams do not disturb the oil flow at pump inlets, and maximize residence time from oil return to pump suction.

NOTE This can be accomplished by a combination of distance, internal piping, or baffling.

6.6.2.2 All atmospheric oil return connections (including fill connections) shall be located above the maximum operating level and shall transport oil (via open-top stilling tubes or degassing trays) as shown in Figure C.23.

6.6.2.3 Stilling tubes shall have bottom baffles.

6.6.2.4 Control back-pressure valve, PLV/PSV, relief valve, and return stream control valve connections shall be separate and shall discharge oil via internal piping below the pump suction-loss level as shown in Figure C.23.

NOTE 1 Combining pressurized oil returns is not desired because one return oil stream might create backpressure or influence another oil return stream.

NOTE 2 If crank or gear cases are used as reservoirs, individual returns are sometimes impossible.

6.6.2.5 Pressurized oil shall not be returned to vented stilling tubes or degassing trays.

6.6.2.6 Internal return piping shall have bottom baffles.

6.6.2.7 Pump suction connections shall be located with at least 50 mm (2 in.) clearance from the reservoir bottom or sides.

6.6.2.8 If the reservoir has a sloped bottom, pump suction connections shall be near the high end.

6.6.2.9 Reservoir pipe connections 40 mm (1 1/2 in.) and larger shall be flanged.

6.6.2.10 ● ♦ If specified, all reservoir pipe connections shall be flanged.

6.6.3 Manways and Drains

6.6.3.1 ● ♦ If specified, the bottom of each reservoir shall be sloped continuously, at least 20 mm/m (1/4 in./ft) to a low-point drain.

6.6.3.2 Reservoirs shall be furnished with a valved low-point drain connection that is either blind-flanged or plugged.

6.6.3.3 ● ♦ If specified, a flanged drain connection (with a valve and a blind flange) at least 50 mm (2 in.) in diameter shall be provided.

6.6.3.4 Reservoirs shall be provided with unobstructed access for direct interior visual inspection and cleaning.

6.6.3.4.1 Manways, if required for this purpose, shall be at least 600 mm × 600 mm (24 in. × 24 in.), or minimum 600 mm (24 in.) in diameter.

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6.6.3.4.2 If personnel entry is not required for inspection or cleaning, a minimum 150 mm × 150 mm (6 in. × 6 in.) or minimum 150 mm (6 in.) in diameter, port or ports shall be provided. Internal manways are not acceptable.

6.6.3.5 For some applications, such as offshore installations that are subject to pitch and roll requirements, or those built-in oil systems with limited access, internal manways may be used with purchaser approval.

6.6.4 Features

6.6.4.1 The reservoir shall have the design and capacity for rundown of the entire system.

6.6.4.2 The reservoir shall be designed to settle moisture and foreign matter.

NOTE See 6.6.2.1, 6.6.7, and Figure C.23 for reservoir design features.

6.6.4.3 The reservoir shall have provision to eliminate air and minimize migration of foreign matter to each pump suction.

6.6.4.4 The reservoir shall have a level indicator such as a dipstick, level gauge, or bulls-eye(s) that spans or is located to indicate the minimum to maximum operating range.

6.6.4.5.1 ● ♦ If specified, a reflex-type, welding-pad oil level glass (with stainless steel weld pad and carbon steel cover) shall be arranged to cover the span from at least 25 mm (1 in.) above the rundown level to 50 mm (2 in.) below the pump suction-loss level.

6.6.4.5.1.1 The oil level glass shall be located as far away as possible from the oil return lines and be visible from the perimeter of the unit.

6.6.4.5.1.2 The maximum and minimum operating levels, rundown level, and suction-loss level shall be indicated on the level glass.

6.6.4.5.1.3 If more than one level glass instrument is provided, they shall be offset to provide visual continuity.

6.6.4.5.2 ● If specified, additional means of level indication shall be supplied, such as magnetic type level indicator with stainless steel float chamber.

6.6.4.5.2.1 The oil level indicator shall be arranged to cover the span from at least 25 mm (1 in.) above the rundown level to 50 mm (2 in.) below the pump suction-loss level.

6.6.4.5.2.2 The oil level indicator shall be located as far away as possible from the oil return lines. Unless otherwise specified, the indicator shall be visible from the perimeter of the unit.

6.6.4.5.2.3 The maximum and minimum operating levels, rundown level, and suction-loss level shall be indicated.

6.6.4.5.2.4 An internal-type float shall be protected by a static-conducting shield.

6.6.4.6 For atmospheric lube-oil reservoirs, a weatherproof, corrosion-resistant filter-breather cap, sized to take account of the flow rate of entrained air, separation gas, coupling windage, and/or purge gas, shall be provided.

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6.6.4.6.1 This vent shall be at least 50 mm (2 in.) in diameter with filtration rating of 10 µm beta 10 or better. (For reservoirs containing seal oil, see 6.6.4.10.)

6.6.4.6.2 If oil mist capture is desired, a mist eliminator system should be considered. See 6.6.5.

NOTE 1 The filter-breather cap connection is separate from the flanged vent connection.

NOTE 2 A filter breather cap with a filtration rating of 10 µm beta 10 will not capture oil mist.

6.6.4.7 ● ♦ If specified, a fill opening, at least 50 mm (2 in.) in diameter, shall be fitted with a spring loaded cap that automatically closes.

NOTE 1 Some user's pipe up fill connections using the connections provided in 6.6.10, which would mean the manual fill described above may not be necessary.

NOTE 2 Readily available spring-loaded fill caps are typically plated aluminum material, which are not suitable for some environments.

6.6.4.8 ● ♦ If specified, the fill opening shall be equipped with a stainless steel 20 mesh or finer mesh strainer basket that has an open area equal to 200 % of the internal pipe area.

6.6.4.9 ● ♦ If specified, a blind-flanged vent connection at least 50 mm (2 in.) in diameter shall be provided on the reservoir.

6.6.4.10 The reservoir design shall include internal baffles that do not trap gas; baffle vent area shall be at least equal in size to the main reservoir vent area.

6.6.4.11 If the driver of the train is lubricated by the same system as the driven equipment, and the oil reservoir contains seal oil, a separate connection shall be provided on the reservoir for the seal-oil return line.

NOTE 1 This line prevents pressurization of the driver's lube-oil drain header if the seals fail.

NOTE 2 If this option is incorporated, it requires separate bearing and seal-oil drains.

6.6.4.12 On reservoirs containing seal oil, a flanged vent sized to handle the total flow of gas coming from the failed seal(s) through the oil drain lines shall be furnished. In lieu of an oversized vent connection, an overpressure protection device may also be provided.

6.6.4.13 Rupture disks shall not be used for over pressure protection of seal-oil reservoirs or oil reservoirs in combined lube- and seal-oil systems with or without control-oil.

6.6.4.14 The supplier with unit responsibility shall provide the purchaser with the vent size and the sizing criteria.

6.6.4.15 For seal-oil systems without overhead seal-oil tanks, the gas reference shall be connected to a direct-acting differential PCV. See Figure C.6 or Figure C.8.

6.6.4.16 ● The overhead seal-oil tank, when provided, shall be connected either upstream or downstream of the seals, as specified. See Figure C.4 or Figure C.5, respectively.

6.6.5 Extraction and Static Oil Mist Eliminator Systems

6.6.5.1 ● An extraction or static oil mist eliminator(s) shall be provided in place of the breather_cap and shall meet the requirements of 6.6.5.2 to 6.6.5.17. See Figure C.30.

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NOTE 2 Extraction can be accomplished by the use of fans, eductors, or other means.

NOTE 3 Some environments such as those that contain corrosive gases, particulates, dust, or excessive humidity preclude the use of an oil mist eliminator system or breather caps.

NOTE 4 Breather caps on equipment bearing housings and/or gearbox housings and coupling guards can help promote oil mist flow toward the extraction demister, whereas improper location or improper sizing of breather caps can impede oil mist eliminator system performance.

6.6.5.2 The supplier with unit responsibility shall design the vent mist eliminator systems, taking into account:

- a) air/oil mist mixture flow rates through the vent mist eliminator(s), separation gas leakage into equipment bearing housings, added volume of any nitrogen purge of the reservoir, coupling guard and gearbox windages;
- b) pressure drops on the interconnecting pipework both to and from the vent mist eliminator(s), including the discharge piping when oil mist eliminator vent is routed to outside of the building in which the lube-oil system is installed;
- c) fan capacity at the required differential pressure (for fan-assisted devices);
- d) temperature of the air/oil mist mixture under all operating conditions;
- e) drainage of the coalesced oil back to the reservoir;
- f) the location of all equipment breathers (such as gearbox housing, coupling guard) and their associated pressure drops;
- g) vent capacity of oil mist separator, in conjunction with any other reservoir relief devices, shall be sufficient to handle total failure of all shaft seals.

NOTE API 692 provides guidelines for conducting seal failure vent studies.

6.6.5.3 Extraction type oil mist eliminators shall be connected to the lube-oil reservoir. Static-type oil mist eliminators can be connected to reservoir vent, bearings, gearbox casings, or other devices (see 6.6.4.4 for breather cap description).

6.6.5.4 Outlet from the extraction or static oil mist eliminator(s) to atmospheric vent point shall be clear of visible oil mist and meet the specified local emission regulations.

6.6.5.5 Extraction type oil mist eliminators shall be provided with element differential pressure monitoring instrumentation.

6.6.5.6 If an extraction type oil mist eliminator is provided, oil reservoir pressure or drain header pressure monitoring instrumentation shall be provided.

6.6.5.7 A method of controlling the vacuum level on extraction type oil mist eliminators, such as variable speed fans, bypass valves, or air ingress/loading valves shall be provided.

NOTE 1 Typical vacuum in reservoir is 5 to 10 mbar (2 to 4 in. WC).

NOTE 2 Some driven equipment original equipment manufacturers specify the vacuum level at the driven equipment bearing housing, rather than at the oil reservoir.

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6.6.5.8 ● A vacuum relief device shall be provided for extraction oil vent mist eliminators.

6.6.5.9 Oil mist eliminators shall be provided with automatic drainage provisions and all pipework shall be sloped [40 mm/m minimum ($1\frac{1}{2}$ in./ft)] to ensure drainage of the coalesced or condensed oil.

6.6.5.9.1 The oil mist eliminator shall have a separate dedicated drain line that extends below the reservoir oil level.

6.6.5.9.2 If a multi-stage vent mist eliminator is used, each drain shall be run separately.

6.6.5.9.3 Drains shall have non-vented stilling tubes or liquid traps to prevent oil mist bypass around vent mist eliminator element(s).

NOTE Extraction type mist eliminators are typically mounted on a vertical vent pipe above the oil reservoir, although maintenance accessibility can sometimes require mounting in a remote location.

6.6.5.10 The mist eliminator discharge pipe shall be designed to ensure that any condensates or precipitation do not run back into the vent mist eliminator.

NOTE Solutions for preventing condensate from returning to the mist eliminator include traps, sloped piping, or heat tracing.

6.6.5.11 Filter cartridge efficiency shall be $> 99.97\%$ for droplet size $0.3\ \mu\text{m}$.

NOTE 99.97% for droplet size $0.3\ \mu\text{m}$ eliminates visible oil mist "smoke." Local regulations can require more stringent levels. Oil smoke is a common term used by demister manufacturers and refers to oil fog, mist or smoke, rather than smoke from combustion.

6.6.5.12 To avoid oil being drawn into the mist eliminator through the oil drain return line, Oil mist eliminators shall be arranged at a minimum elevation above reservoir rundown oil level that ensures drainage of oil via return line from the mist eliminator casing at maximum element differential pressure.

EXAMPLE With a maximum vacuum of the mist eliminator of 130 mbar (52 in. WC), and an oil specific gravity of 0.85, a minimum height of 1.6 m. (61 in.) is required.

NOTE Incorrect design can lead to oil being drawn into the mist eliminator through the drain return line.

6.6.5.13 ● Oil mist eliminator arrangements shall be fitted with suitable isolation and bypass valves to enable maintenance while in operation.

6.6.5.14 ● A 100 % capacity standby extraction oil mist eliminator system with online transfer capability shall be supplied.

NOTE When multiple oil mist eliminators are specified, the check valve shown in Figure C.30 pressure drop (cracking pressure) affect blower sizing and selection.

6.6.5.15 ● Other oil mist eliminator system arrangements, such as three 50 % capacity systems, shall be supplied.

6.6.5.16 Elastomeric elements shall be compatible with the specified oil(s) and return temperature.

6.6.5.17 Mist eliminator components that can return oil to the reservoir, such as the element housing, shall be constructed from austenitic stainless steel, with flanged inlet and outlet connections (small drain connections may be routed in tubing). The element may be nonmetallic.

6.6.6 Flame Arrestors

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6.6.6.1 • Flame arrestor(s) shall be provided.

6.6.6.2 • If flame arrestor(s) are specified, the purchaser shall identify specific points requiring vent flame arrestors, which can include vents on oil reservoirs, lube-oil rundown tanks, bearing housings, gear box housings, coupling guards, oil drain lines, or common vents from a manifolded vent system..

6.6.6.3 • The purchaser shall specify any applicable flame arrestor standards, regulations, or project-specific requirements.

6.6.7 Capacity and Configurations

6.6.7.1 The criteria for sizing a reservoir are given in 6.6.7.2 through 6.6.7.12.

NOTE All level references refer to Annex G.

6.6.7.2 The working capacity shall be sufficient for at least 3 minutes of normal flow between minimum operating level, G.3, and suction loss level, G.4.

6.6.7.3 The minimum retention capacity shall be calculated based on 5 minutes of normal oil flow.

6.6.7.4 • ♦ If specified, the working capacity between minimum operating level, G.3, and suction loss level, G.4, shall be sufficient for at least 5 minutes of normal flow.

6.6.7.5 • ♦ If specified, the minimum retention capacity shall be calculated based on 8 minutes of normal oil flow.

6.6.7.6 To prevent backup of oil in the drain lines entering the reservoir, The rundown capacity shall allow for all of the oil contained in all of the components that drain back to the reservoir. This can include components such as bearings and seal housings, overhead seal tanks, rundown tanks, accumulators, heat exchangers, control elements, and vendor-furnished piping.

6.6.7.6.1 The rundown capacity shall also allow for at least an additional 10 % of the volumes defined in 6.6.7.6 for the purchaser's interconnecting piping.

NOTE Rundown can cause some backup in the drain lines entering the reservoir.

6.6.7.6.2 The designer of the interconnecting piping shall confirm with the supplier having unit responsibility that the capacity of all piping that drains into the reservoir upon shutdown does not exceed additional 10% allowance for rundown capacity.

NOTE All piping is inclusive of piping that drains down to the reservoir upon shutdown.

6.6.7.6.3 In a lube-oil system, the capacity between the minimum and maximum operating levels shall be at least 50 mm (2 in.) of reservoir height.

NOTE The purpose of 50 mm (2 in.) minimum distance is to provide sufficient differentiation for the level measuring devices.

6.6.7.6.4 In a seal-oil system, the capacity between the minimum and maximum operating levels shall be at least 50 mm (2 in.) of reservoir height, and, based on the manufacturer's estimated seal-oil consumption rate when the seals have worn to two times their maximum design clearance, the capacity shall be sufficient to permit at least 3 days of operation without requiring that oil be added to the reservoir.

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6.6.7.6.5 The seal-oil consumption rate shall be provided by the seal manufacturer.

NOTE This is of special concern when the sour oil is not returned to the reservoir.

6.6.7.6.6 ● ♦ If specified, a low-level alarm that actuates at the minimum operating level shall be provided, regardless of whether a heater is included.

6.6.7.6.7 ● ♦ If specified, the free surface of the oil in the reservoir shall be a minimum of 60 cm² for each liter per minute (0.25 ft² for each gallon per minute) of normal flow.

NOTE This requirement is not intended where the equipment case serves as the oil reservoir.

6.6.8 Heating

6.6.8.1 Electric heaters shall be provided if the minimum site temperature on the data sheet is less than the minimum oil start-up temperature required of the equipment being served.

NOTE 1 Some users elect to use tempered cooling water (see 6.8.1.17 and 6.8.1.18) in the lube-oil heat exchanger to function as a lube-oil heater prior to start-up.

NOTE 2 There are many factors to consider if heating the lube oil to minimum starting temperature, including lube pump start-up minimum oil temperature, equipment minimum oil temperature, circulating heat loss, etc. Many of these factors are the responsibility of the installing contractor in coordination with the console designer. Insulation, location, and heat tracing requirements are considerations of the installation.

6.6.8.2 ● If specified, steam heaters shall be supplied.

6.6.8.3 The heater shall have the capacity to heat the oil in the reservoir from the specified minimum machinery ambient temperature to the manufacturer's served equipment's required start-up temperature within 8 hours while circulating oil through the system.

NOTE Subsection 6.7.15 provides minimum oil temperatures for starting pumps.

6.6.8.4 If a steam heater is specified, a removable element external to the oil reservoir shall be provided.

6.6.8.5 If an electric heater is specified, a removable electric immersion heating element shall be provided.

6.6.8.6 Electric heaters shall have an integral thermostat for reservoir oil temperature control.

6.6.8.7 Unless otherwise specified, the reservoir heat loss during heating shall be determined based on an uninsulated reservoir, the minimum site ambient temperature and a 4.5 m/s (10 mph) wind.

6.6.8.8 The vendor shall provide data to support this.

NOTE The purchaser and the supplier can consider appropriate design conditions for applications having oil reservoirs mounted within enclosures or buildings that are heated, or not exposed to outdoor ambient conditions.

6.6.8.9 ● ♦ If specified, temperature devices for remote monitoring and control shall be provided in lieu of an integral thermostat.

NOTE Reservoir heater control can be accomplished by remote monitoring of a temperature sensing element or transmitter versus integral heater thermostat for improved reservoir temperature control.

6.6.8.10 Electric heaters shall include the features described in 6.6.8.6.1 through 6.6.8.6.6.

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6.6.8.10.1 Electric heaters shall not exceed a maximum watt density of 2.3 W/cm² (15 W/in.²).

6.6.8.10.2 Heater elements shall be sheathed in austenitic stainless steel or nickel-based alloys.

6.6.8.10.3 Copper or copper-bearing materials shall not contact the oil.

6.6.8.10.4 Electric immersion heaters shall be interlocked to be de-energized if the oil level drops below the minimum operating level.

6.6.8.10.5 The hot section of the heater element shall be located a minimum of 50 mm (2 in.) below the reservoir minimum operating level.

6.6.8.10.6 Electric heater assemblies shall include a thermal device for over-temperature protection, which is separate from the temperature control device.

6.6.8.11 ● If specified, electric immersion heaters shall be installed in a manner that allows the heater elements to be removed during operation of the oil system. Top or angle-mounted direct immersion heaters are preferred.

6.6.8.11.1 If dry pipe well (tube) heating elements are used, the cold section of the element shall extend at least 30 cm (12 in.) beyond the reservoir wall, and the thermostat shall be located external to the dry well.

6.6.8.11.2 ● If specified, heaters shall be installed in oil-filled pipe wells (tubes) and shall have the following features:

- a) the heaters shall have vented expansion chambers;
- b) provisions to allow filling and draining of the pipe well;
- c) a positive level indication (sight glass) shall also be provided to ensure that the well has been filled prior to operation;
- d) the oil inside the pipe well shall be the same as in the reservoir;
- e) oil-filled pipe well heaters shall be provided with temperature controls for limiting the well oil temperature to a value 20 °C (36 °F) below the oil's "flash point" temperature and/or "coking" temperature, whichever is the lower value.

6.6.8.12 ● If specified, the vendor having unit responsibility shall conduct an analysis of the complete system, including lube-oil console, interconnecting piping, rundown tanks, equipment heat loss and other system components, to verify that the complete system heats up to the minimum equipment starting temperature in 8 hours if the equipment temperature is at the minimum specified machinery ambient temperature.

NOTE Consideration of lighter-viscosity oil compatible with the entire train can allow the permissive starting temperature to be lowered. **6.6.8.12.1** The analysis shall be provided to the purchaser.

6.6.8.12.2 Detailed design of the interconnecting piping shall be provided by the engineering contractor to the vendor performing the analysis, to determine if there is a need for additional heating.

6.6.9 Provision for Insulation

6.6.9.1 ● Reservoirs shall be fitted with insulation clips.

6.6.9.2 The purchaser shall furnish and install the insulation.

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6.6.10 Provisions for Purge Gas or Makeup Oil Supply

6.6.10.1 ● ♦ If specified, each reservoir shall be provided with two flanged and blinded connections above the rundown oil level that are at least 25 mm (1 in.) in diameter.

6.6.10.2 These connections shall be located to ensure an effective sweep of purge gas toward the vents. No extension tubes or seals are permitted.

6.6.11 Provision for Oil Conditioner

6.6.11.1 ● The vendor shall provide two 25 mm (1 in.) flanged, valved and blinded connections (see Figure C.23, footnotes c and i), one located below the minimum operating level for use as an oil supply connection for an oil conditioner and one above the rundown oil level and equipped with a stilling tube.

6.6.11.2 If a conditioner connection is specified in 6.6.11.1, the vendor shall provide inside the reservoir a pipe loop with a siphon-breaker hole at the top, which has a maximum diameter of 6 mm ($\frac{1}{4}$ in.).

6.6.11.3 This pipe loop shall prevent the oil level from falling more than 50 mm (2 in.) below the minimum operating level due to the action of the conditioner recirculation.

6.6.12 Welds

6.6.12.1 Joints, pads, and connections shall be both internally and externally welded to eliminate cavities, potential sources of corrosion, and contamination. The reservoir's wall-to-top junctions may be welded from the outside if a full-penetration weld is used.

6.6.12.2 All welds shall be continuous.

6.6.12.3 Internal joints shall be made smooth by grinding or other suitable means as necessary to eliminate pockets and provide an unbroken finish.

6.6.13 Special Features

6.6.13.1 If the top of the oil reservoir contains equipment that requires routine operations or maintenance access and is higher than 1.2 m (4 ft), an accessible ladder with extended handrails, handrails around the perimeter of the reservoir top, and nonskid surface decking through the use of nonskid coatings, diamond plate, or grating over the metal decking shall be provided in alignment with OSHA chapter 11.

NOTE: Manway access is not considered part of routine maintenance.

6.6.13.2 ● An accessible ladder with extended handrails shall be provided.

6.6.13.3 ● Handrails around the perimeter of the reservoir top shall be provided.

6.6.13.4 ● Nonskid surface decking (nonskid coatings, diamond plate, or hot-dipped galvanized steel grating) shall be provided on the top of the reservoir. Local safety regulations or purchaser's risk assessment often determine the necessity of features, such as ladders and handrails are needed if personnel will be on top of the reservoir for any reason, such as maintenance, servicing, access to other equipment, etc. (refer to 5.3).

6.6.13.5 For equipment mounted on the reservoir, the reservoir shall provide sufficient structural stiffness to properly support the equipment.

6.6.13.6 The reservoir top and manway cover shall be designed and fabricated to withstand minimum live loading of 12 kN/m² (250 lb/ft²) without permanent distortion.

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6.6.13.7 ● The reservoir top shall be designed and fabricated to other criteria or to a particular design code or standard.

6.6.14 Materials

6.6.14.1 Reservoirs and all features welded to reservoirs shall be fabricated from austenitic stainless steel in accordance with ASTM A240/A240M, Type 304L.

6.6.14.2 Pipe connection materials shall be as specified in 7.1.

NOTE Dissimilar material features, such as ladders and handrails, can be bolted to clips welded to the reservoir.

6.6.14.3 Where reservoirs are integral with equipment or equipment baseplates, and where stainless steel inserts or cladding is not practical, other materials or internal coatings are acceptable upon purchaser approval.

NOTE Certain equipment, such as reciprocating compressors or gearboxes, which use crankcases or casings as reservoirs, are sometimes available only in alternate materials, such as cast iron.

6.6.14.4 ● ♦ Minimum reservoir thickness shall be 6 mm (¼ in.) minimum.

6.6.15 Grounding

6.6.15.1 The reservoir shall be grounded through grounding clips or pads attached to the reservoir for free-standing reservoirs or to the base structure for reservoirs integral with the base. In either case, two grounding clips or pads diagonally opposed to each other (see Figure C.23) are required.

6.6.15.2 The pads shall accommodate a 13 mm (½ in. UNC) bolt.

6.6.15.3 Two grounding clips or pads on diagonally opposite sides of the console baseplate shall be provided in addition to the grounding clips or pads on the reservoir regardless if the reservoir is integral to the baseplate or not.

6.7 Pumps and Pump Drivers

6.7.1 The oil system shall include an oil pump suitable for continuous operation.

6.7.1.1 ● The type of pump shall be specified by the purchaser (centrifugal or rotary).

6.7.1.2 ● Pumps shall conform to API 610, ASME B73.1, ASME B73.2, or API 676.

6.7.1.3 ● ♦ If specified, or required by the lubricated equipment supplier, an electric motor-driven standby pump, suitable for continuous operation, shall be provided for start-up and/or main-pump failure backup.

6.7.1.4 For non-shaft-driven pumps, the main and standby pumps shall be identical.

NOTE 1 Standby pumps are not always required. Some equipment, such as equipment utilizing ring-oiled bearing lubrication, might not require pre-priming and use of a standby pump.

NOTE 2 Some large lube-oil systems utilize different configurations, such as three 50 % capacity pumps.

6.7.1.5 Standby pumps shall be configured to prevent vapor accumulation while idle.

NOTE Vapor accumulation could cause delayed oil flow on start-up.

6.7.1.6 Use of booster pumps requires purchaser approval.

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NOTE If booster pumps are not permitted in high pressure seal oil systems >70 Bar (>1,000 psig), then a second set of direct connected seal oil pumps with their additional coolers would be needed.

6.7.2 ● ♦ If specified, pumps shall be external to the reservoir, since pumps mounted inside the reservoir can be difficult to remove for maintenance.

6.7.3 ● If specified, an emergency oil pump shall be furnished to allow safe shutdown without damage to the equipment in the event that both the main and standby pumps fail.

6.7.4 The purchaser and driven equipment suppliers shall define the requirements for safe shutdown, which can include the use of a The purchaser and driven equipment suppliers shall define the requirements for safe shutdown, which can include the use of a lube-oil rundown tank to provide bearing oil during rundown, the use of emergency oil pump with separate power source to provide cool-down oil subsequent to coast-down, or other features as specified..

6.7.5 Oil pumps not submerged in the reservoir shall comply with the following.

- a) Have pressure casing made of steel.
- b) Be fitted with mechanical seals, which have:
 - 1) sealing faces shall be carbon against tungsten or silicon carbide;
 - 2) O-rings shall be compatible for the type of oil specified;
 - 3) other metallic materials shall be 300 series stainless steel.
- c) Centrifugal pumps shall have end plates with throttle bushings.

6.7.6 Submerged pump casings may be made of cast iron.

6.7.7 ● Main oil pump shall be steam turbine driven.

NOTE Steam turbine-driven main oil pumps are often used in oil systems serving steam turbine-driven main equipment.

6.7.7.1 Both main and standby pumps shall be motor driven.

NOTE 1 Standby pumps are motor driven due to relatively long start-up times for turbine-driven pumps.

NOTE 2 Typically, installations for two motor-driven pumps have electric feeds from independent sources.

6.7.7.2 Steam turbines shall conform to API 611.

6.7.7.3 ● The purchaser shall specify the minimum inlet steam temperature and pressure and the highest exhaust pressure under which the turbine is expected to operate.

6.7.8 If separate pumps are used for lube-oil and seal-oil service, they shall be driven separately.

NOTE Special multi-section pumps, such as those used by gas turbines, are typically driven by a common shaft.

6.7.9 A shaft-driven pump may be provided if approved by the purchaser.

6.7.10 Shaft-driven pumps shall be positive displacement type.

NOTE 1 If the shaft-driven pump fails, online maintenance of the pump is not possible and requires an outage for maintenance of the pump.

NOTE 2 If a shaft-driven pump is provided, a lube-oil rundown tank is sometimes unnecessary.

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6.7.11 If a shaft-driven pump is provided, the following pump design requirements shall be considered as a minimum:

NOTE Suction piping frictional losses and static head differences are factors in calculating net positive suction head available.

a) priming;

NOTE 1 Shaft-driven pumps are usually primed by starting the auxiliary pump prior to starting the unit.

NOTE 2 Drilled check valves are sometimes utilized with shaft-driven pumps to assist with priming.

b) maintenance accessibility;

c) shaft coupling;

d) drive shaft positioning due to thermal growth;

e) oil flow rate throughout the speed range, if adjustable speed drives are used.

6.7.12 • Electric motor drives shall conform to guidelines of 6.7.12.1 or 6.7.12.2, or other standard as specified by the purchaser.

6.7.12.1 Low-voltage induction motors shall be in accordance with IEEE 841 (up to 370 kW [500 hp]).

NOTE Some applications utilize IEC motors complying with IEC 60034-1.

6.7.12.2 General-purpose medium-voltage induction motors shall be in accordance with API 547 [186 kW (250 hp) and larger].

NOTE API 547 is applicable to either NEMA or IEC, ISO as specified. IEEE 841 at this time is NEMA. There is no equivalent IEC or ISO standard to IEEE 841 at this time.

6.7.13 The minimum criteria given in a) through h) shall be used for sizing pumps.

a) In all cases, pumps shall be sized to deliver the required capacity if operating at the highest rated temperature and the corresponding minimum oil viscosity.

b) Each pump shall be capable of the following.

1) Supplying the normal oil flow required by the equipment plus the following.

i. For flow rates up to 95 l/min (25 gal/min): 20 l/min (5 gal/min).

ii. For flow rates greater than 95 l/min (25 gal/min) and up to 760 l/min (200 gal/min): 20 % of the normal oil flow.

iii. For flow rates greater than 760 l/min (200 gal/min): 15 % of the normal oil flow.

NOTE For very large systems, excess pump capacity of less than 15 % can be agreed between the vendor and the purchaser.

2) Transient oil requirements where applicable and as defined by the driven equipment vendor.

3) Equipment vendor's allowance for normal wear.

4) Sizing shall account for all losses including but not limited to the pressure drop across dirty filters, heat exchangers, and piping.

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- c) Accumulators may be provided to meet transient control-oil requirements, if approved by the purchaser. Accumulators shall be sized according to 6.11.1. The equipment supplier shall define all transient conditions.
- d) In booster systems, the capacity of the main pump, as established in 6.7.13 a), shall be increased by the amount required to supply both the main and the standby booster oil pumps simultaneously.
- e) Rotary pumps shall be selected so that the pressure differential through the pump is no greater than 90 % of the manufacturer's rating at the pumps rated capacity, with minimum oil viscosity and subject to the PLV set point.
- f) The pump shall also be capable of operating continuously at the rated flow, pressure-relief-valve or pressure-limiting-valve set pressure and minimum operating viscosity.

NOTE The selection criterion in e) and f) is necessary to avoid pump rotor contact during operation under extreme conditions.

- g) The pump shall also be capable of operating at the minimum pump starting temperature.
- h) Variable speed oil pumps, such as shaft-driven or steam turbine-driven pumps, shall meet the above requirements if operating at the minimum operating speed of the pump.

6.7.14 Centrifugal pumps shall be selected so that normal operating capacity is within 50 % to 110 % of the best efficiency point. From their normal operating point to shutoff, head rise to shutoff shall be minimum 5 %.

6.7.15 Pump drivers shall be sized for the following:

- a) Centrifugal pump drivers shall be:
 - 1) capable of operating if the temperature of the pumped oil is 10 °C (50 °F);
 - 2) rated for at least 100 % of the power required by end-of-curve operation with the supplied impeller, including all losses.
- b) Rotary pump drivers shall be:
 - 1) capable of operating at the specified pump PLV setting (including accumulation) if the temperature of the pumped oil is 10 °C (50 °F);
 - 2) rated for at least 110 % of the greatest power required for any specified operating condition, including all losses.

6.7.16 ● Pump drivers shall be sized for satisfactory operation at the minimum machinery ambient temperature shown on the Site and Utility Data Sheet, or -7 °C (20 °F), whichever is lower.

NOTE For cold-starting of oil systems, recirculating oil from pump discharge directly back to the reservoir can help reach the minimum oil temperature throughout the reservoir.

6.7.17 Check valves shall be provided on each pump discharge to prevent the flow of oil backwards through a standby or idling pump.

6.7.17.1 ● To reduce the required seal-oil reservoir vent size, dual check valves of dissimilar types shall be provided on the seal oil pump discharge line to reduce the potential backflow leakage.

6.7.18 ● ♦ shaft-driven pumps shall have check valves and bypasses arranged such that the shaft-driven pump continues to supply pressurized oil during periods of reverse rotation.

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6.7.19 When 6.7.18 is specified, the supplied pump shall be capable of supplying pressure while running backwards.

NOTE 1 Some types of equipment can be damaged by reverse rotation if process check valve fails.

NOTE 2 Reverse rotation can result from process check valve and power failures. Alternative measures to protect the driven equipment, such as automatic closing of discharge and suction valves, can also be considered.

6.7.20 For rotary pump systems, the vendor shall furnish external oil PLVs.

6.7.20.1 Oil PLVs shall be installed in the vendor supplied piping.

6.7.20.2 Oil PLV settings, including an allowance for accumulation, shall be determined after all of the possible equipment and component failures are considered.

6.7.20.3 The settings shall protect the oil system components and piping.

6.7.20.4 Fully accumulated pressure shall not exceed 110 % of the system MAWP.

6.7.21 Oil PLVs shall:

- a) be pressure-modulating devices (as opposed to snap-acting or pop-type safety relief valves) with a pressure increase proportional to flow above the valve cracking pressure (i.e. the pressure at which the valve begins to open);
- b) be mounted external to the reservoir and shall operate smoothly, without chattering and without causing a drop in supply pressure to the equipment.

6.7.21.1 PLV piping shall be sized for the full flow of each pump; the valves shall not chatter and the piping shall not vibrate.

6.7.21.2 The minimum PLV cracking pressure shall be 10 % or 170 kPa (1.7 bar; 25 psi) higher than the highest required operating pressure, including operation at 10 °C (50 °F), whichever is greater.

6.7.21.3 The PLV inlet piping and components shall be designed to avoid air entrapment/accumulation.

NOTE 1 Since many PLVs do not have tight shutoff, PLV vented discharge piping configuration can allow air into the standby pump discharge piping system, which can cause delay in system response if standby pump is started.

NOTE 2 Designs that help avoid air entrapment/accumulation can include one or more of the following examples:

- a) PLV located outside the reservoir, below minimum operating level;
- b) drilled pump discharge check valve, or orificed check valve bypass line sized to avoid air entrapment without causing reverse rotation of the standby pump.

6.7.21.4 ● ♦ PLVs shall not be used for continuous pressure regulation.

6.7.21.5 For high-pressure applications typically above 55 bar (800 psig), where pressure-modulating valves cannot be provided, provisions for venting or otherwise relieving the pumps shall be provided.

6.7.21.6 ● PLVs shall be tight shutoff.

NOTE Nonliquid modulating valves with rapid full opening or pop action characteristic can result in chatter.

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6.7.21.7 ● Globe type manual bypass valves shall be provided around PLVs. See Figure C.21 and Figure C.22.

6.7.21.8 ● Oil pump discharge PLVs shall be routed back to the oil reservoir through sight flow indicators. **6.7.22** The oil system shall be provided with pressure-regulating devices that prevent fluctuation of the oil pressure to the equipment serviced by the lube-oil console if both the main and the standby pump are in operation or if either the main or the standby pump is in operation and the other pump is started, brought up to operating speed or stopped.

6.7.22.1 Each device shall have an adequate response time.

6.7.22.2 Each device shall operate smoothly without hunting, chattering, or producing pressure or flow transients that can cause a mechanical problem or shutdown of the equipment [see 9.3.3.10 d)].

6.7.22.3 These pressure-regulating devices shall be located so that an excessive rise in oil temperature resulting from a recirculation of uncooled oil is avoided.

6.7.22.4 Bypass pressure-regulating valves shall be sized to cover a range from the minimum usage of one pump to the maximum usage of two pumps.

6.7.23 Where non-pressure-regulating PLVs are used, the pressure-regulating valve shall be selected such that the PLVs do not lift during two-pump operation.

6.7.24 All pumps (except shaft-driven pumps) shall be installed with flooded suctions to ensure self-priming.

6.7.25 All pumps shall be installed with suction-block valves (unless the pumps are inside the reservoir) and with discharge-block and discharge check valves.

6.7.26 Vertically mounted pumps shall be continuously vented to ensure that the entire pump remains flooded.

6.7.27 Suction piping shall comply with the following.

- a) Be continuously vented or arranged to avoid pockets in which air can accumulate or become trapped.
- b) Each pump is designed with a separate suction line from the reservoir.
- c) The pump-suction lines are designed to avoid excessive piping loads on the pump casing flanges.
- d) Designs for suction piping, suction-block valves, pump casings, and all other components (particularly those for booster-pump arrangements) avoid the possibility of overpressure caused by leaking discharge check valves.

6.7.28 When centrifugal pumps are supplied, the recirculation line between the pump discharge flange and the discharge check valve shall be continuously vented through an orifice back to the reservoir.

6.7.28.1 The orifice used in the recirculation line shall be sized for the pump minimum flow.

6.7.28.2 The recirculation line shall be connected to a non-vented down comer. **6.7.28.3** The elevation of the discharge check valve shall be below the normal operating level in the reservoir.

6.7.28.4 For the protection of centrifugal pumps during flushing and for the initial operation of new or refurbished oil systems, a removable strainer made from austenitic stainless steel and having an open

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flow area equal to 150 % of the cross-sectional area of the suction pipe shall be installed in the suction piping of each pump between the pump-suction flange and the block valve.

6.7.28.4.1 The removable strainer shall be identified by a protruding tab, and shall have a mesh size adequate to stop all objects that can be damaging to the pump.

6.7.28.4.2 The removable strainer shall have a mesh size adequate to stop all objects that can be damaging to the pump.

6.7.28.4.3 The piping arrangement shall permit the removal of the strainer without disturbing the alignment of the pump.

6.7.28.4.4 The maximum strainer hole size shall be 3 mm ($\frac{1}{8}$ in.).

● ♦ **6.7.28.4.5** If specified, cone strainers shall be installed in spool pieces to minimize piping removed.

NOTE 1 Strainer can be cone, basket, T-type, or Y-type.

NOTE 2 Typically does not apply to submerged pumps mounted in the reservoir.

6.7.29 For rotary pumps, a permanent Y-type or T-type strainer with an austenitic stainless steel basket having a minimum open flow area equal to 150 % of the cross-sectional area of the suction pipe shall be installed in the suction piping of each pump.

6.7.29.1 The strainer shall have a mesh size in accordance with the pump manufacturer's recommendation.

6.7.29.2 The maximum strainer hole size shall be 3 mm ($\frac{1}{8}$ in.).

6.7.29.3 A blowdown/drain valve shall be provided on strainers.

6.7.29.4 Strainers can require use of a bushing for blowdown connections if required by space limitations. These bushings shall be rated for the pressure rating of the pipe as a minimum.

NOTE Elimination of these bushings can raise pump suction connections.

6.7.29.5 The design, location and arrangement of strainers shall permit removal of the internal basket or element without removing the strainer body.

6.7.30 Strainers are not required for booster pumps that are located downstream of primary filters.

6.7.31 ● ♦ If a permanent strainer is being used, a compound-type pressure gauge shall be installed between a permanent strainer and the pump suction.

NOTE This typically does not apply to submerged pumps that have a permanent strainer and no provisions for a gage

6.7.32 When specified by 6.7.31, the gauge shall be scaled properly to detect a fouled strainer.

6.7.33 If a standby pump is furnished, the vendor shall provide the primary element for the purchaser's start-up control of the standby oil pump.

6.7.33.1 The start-up control of the standby pump shall be actuated by low oil-supply pressure to the served equipment or low oil level in the overhead seal-oil tanks, as appropriate.

6.7.33.2 Motor control centers shall be provided by the purchaser.

6.7.33.3 The control system shall have a manual reset. See 8.2.1.1 for instrumentation that allows the operation of the standby-oil-pump controls to be checked while the main pump is in operation.

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6.7.33.4 Scope of supply for controls and reset shall be determined by the purchaser and the vendor.

6.7.34 Each exposed coupling shall have a coupling guard that is removable without disturbing the coupled elements.

NOTE 1 If couplings of submerged pumps are not exposed, guards may not be applicable.

NOTE 2 If couplings of submerged pumps are not exposed, typically the pump assembly is removed to replace the driver.

6.7.34.1 Coupling guards shall enclose the coupling and the shafts to prevent personnel from contacting moving parts during operation of the equipment train.

6.7.34.2 Allowable access dimensions shall comply with ISO 14120 or ANSI B11.19.

6.7.34.3 Guards shall be constructed with sufficient rigidity to withstand a 900 N (200 lbf) static point load in any direction without the guard contacting moving parts.

6.7.34.4 Guards shall be fabricated from solid sheet or plate with no openings. Guards fabricated from expanded metal or perforated sheets may be used if the size of the openings does not exceed 10 mm (0.375 in.).

6.7.34.5 Spark-resistant guards of agreed material shall be supplied.

NOTE 1 Many users consider pure aluminum and aluminum alloys with less than 5 % iron and a maximum content of 2 % magnesium or 0.2 % copper to be spark resistant. However, local regulations, such as EN 13463-1, sometimes prohibit aluminum or nonmetallic materials within potentially explosive atmospheres. Nickel-copper alloys (UNSN0440X or UNSN0550X) and copper-based alloys (e.g. brass, bronze, aluminum bronze, beryllium bronze) are generally considered to be spark resistant. Nickel based alloys including alloy 600 (UNSN06600) and alloy 625 (UNSN06625) are considered spark resistant.

NOTE 2 Materials that are not considered spark resistant include stainless steels, iron, steel (all alloys), magnesium, and titanium.

6.7.34.6 Drains are required on closed coupling guards.

6.7.35 Nonspacer elastomeric couplings may be used for driver power ratings below 22 kW (30 hp).

6.7.36 • For driver power ratings below 22 kW (30 hp), couplings shall meet the requirements of 6.7.35.

6.7.37 For driver power ratings 22 kW (30 hp) and above, couplings shall be all-metal flexible element, spacer-type couplings manufactured to meet AGMA 9000 Class 9 and shall comply with the following.

- a) Flexible elements shall be of corrosion-resistant material.
- b) Couplings shall be designed to retain the spacer if a flexible element ruptures.
- c) Coupling hubs shall be steel.
- d) The distance between the driven and driver shaft ends [distance between shaft ends (DBSE)] shall be at least 125 mm (5 in.) and shall permit removal of the coupling, bearings, seal and rotor, as applicable, without disturbing the driver, driver coupling hub or the suction, and discharge piping. This dimension, DBSE, shall always be greater than the minimum total seal length.
- e) Provision shall be made for the attachment of alignment equipment without the need to remove the spacer or dismantle the coupling in any way.

6.7.38 • Couplings shall be balanced to ISO 21940-11 grade G6.3.

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NOTE AGMA 9000 Class 9 manufacturing tolerances result in balance adequate for most lube-oil pump applications.

6.7.39 Couplings shall be keyed to the shafts.

6.7.40 Keys and keyways and their tolerances shall conform to AGMA 9002, Commercial Class.

6.7.41 Couplings and coupling-to-shaft junctures shall be designed and manufactured to be capable of transmitting power at least equal to the power rating of the driver including any applicable driver service factor.

6.7.42 ● ♦ Couplings shall have a minimum service factor of 1.5 based on the driver rating including any applicable driver service factor.

6.7.43 To ensure that the connected machinery can be accurately aligned, the total indicator reading of coupling rim and face alignment surfaces shall be controlled within specific limits.

6.7.44 For all pumps, the coupling surfaces normally used for checking alignment shall be true with the axis of coupling hub rotation within the following limits.

- a) Face alignment surfaces should be flat and square to axis of rotation within 13 μm (0.0005 in.) total indicator reading.
- b) Radial rim surfaces should be round and concentric to axis of rotation within 50 μm (0.002 in.) total indicator reading.
- c) All other diameters and faces not used for location, registration, or alignment shall be to the coupling manufacturer's standard, provided balance requirements are met.

NOTE Elastomeric-style couplings may be exempted if there are no machined surfaces provided on the coupling hub.

6.7.45 Unless otherwise specified, "C-flanged" motors may be used for motors equal to or below 7.5 kW (10 hp).

6.7.46 ● If specified, the oil pump and driver shall be mounted on a separate sub-baseplate.

NOTE The separate sub-baseplate for the oil pump and driver is referred to in this standard as the oil pump and driver baseplate to distinguish it from the overall oil console baseplate.

6.7.47 A separate sub-baseplate shall be provided for horizontal pump assemblies as specified in 6.7.45.1.1 through 6.7.45.1.7.

6.7.47.1 ● ♦ If specified, or for drivers larger than 7.5 kW (10 hp), mounting pads shall be provided for each pump and its driver.

6.7.47.1.1 Pads shall be at least 25 mm (1 in.) larger than the feet of the mounted equipment to allow for leveling of the sub-base without removal of the equipment.

6.7.47.1.2 The pads shall be fully machined, flat, and parallel to a finish of 6 μm (250 $\mu\text{in.}$) Ra or better.

6.7.47.1.3 Corresponding surfaces shall be in the same plane within 125 $\mu\text{m/m}$ (0.002 in./ft) of distance between the pads.

NOTE This paragraph refers to surfaces for the same piece of equipment, for example, a centerline supported centrifugal pump with two separate, corresponding mounting pads. These pads may also be continuous as depicted in Figure 2 below.

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6.7.47.1.4 The difference in slope between pump and driver mounting surfaces shall be ≤ 0.42 mm/m (≤ 0.005 in./ft) when evaluated in the axial (shaft-parallel) and transverse (shaft-perpendicular) directions

NOTE: Excessive angular deviation between pump and driver mounting planes may result in large shim stacks, reduced stiffness, and alignment instability. Purchasers may specify tighter criteria where required for high-speed or high-power-density equipment.

Fig. 2

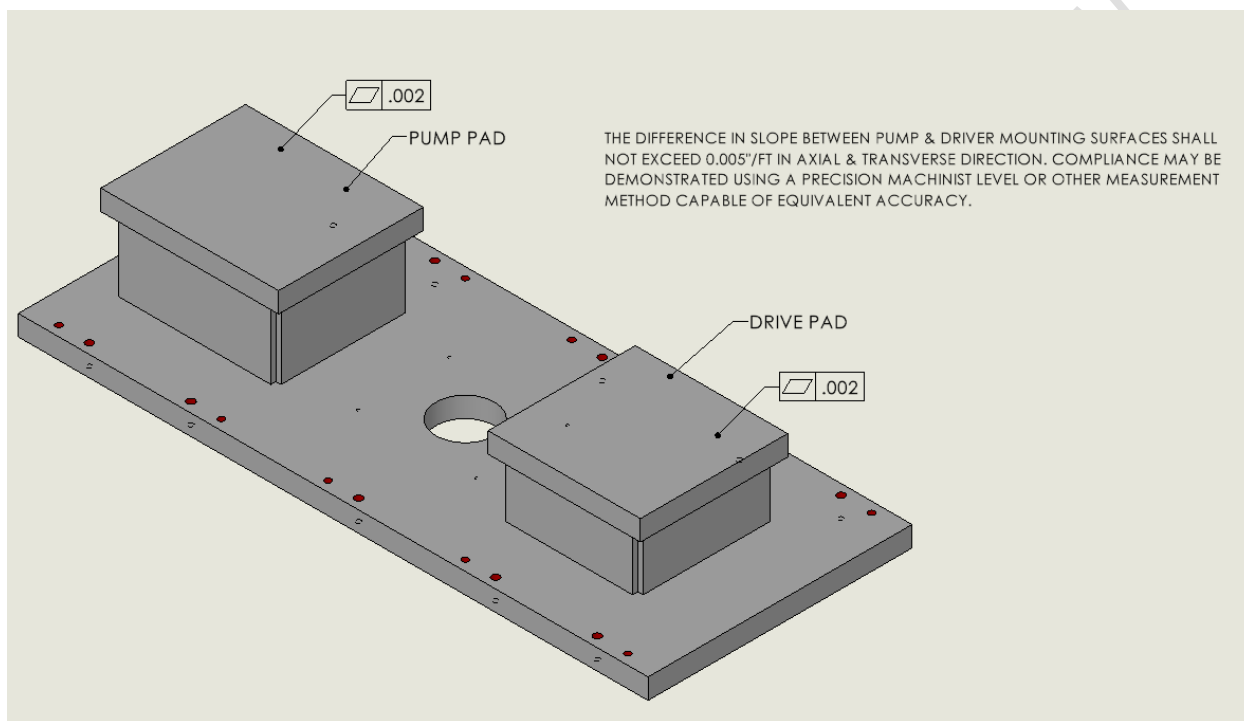


Figure 2 - Example Oil Pump and Driver Baseplate Showing Corresponding Mounting Plane Requirement

6.7.47.1.5 The difference in slope between pump and driver mounting surfaces shall be less than or equal to 0.42 mm/m (0.005 in./ft) when evaluated in the axial (shaft-parallel) and transverse (shaft-perpendicular) directions.

NOTE Excessive angular deviation between pump and driver mounting planes may result in large shim stacks, reduced stiffness, and alignment instability. Purchasers may specify tighter criteria where required for high-speed or high-power-density equipment.

6.7.47.1.6 To prevent distortion, machining of mounting pads shall be deferred until welding on the pump and motor sub-base in close proximity to the mounting pads has been completed.

6.7.47.1.7 This tolerance shall be met at the time of assembly at the vendor's shop between coupled rotating pieces of equipment.

6.7.47.1.8 The coupled pieces shall be capable of being realigned in the field if the console is properly installed in accordance with API 686.

6.7.47.2 Pumps and drivers shall be mounted on a machined surface.

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6.7.47.2.1 All pads for oil pumps and drivers shall be machined to allow for the installation of stainless steel shims.

6.7.47.2.2 Shim packs, at least 3 mm ($\frac{1}{8}$ in.) thick, shall be placed under the feet of each component.

NOTE Due to mounting surface tolerances on purchased pumps and drivers, the installation of shims with different thicknesses under each foot can be necessary. Additionally, shims under the pump are required to allow future shimming of a replacement pump to the inlet pipe. [IEEE 841 motor and small PD pump tolerance 130 μ m (0.005 in.) from foot to foot, NEMA MG-1 motor and large PD pump 260 μ m (0.010 in.) from foot to foot.]

6.7.47.3 To minimize misalignment of the pump and driver shafts, the pump and its sub-baseplate shall be constructed with structural stiffness that will limit total misalignment to within the tolerance as outlined in API 686.

6.7.47.4 If the pump and driver are mounted on the console without a separate sub-baseplate, the pump and driver shall be mounted to a structural member of the console base rather than attached to the deck plate or other nonstructural components.

6.7.47.5 • ♦ if drivers exceed 45 kg (100 lb), transverse- and axial-alignment positioning jackscrews shall be provided for all pump drivers.

6.7.47.5.1 The lugs holding these positioning screws shall be attached to the baseplate or sub-baseplate so that the lugs do not interfere with the installation or removal of the component.

6.7.47.5.2 Alignment positioning screws shall be at least the same size as the jackscrews furnished with each component.

6.7.47.6 Supports, jack screws, and their attachments shall be rigid enough to permit the machine to be moved by the use of its lateral and axial jackscrews, if provided.

6.8 Lube-oil Heat Exchangers

6.8.1 General

6.8.1.1 A liquid-cooled lube oil exchanger shall be provided.

6.8.1.2 • ♦ Dual liquid-cooled heat exchangers shall be provided and shall be piped in a parallel arrangement using a continuous-flow transfer valve (see 6.10).

6.8.1.3 Heat exchanger(s) shall be shell-and-tube type and shall be in accordance with the requirements of 6.8.2.

6.8.1.4 • If specified, multi-plate frame or air-cooled heat exchangers, in accordance with 6.8.3 or 6.8.4, respectively, shall be supplied.

6.8.1.5 The vendor shall include in the proposal details of any air-cooled or plate-frame heat exchanger.

6.8.1.6 • The vendor shall supply connections for installation of the purchaser's heat exchanger(s) off the oil console.

6.8.1.6.1 If the purchaser supplies the off-console heat exchanger(s), the interconnecting piping pressure drop, elevation, and runback volume shall be detailed to the console supplier in order to properly size pumps and reservoir.

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6.8.1.6.2 The vendor shall supply all relevant data such as heat load and oil flow.

6.8.1.6.3 Pressure-drop criteria for the oil side shall be agreed between the vendor and the purchaser.

6.8.1.7 Unless otherwise specified for dual heat exchanger arrangements, an equalization/fill line with a suitably sized restriction orifice and a block valve shall be provided for thermal overpressure protection, with the equalization/fill valve locked or car sealed in the open position to perform two functions: (1) pressure equalization during heat exchanger filling and switching operations, and (2) thermal overpressure protection of the standby heat exchanger in the event of a fire..

6.8.1.8 ● In lieu of the requirements of 6.8.1.7, for dual heat exchanger arrangements, the vendor shall provide thermal overpressure protection of the oil side of the heat exchangers by providing separate thermal relief valves on each heat exchanger (refer to 6.9.3 for requirements regarding routing of oil from discharge of thermal relief valves routed back to the reservoir.).

6.8.1.9 The water side of the heat exchanger shall be designed for the following conditions:

— water side velocity	1.5 m/s to 2.5 m/s	(5 ft/s to 8 ft/s);
— minimum pressure rating	700 kPa [7 bar]	(100 psig);
— maximum pressure drop	70 kPa [0.7 bar]	(10 psi);
— maximum inlet temperature	30 °C	(90 °F);
— maximum outlet temperature	50 °C	(120 °F);
— maximum temperature rise	20 °C	(30 °F);
— minimum temperature rise	as needed to maintain minimum velocity;	
— fouling factor on water side	0.35 m ² K/kW (0.002 h·ft ² °F/Btu);	

NOTE Fouling factor will change depending on water source and conditions.

— corrosion allowance for carbon steel	3 mm, 1/8 in. (0.125 in.).
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6.8.1.10 The vendor shall notify the purchaser if the criteria for temperature rise or velocity over heat-exchange surfaces result in a conflict.

6.8.1.11 Provision shall be made for complete venting and draining of the system or systems.

6.8.1.12 Heat exchangers shall be provided to maintain the oil-supply temperature at or below 50 °C (120 °F).

NOTE Certain ambient conditions or oil viscosities can necessitate operation with an oil-supply temperature greater than 50 °C (120 °F).

6.8.1.13 Each heat exchanger shall be sized to accommodate the cooling load of the oil.

6.8.1.14 Oil heat exchangers shall not be located inside the reservoir.

6.8.1.15 ● ♦ An oil bypass line around the heat exchangers with a temperature control valve shall be included to regulate the oil-supply temperature.

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6.8.1.15.1 In no case shall oil bypass the filter.

6.8.1.15.2 The control valve shall be in accordance with the provisions of 6.8.1.15.3 through 6.8.1.15.9.

NOTE 1 This includes oil systems where the purchaser supplies the heat exchangers.

NOTE 2 If fouling or freezing of the water side of a heat exchanger is a factor and oil temperature is regulated by adjusting water flow through the heat exchangers, it is possible for the heat exchanger water side to silt up or freeze and break at low water flow.

6.8.1.15.3 ● ♦ If specified, the oil bypass valve shall be a flanged and pneumatically operated (air-to-open fail-close), two-port or three-port, temperature control valve.

6.8.1.15.4 Failure of the control valve shall cause all the oil to pass through the heat exchangers.

NOTE 1 Three-port valves can direct the oil more advantageously due to system pressure drops and allow all of the oil to bypass the heat exchangers; however, they can complicate bypass arrangements required for maintenance vs. a two-port valve.

NOTE 2 In special cases, such as using air-cooled heat exchanger in low-ambient temperature environments, it can be appropriate to consider fail-locked temperature control valves.

6.8.1.15.5 ● If specified, the temperature control valve shall be an internal thermostat-operated three-port valve.

6.8.1.15.6 ● ♦ If specified, the temperature control valve shall be provided with a manual override that permits operation independent of temperature conditions.

6.8.1.15.7 ● If specified, the temperature control valve shall be provided with a block & bypass valve arrangement.

6.8.1.15.8 The temperature control valve and piping shall be sized to handle all oil flow passing through the heat exchanger.

6.8.1.15.9 For a three-way temperature control valve, the pressure drop should not exceed that through the heat exchanger.

6.8.1.15.10 For a two-way temperature control valve, pressure drop should not exceed 50 % of the pressure drop through the heat exchanger.

6.8.1.16 ● If specified, shell-and-tube or plate-frame heat exchangers shall be suitable for use of a 150 °C (300 °F) heating medium, such as steam or a mixture of steam and water.

6.8.1.17 Steam may be used for auxiliary heating on start-up by sparging it into the cooling water.

6.8.1.18 Steam should not be introduced directly into the heat exchanger.

6.8.1.19 Both the water side and the oil side of the heat exchanger shall be provided with valved vent/drain connections.

6.8.1.20 ● If specified, the heat exchangers shall be fabricated with flanged vent and drain nozzles. Screwed and seal-welded or socket-welded pipe and flange additions to heat exchangers after heat exchangers certification are not acceptable.

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6.8.1.21 ● Heat exchanger oil drains shall be manifolded, but to avoid cross-contamination, not together with filter clean side drains, and extended to the skid edge.

6.8.1.22 ● Vents on the oil side shall be routed back to the reservoir through flow indicators.

6.8.1.23 To prevent the oil from being contaminated if the heat exchanger fails, the oil-side operating pressure shall be higher than the water-side operating pressure.

6.8.1.24 If oil pressure is higher than the required equipment lube-oil supply pressure, a pressure reducing device shall be provided.

6.8.1.25 ● To reduce the potential for contamination of water with oil, the oil-side operating pressure shall be less than the water-side operating pressure.

NOTE 2 Environmental oil spill concerns can result from overfilling of the oil reservoir if water side pressure is higher than oil side pressure.

6.8.1.26 U-bend tubes are not permitted.

6.8.2 Shell-and-tube Heat Exchangers

6.8.2.1 In addition to the requirements of the general heat exchanger section, shell-and-tube heat exchangers shall be in accordance with 6.8.2.2 through 6.8.2.8.

6.8.2.2 Shell-and-tube heat exchangers shall have water on the tube side.

6.8.2.2.1 Unless otherwise specified, a removable-bundle design is required for heat exchangers with more than 0.5 m² (5 ft²) of heat-transfer area.

6.8.2.2.2 Removable-bundle heat exchangers shall be in accordance with TEMA Class C or other code specified for heat exchangers and shall be constructed with a removable channel cover.

6.8.2.2.3 Nominal tube outside diameter shall be at least 9 mm (³/₈ in.), and nominal tube wall thickness shall be at least 18 BWG [1.245 mm (0.049 in.)].

NOTE Cooling water from sources other than a cooling tower, if considered less clean, can warrant consideration of larger tubes such as 16 mm (⁵/₈ in.) diameter.

6.8.2.2.4 ● Nonrepairable heat exchangers are permitted only if approved by the purchaser.

NOTE Some nonrepairable heat exchangers might be available with thinner tubes. 26 BWG [0.457 mm (0.018 in.)] for 10 mm (³/₈ in.) diameter tube is commonly available.

6.8.2.3 With purchaser's approval, alternative designs to 6.8.2.2 may be offered for high-pressure oil heat exchangers [pressures greater than 3 MPa (30 bar; 500 psig)].

NOTE High-pressure seal-oil heat exchangers sometimes have oil in the tubes, to avoid excessive shell thickness.

6.8.2.4 ● ♦ If specified, nominal tube outside diameter shall be at least 16 mm (⁵/₈ in.), and nominal tube wall thickness shall be at least 18 BWG [1.245 mm (0.049 in.)].

NOTE 16 mm (⁵/₈ in.) diameter tubes are often used for poor water quality conditions.

6.8.2.5 Heat exchangers tubes shall be bare (plain) tube or integral low fin design.

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NOTE Integral fin heat exchanger tube design generally refers to bare tubes in which grooves are cut or extruded, thereby increasing the overall surface area.

6.8.2.6 Unless otherwise specified, heat exchanger shells, channels, and covers shall be of steel.

6.8.2.6.1 Tube sheets shall be of brass.

6.8.2.6.2 Tubes shall be of a copper/zinc/tin nonferrous material such as UNS C44300 (ASTM B111) (inhibited admiralty brass).

NOTE 1 Naval brasses and admiralty brass (copper/zinc/tin alloys) are particularly resistant to impingement of high-velocity water and are commonly used in marine condensers. An alternate choice can be aluminium bronze material.

NOTE 2 Tube materials such as 90-10 copper-nickel can be an appropriate choice for salt- and brackish-water services. Stainless steel tubes are generally not recommended in salt- and brackish-water services because of chloride-cracking problems at higher temperatures. Stainless steel tubes also have poorer heat-transfer characteristics than copper-nickel tube materials.

NOTE 3 High-pressure oil heat exchangers can require steel tubes and tube sheets.

6.8.2.7 Baffles and tie rods material shall be compatible with the tube material.

6.8.2.8 Heat exchangers shall be constructed with drain holes or notches in the lower baffles of the bundle to allow oil in the all sections of the entire length of the heat exchanger to drain to the shell side drain connection.

6.8.3 Plate-and-frame Heat Exchangers

6.8.3.1 If plate-and-frame heat exchangers are specified, they shall be in accordance with 6.8.3.2 and 6.8.3.3, in addition to the requirements of the general heat exchanger section.

NOTE API 667 covers plate heat exchangers, sometimes referred to plate-and-frame heat exchangers. It covers gasketed and semi-welded heat exchangers constrained within a frame.

6.8.3.2 Plate-and-frame heat exchangers shall have plates of austenitic stainless steel for fresh-water cooling or titanium for brackish or salt water, or as specified by the purchaser.

6.8.3.3 The frame and tie bolts of the gasketed or semi-welded plate-and-frame heat exchanger shall be designed to permit the future installation of at least 20 % additional plates.

6.8.4 Air-cooled Heat Exchangers

6.8.4.1 If air-cooled heat exchangers are specified, they shall be in accordance with purchaser's specifications and/or industry standards such as API 661.

6.8.4.2 Air-cooled heat exchangers having a single-bundle design shall be provided with 10 % extra tubes to allow for plugging tubes in the event of tube leaks.

6.8.4.3 ● The purchaser may specify sizing and configuration of connections or "connections only" for purchaser's separate supply of air-cooled heat exchangers.

6.8.4.4 Air-cooled heat exchangers shall be in accordance with 6.8.4.4.1 through 6.8.4.4.11.

6.8.4.4.1 ● ♦ If specified, the heat exchanger shall be provided with two or more fans, and the heat exchanger shall be capable of 100 % of the duty requirement with one fan out of service.

6.8.4.4.2 The heat exchanger tubes shall be austenitic stainless steel.

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6.8.4.4.3 Heat exchanger headers shall be made of austenitic stainless steel.

6.8.4.4.4 ● The header plug material shall be selected to prevent galling.

6.8.4.4.5 ● ♦ If specified, electronic vibration transducers shall be provided for each fan to enable condition monitoring. The vendor shall advise recommended settings for fan alarm or shutdown on high vibration.

6.8.4.4.6 Belt drive requirements shall be in accordance with API 661.

6.8.4.4.7 Oil side turbulence promoters shall not be used.

6.8.4.4.8 ● Oil side turbulence promoters are permitted.

NOTE Turbulence promoters prevent laminar flow and result in smaller heat exchanger size, but also act as a trap for particulates—which increases maintenance.

6.8.4.4.9 ● Hail guards shall be provided.

6.8.4.4.10 A forced-draft heat exchanger shall be provided.

6.8.4.4.11 ● Adjustable louvers shall be provided for additional temperature control.

6.9 Filters

6.9.1 Dual full-flow filters with replaceable elements or cartridges shall be provided.

6.9.1.1 Filters shall provide a minimum particle removal efficiency of 90 % for 10 $\mu\text{m(c)}$ particles ($\beta_{10} \geq 10$) and a minimum particle removal efficiency of 99.5 % for 14 $\mu\text{m(c)}$ particles ($\beta_{14} \geq 200$), both in accordance with ISO 16889 when tested to a minimum terminal (end-of-test-run) differential pressure of 350 kPa (3.5 bar; 50 psi). See Annex K for additional information concerning filter ratings.

NOTE 2 This applies to all filters in the system, including booster-pump-discharge and control-oil filters, if provided.

NOTE 3 These filtration levels are based on the film thickness in hydrodynamic bearings. The film thickness of rolling-element bearings is typically less than 1 μm ; see Annex E for further information. Consideration of oil-film thickness and particle hardness can require even finer filtration levels.

NOTE 4 Semi-soft, resinous material that is produced as a result of oil degradation and forms “varnish” deposits, requires special types of filters for its removal. See Annex L for additional information on the subject of varnish and its mitigation. The annex also discusses the phenomenon of filter-induced electrostatic charge that is related to the varnish formation. Filters designed to control electrostatic charging are available.

6.9.1.2 ●, For systems where shutting down the equipment serviced by the oil system to change the filter element is acceptable as determined by the purchaser, a single filter shall be provided.

6.9.1.3 Since Heat exchangers can trap and release dirt and debris, The filter(s) shall be located downstream of the heat exchangers.

6.9.1.4 Dual filters shall be piped in a parallel arrangement using a continuous-flow transfer valve (see 6.10).

6.9.1.5 Filter housings that have covers weighing more than 15 kg (35 lb) shall have cover lifters.

6.9.1.6 The filter housings shall not be equipped with differential PLVs or other valves that can cause bypass of unfiltered (dirty) oil around the filter elements.

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6.9.1.7 The filter housings shall be equipped with vent and drain connections.

6.9.1.7.1 For filter designs that have separate clean and dirty oil compartments, each compartment shall include a drain.

6.9.1.7.2 The dirty-side connections shall be located lower in the housing than the filter elements or cartridge support bases to allow complete drainage of the dirty side.

6.9.1.8 • All connections on filter housings shall be flanged.

6.9.1.9 Vents and drain connections shall be plugged or blind-flanged.

6.9.1.10 • ♦ If specified, the filter housings shall be equipped with valved vents and clean- and dirty-side valved drain connections.

6.9.1.11 The equalization/fill valve shall be locked or car sealed in the open position with the equalization/fill line orifice thermally sized by the vendor.

6.9.1.12 • Oil filter housings shall be grounded with electrical grounding bonding cables to the console baseplate to mitigate static electricity build-up. See 6.2.10 NOTE 3.

6.9.2 • For dual filter arrangements where filters are not in accordance with 6.9.1.11, the vendor shall provide thermal overpressure protection of the offline filter.

6.9.3 • The oil from discharge of thermal relief valves shall be routed back to the reservoir.

6.9.4 • Filter drains shall be manifolded and extended to the skid edge.

6.9.5 Clean- and dirty-side drains shall not be manifolded together.

6.9.6 • The filter vents shall be routed back to the oil reservoir through a sight flow glass.

6.9.7 Oil filter design shall be in accordance with the following.

- a) Oil shall flow from the outside inward toward the center of the filter element.
- b) Oil flow from the center toward the outside of the filter element may be provided with purchaser's approval.
- c) Adequate support of the filter elements shall be provided to prevent them from rupturing or to prevent unfiltered (dirty) oil from bypassing the elements and reaching the equipment.
- d) Center posts and other hardware in contact with filtered oil but not integral with the filter housing shall be made of austenitic stainless steel.
- e) Stacked filter elements are not permitted.
- f) It shall be possible to drain oil from the filter housing while avoiding contamination of the downstream (clean) side with unfiltered (dirty) oil during replacement of the filter elements.

6.9.8 Nonhygroscopic filter elements shall be used (refer to Annex E).

6.9.8.1 • If a specific filter element or cartridge is required, it shall be specified by the purchaser.

6.9.8.2 Metal mesh or stainless metal filter elements are not acceptable.

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6.9.9 The pressure drop for filter assembly, including transfer valve, with clean filter elements or cartridges shall not exceed 35 kPa (0.35 bar; 5 psi) at an operating temperature of 40 °C (100 °F) and normal flow.

6.9.10 Elements or cartridges shall have a minimum collapsing differential pressure of 500 kPa (5.0 bar; 70 psi).

6.9.11 If the tops of filter housing covers are more than 1.2 m (4 ft) above the console base, the vendor shall provide a step to facilitate their maintenance.

6.9.12 Systems with booster pumps shall be provided with dual filters downstream of the pumps to protect the equipment from damage from particles resulting from pump wear.

6.9.13 • Filtration requirements of serviced equipment, such as hydraulic servo valves, shall be used when determining whether more stringent filtration requirements are necessary for the control-oil system

6.9.14 • One sample point shall be provided on each oil tank, one downstream of the lube-oil filters, and one on each common return line to allow representative samples of circulating oil to be obtained.

6.9.14.1 The sample connections shall have a valve.

6.9.14.2 A restriction orifice shall be provided on pressurized systems downstream of the filter.

6.9.15 • Filter housings and covers shall be 300 series stainless steel.

6.10 Transfer Valves

6.10.1 The vendor shall supply transfer valves independently serving each heat exchanger set and each filter set (see Figures C.20A through C.20D).

6.10.2 Transfer valves shall be two-way, continuous-flow valves. A single-body, six-port straight plug valve, with or without resilient seats, may be used or two three-way plug or ball valves permanently aligned and joined with a single operating lever may be used.

6.10.3 Transfer valves shall conform to the following provisions a) to c).

- a) Valves shall be designed so that, if the internal valve mechanisms fail, both flow paths shall not be blocked.
- b) Valves and assemblies shall be designed to prevent incorrect assembly.
- c) Transfer valves with resilient seats shall be capable of transfer without sliding contact. Resilient seats shall be positively retained.

6.10.4 Valve stems and valve plugs or balls shall be made of austenitic stainless steel.

6.10.5 • If specified, spectacle blinds shall be provided to ensure tight shutoff.

NOTE 1 Transfer valves are not intended for use as tight shutoff devices for the maintenance of filters and heat exchangers [see 9.3.3.10 i)].

NOTE 2 Transfer valves with resilient seats provide tighter shutoff.

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6.11 Accumulators

6.11.1 An accumulator shall be provided if it is needed to maintain the turbine control-oil pressure during transient flow or to maintain lube- or seal-oil pressure while the standby pump accelerates from an idle condition to operating speed at normal flow.

NOTE The decision about whether to include an accumulator is a collaborative effort between the purchaser, driven equipment OEM and oil system supplier.

6.11.2 ● A bladder-type accumulator shall be provided.

6.11.3 ● A direct-contact-type accumulator shall be provided, furnished with a manual pre-charge valve or a constant pressure-regulating system (see Figure C.19).

6.11.4 If a direct-contact-type accumulator is specified in 6.11.3, it shall be equipped with an armored reflex-type gauge glass that extends from 25 mm (1 in.) above the maximum operating level to not less than 25 mm (1 in.) below the minimum operating level. The glass shall show the oil level when the vessel is pre-charged at the controlled normal operating pressure.

6.11.5 ● A minimum 2-inch (DN 50) connection for an accumulator shall be included. The connection shall be flanged and shipped with a blind flange installed including bolts and gaskets that match the project pipe specifications.

6.11.5.1 If the service of the accumulator is to support the system pressure during pump changeover, the accumulator shall be installed on the console.

6.11.5.2 If the service of the accumulator is to maintain the control-oil pressure during transient movements of hydraulic actuators, the accumulator shall be installed close to the actuator to achieve proper dynamic response.

6.11.5.3 When necessary, multiple accumulator systems shall be used as necessary to achieve the proper dynamic response.

6.11.6 The control-oil pressure shall be maintained above the equipment manufacturer's minimum specified supply pressure for all operating conditions (including transients).

NOTE Typically, this occurs during a 1-second full stroke actuation.

6.11.7 The system delivery pressure shall be maintained above the shutdown settings during standby pump acceleration.

6.11.8 Acceptable system response shall be verified during shop testing [see 9.3.3.10 e)].

NOTE Field-related factors such as voltage line loss during starting, or DCS response time can affect motor start initiation or acceleration time and might not necessarily be replicated during shop testing.

6.11.9 ● ♦ If specified, accumulator vessels shall be made of austenitic stainless steel.

6.11.10 Bladder-type accumulators shall be supplied with an oil-side anti-extrusion feature (see Figure C.18).

6.11.11 A connection shall be provided for charging and checking the pre-charge pressure in the accumulator.

6.11.12 The physical location and piping arrangement of the accumulator shall avoid pockets in which foreign materials or air could accumulate.

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6.11.13 • The accumulator shall have provision for heat trace and insulation to maintain the contained oil at the required system oil temperature.

6.11.14 Accumulator designs shall not allow precharge gas to be delivered with the oil to the equipment or to impair the flow of the oil to the equipment.

6.11.15 Accumulators shall be isolated (for example, by a check valve; see Figure C.18) from the standby-oil-pump start controls to eliminate delay in the actuation of the starting signal.

6.11.16 To avoid the risk of shutdown due to large oil pressure swings during accumulator draining or filling while the machine is operating, Provisions shall be included to allow for controlled filling and draining of the accumulator.

NOTE 2 Block valves and calibrated restriction orifices or gate valves (due to the time necessary to open manually, as compared to ball valves) are examples of devices to be considered. Accumulator size is also a prevailing factor.

NOTE 3 Bladder-type accumulator pre-charge pressures can only be checked if the oil is drained from the accumulator, i.e. if the bladder is fully expanded.

6.11.17 • A rotating-type sight glass shall be installed in the accumulator bleed-down to the reservoir or drain header.

6.11.18 • The accumulator block valve shall be locked or car sealed in the open position.

6.11.19 Thermal overpressure protection of the accumulator shall be provided during accumulator isolation.

6.11.19.1 Thermal overpressure protection of the accumulator during maintenance shall be provided. Refer to Figure C.19.

6.11.19.2 Thermal overpressure protection resulting from fire, for example if the FCV fails in the closed position, shall be provided.

6.11.20 A nozzle with minimum size of ON 150 (NPS 6) shall be provided for accessing and inspecting the interior of the accumulator.

6.12 Overhead Tanks

6.12.1 General

If overhead tanks are specified, they shall be provided with the following.

a) 6.12.1.1 Tanks shall be made of austenitic stainless steel.

b) 6.12.1.2 Installation height of the overhead oil tank above the equipment shaft centerline shall be specified by the vendor having unit responsibility.

c) 6.12.1.3 Except for pressurized lube-oil rundown tanks, a level transmitter externally mounted to the tank and provided with isolation valves, a vent connection, and a valved drain.

d) 6.12.1.4 For pressurized tanks, the vent connections of level instruments shall be valved.

e) 6.12.1.5 The minimum design pressure rating of pressurized overhead tanks must be at least equal to the oil supply header design pressure.

6.12.1.6 Overhead tanks shall be provided with ground clips or pads.

6.12.2 Lube-oil Rundown Tanks

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6.12.2.1 ● A separately mounted emergency lube-oil rundown tank, either atmospheric in accordance with Figure C.15 or pressurized in accordance with Figure C.16, shall provide oil for the coast-down period.

6.12.2.2 The coast-down period shall be determined by the equipment train supplier. The coast-down period can be affected by process controls and operational characteristics (e.g. bypass valves, recycle loops, block and vent valves).

6.12.2.3 The lube oil rundown tank shall be sized for the specified coast-down period, but not less than 3 minutes of normal operating lube-oil flow.

NOTE This minimum sizing criteria can result in more than 3 minutes of coast-down oil flow due to supply pressure decay.

6.12.2.4 A sight flow glass shall be provided in the rundown tank overflow line and positioned in a location that can be readily observed.

NOTE Typical locations include on top of the reservoir or in the lube-oil drain header.

6.12.2.5 The overflow line shall be continuously sloped, with no pockets.

6.12.2.6 A nozzle with minimum size of DN 150 (NPS 6) shall be provided for accessing and inspecting the interior of the rundown tank. Alternatively, for atmospheric rundown tanks, a bolted cover may be provided in lieu of the nozzle.

6.12.2.7 For atmospheric rundown tanks, a drilled check valve or an orifice plate piped in parallel and fill valve shall be provided (see Figure C.15).

6.12.2.8 The bottom outlet connection of emergency lube oil run-down tanks shall extend at least 25 mm (1 in) inside the vessel to retain foreign matter.

6.12.2.9 The emergency lube-oil rundown tank vent shall be equipped with a filter-breather cap having a rain hood and with filtration rating of 10 µm beta 10 or better.

6.12.2.10 The tank shall be designed to ensure appropriate minimum oil head pressure at the near-empty condition, while not exceeding the oil pressure shutdown setting at the full condition.

6.12.2.11 Atmospheric rundown tanks shall be provided with low-level alarm and high-level permissive start functions. These functions may be served by a common device.

NOTE Because an atmospheric rundown tank is typically mounted in unmanned areas and is already equipped with level instrumentation, a level gauge is not needed.

6.12.2.12 Pressurized rundown tanks do not require level instrumentation.

6.12.2.13 ● For pressurized rundown tanks, a bypass orifice around the ball float check valve shall be provided to help prevent sticking of the ball float due to vacuum in the spillover line. See Figure C.16.

6.12.3 Seal-oil Tanks

6.12.3.1 Separately mounted or equipment-mounted overhead tanks shall be provided if they are required by the designs of the seals and the seal-oil control systems.

6.12.3.2 Each overhead seal-oil tank (see Figure 3) shall be sized so that the oil capacity above the low-level alarm setting is equal to a 2-minute flow at normal seal-oil rates.

6.12.3.2.1 ● Each tank shall have the capacity for a 10-minute flow from low-level alarm to low-low-level shutdown plus sufficient time (as specified by the purchaser, but not less than 3 minutes at normal flow rates after shutdown) for coast-down, block-in, and depressurization of the equipment.

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6.12.3.2.2 Larger tanks can be required for special operating conditions, such as rapid depressurization of high-pressure equipment.

6.12.3.2.3 The vapor column above the high-level alarm setting shall be no less than 1 minute of normal flow.

6.12.3.2.4 The purchaser and the manufacturer together shall determine the required capacity after shutdown, based on the compressor block-in and blowdown and the seal-oil flow rate for various conditions.

6.12.3.3 The elevation shall be established to ensure appropriate minimum seal-oil head pressure.

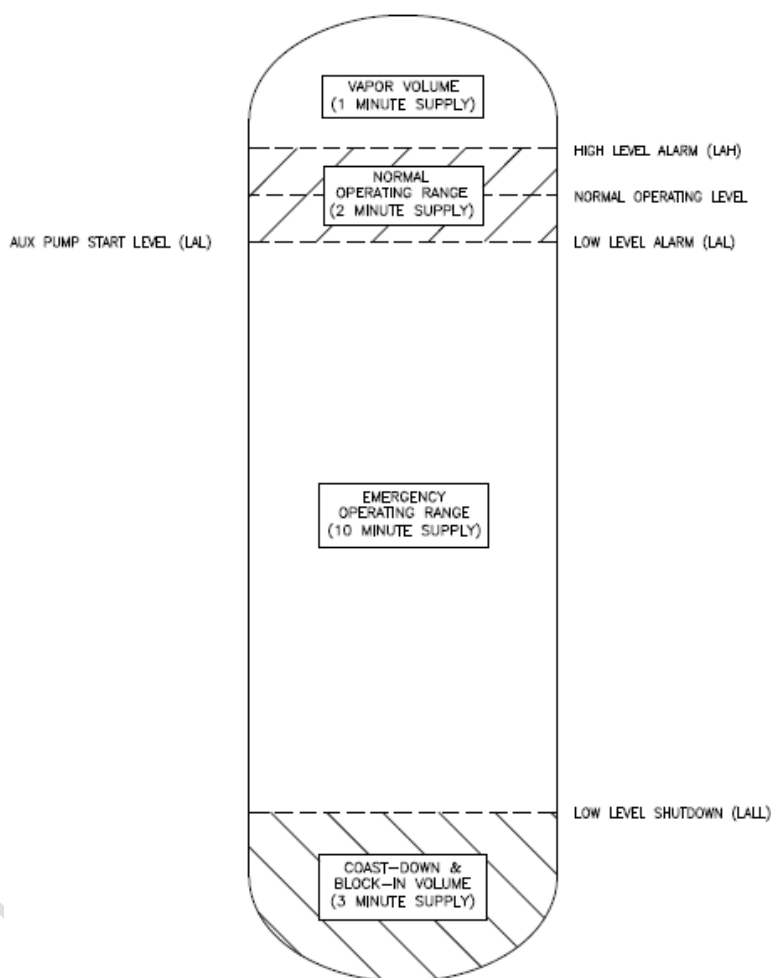


Figure 3—Overhead Seal-oil Tank Levels and Volumes

6.12.3.4 Overhead seal-oil tanks shall be provided with the following items a) to g):

- a) one bottom outlet nozzle, at least DN 150 (NPS 6) in size, which does not extend inside the vessel; this nozzle shall be used for internal access and inspection;
- b) one reference gas connection at least DN 25 (NPS 1) in size;
- c) reference line that is routed to prevent traps that can accumulate liquid;
- d) full-length reflex-type level glass that extends from 25 mm (1 in.) above the high-level alarm to 25 mm (1 in.) below the low-level shutdown;

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- e) one DN 150 × DN 50 (NPS 6 × NPS 2) flanged reducing spacer that is 450 mm (18 in.) long and is fitted to the bottom outlet connection;

6.12.3.4.1 ● For dirty, sludge-building gas service, a valved blowdown connection shall be provided (see Figure 4)

NOTE A flow-through system helps reduce sludge build-up.

6.12.3.4.2 The oil inlet/outlet nozzle shall project at least 200 mm (8 in.) into the reducing spacer

6.12.3.4.3 ● A level transmitter externally mounted to the tank and provided with isolation valves, a vent connection, and a valved drain.

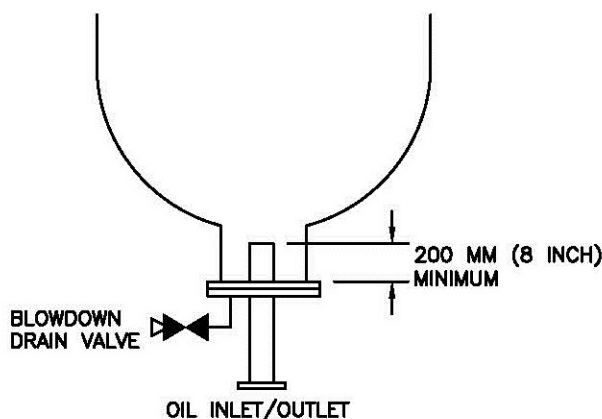


Figure 4—Blowdown Connection Configuration

6.12.3.5 ● If specified, the reference gas shall be isolated from the seal oil by a bladder of material suitable for the service (see Figure C.17).

NOTE The presence of free water, dirt, and dissolved gases in lubrication, control and seal oil can contribute to accelerated wear, corrosion, sludge formation and sticking of hydraulic controls. Dilution or contamination of compressor seal oil by hydrocarbons, hydrogen sulfide, and other contaminants also causes a reduction in viscosity and flashpoint. Oil-condition maintenance procedures and equipment should be considered during project planning.

6.13 Seal-oil Drain Traps

6.13.1 Seal oil drain traps shall be provided with the following:

6.13.1.1 One drain trap shall be provided per seal.

6.13.1.2 An emergency line and isolating valves and valve to cross-connect trap inlets and permit trap maintenance shall be provided where seals operate at the same oil-sealing pressure (see Figure C.14).

6.13.2 ● Spectacle blinds shall be provided to isolate individual seal-oil drain traps during maintenance.

6.13.3 Drainer bypass orifices shall be a minimum of 1 1/2 mm (1/16 in.).

6.13.4 Automatic seal traps are required.

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6.13.4.1 For gas pressures less than or equal to 5 MPa (50 bar; 725 psig), mechanical float-type traps are permitted.

6.13.4.2 The float and trim shall be the single-lever, stainless steel design and arranged so that the gas flow does not impinge upon the float or float mechanisms.

6.13.5 For pressures greater than 5 MPa (50 bar; 725 psig), snap-acting level transmitter/controllers and separate control valves shall be used.

6.13.6 ● Level transmitter control-type traps shall be used if gas fouling interferes with the operation of mechanical float-type traps.

6.13.7 Drain traps shall be pre-piped and mounted in a package arrangement.

6.13.7.1 All appurtenances shall be located within the confines of the package base.

6.13.7.2 Manually operated drain valves shall be provided on each trap.

6.13.8 Traps shall be furnished with reflex-type gauge glasses and equipped with provisions for flushing

6.13.9 The inlet piping shall enter the seal traps above the oil level of the traps.

6.13.10 Seal-trap vents shall be equipped with mist eliminators (with appropriate connections) to agglomerate the residual oil before the vent gas is recycled to the compressor suction or vented to other disposal outlets.

6.13.11 Mist eliminators shall be self-draining or provided with separate automatic drain traps.

6.13.12 The seal oil trap vent piping arrangement shall be jointly developed by the purchaser and the vendor to ensure proper function of the compressor shaft seals (compressor oil seals).

6.13.12.1 The seal oil trap vent piping shall be arranged to avoid pocketing of liquids.

6.13.12.2 System backpressure, motive flow available, and other issues shall be accounted for the in the seal oil trap vent piping.

6.13.13 ● The drain line for each trap shall be piped to a proper disposal system, to the degassing drum or to the reservoir, as specified.

6.13.14 ● Separate drain lines shall be provided for each seal oil trap to allow for the monitoring of seal leakage for each seal.

6.13.15 Level-transmitter-controller-type drain traps shall be considered pressure vessels.

6.13.16 Seal oil drain trap systems shall be sized for the 2 times total guaranteed inner-seal-oil leakage rate considering all operating conditions including startup, normal and settle out.

NOTE Seal oil drainer valve and orificed bypasses can be necessary for unit startup when insufficient casing gas pressure is present .

6.14 Degassing Drum

6.14.1 ● Seal-oil degassing facilities shall be provided.

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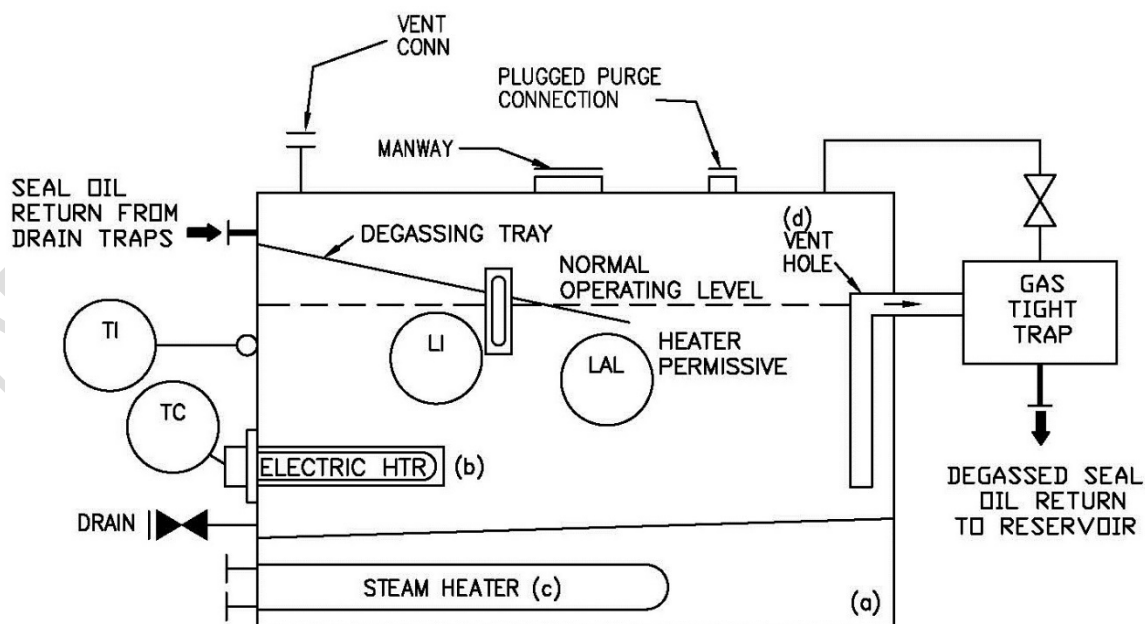
6.14.2 Tank and internals shall be made of austenitic stainless steel.

6.14.3 The degassing drum shall be a single-chamber tank (see Figure 5) provided with the following features a) to g):

- a) sloped inlet tray, extending below the operating level, which ensures that the oil enters the tank in a thin layer to facilitate degassing;
- b) oversized gas-vent connection to handle the flow of gas from the seals through the oil drains;
- c) the size of the gas-vent connection is at least DN 50 (NPS 2);
- d) the gas-vent connection is flanged;
- e) the vent gas connection is routed by the purchaser to an appropriate location based on dispersion analysis;

NOTE Environmental considerations sometimes do not allow atmospheric venting. In such cases, the gas is often directed to vapor recovery systems.

- f) purge connection with a minimum size of DN 25 (NPS 1);
- g) cleanout opening and a valved, low-point drain;
- h) weld-pad reflex level glass extending a minimum of 50 mm (2 in.) above and 50 mm (2 in.) below the operating level;
- i) temperature indicator with a thermowell;
- j) level transmitter for high alarm and, if an oil heater is specified, low-level interlocking;
- k) Provide a 3 mm (1/8 in.) vent hole inside the degassing tank on the oil outlet pipe.



Key

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- a Refer to 6.14 for design details.
- b Purchaser can specify an electric heater.
- c Purchaser can specify a steam heater.
- d Provide a 3 mm ($1/8$ in.) hole inside the degassing tank. The trap prevents the gas from entering the reservoir via the hole.

Figure 5—Typical Degassing Drum Arrangement

6.14.4 ● An electric immersion heater, steam heater, or some other method of heating shall be provided to assist in degassing the oil.

6.14.4.1 If a steam heater is used, it shall be external to the drum and shall be removable.

6.14.4.2 If an electric immersion heater is used, its heat flow (power) density shall not exceed 2 W/cm² (15 W/in.²).

6.14.5 Electric heater elements shall be sheathed in austenitic stainless steel; copper or copper-bearing materials shall not contact the oil.

6.14.6 The vendor shall provide temperature element and controls for the heater as mutually agreed upon with the purchaser.

6.14.7 Electric immersion heaters shall be interlocked to be de-energized if the oil level drops below the heater.

6.14.8 The drum shall have a 4-hour minimum retention time, based on the total expected inner-seal-oil leakage rate for all seals operating at twice the maximum allowable design clearance or a minimum liquid volumetric capacity of 60 l (15 gal) per compressor body, whichever is greater.

6.14.9 ● The degassing drum shall be designed and constructed for pressurized service in accordance with design pressure and temperature requirements supplied by the customer.

7 Piping

7.1 General

7.1.1 Piping Design

7.1.1.1 Piping design and joint fabrication examination and inspection shall comply with the design code specified in 6.3.

7.1.1.2 Welding of piping shall be performed in accordance with 6.4.

7.1.1.3 The permissible working pressure depends upon the materials, design, and working temperature and shall be selected from the pressure/temperature rating tables in corresponding standards.

7.1.2 Auxiliary systems are defined as piping systems that are in the following services.

a) Group I—Auxiliary process fluids (see Table 3):

- 1) sealing fluid;
- 2) gland and flushing fluid;

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- 3) recirculation fluid;
 - 4) balance gas;
 - 5) buffer/reference/purge gas ;
 - 6) separation gas;
 - 7) solvents injection;
 - 8) drains and vents associated with group I systems.
- b) Group II—Steam and air (see Table 4):
- 1) sealing steam;
 - 2) steam injection;
 - 3) water injection;
 - 4) starting gas (air or nitrogen only);
 - 5) instrument and control air;
 - 6) drains and vents associated with group II systems.
- c) Group III—Cooling water (see Table 5):
- 1) cooling water;
 - 2) liquid wash (water based);
 - 3) drains and vents associated with group III systems.
- d) Group IV—Lubricating, control, and seal oil (see Table 6):
- 1) lubricating oil;
 - 2) control oil;
 - 3) seal oil (see 7.4 for seal oil contaminated with process fluid);
 - 4) drains and vents associated with group IV systems.

7.1.3 Auxiliary systems shall comply with the requirements of Tables 3 through 7, except as modified in referencing standards.

NOTE Casing connections are covered in the associated equipment standards.

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Table 2—Minimum Requirements for Piping Materials—Auxiliary Process Fluid

Pipe	Austenitic stainless steel (e.g. ASTM A312 Type 304 or 316 or the equivalent material designation located in Annex F); seamless, except Schedule 10S and 40S may be electric fusion welded; seamless carbon steel (e.g. ASTM A106-B, A53-B or the equivalent material designation located in Annex F)
Pipe fitting	Austenitic stainless steel (e.g. ASTM A403 or the equivalent material designation located in Annex F, Type 304 or 316 stainless steel); seamless, except Schedule 10S and 40S may be electric fusion welded; austenitic stainless steel, (e.g. ASTM A182 Type 304 or 316 or the equivalent material designation located in Annex F), Class 3000; seamless carbon steel (e.g. ASTM A234 or the equivalent material designation located in Annex F); carbon steel (e.g. ASTM A105 or the equivalent material designation located in Annex F), Class 3000
Flange	Austenitic stainless steel (e.g. ASTM A182 Type 304 or 316 or the equivalent code material designation located in Annex F) weld neck or slip-on; carbon steel (e.g. ASTM A105) or the equivalent material designation located in Annex F, weld neck or slip-on
Tubing	Stainless steel (ASTM A269 Type 316 or the equivalent material designation located in Annex F)
Tube fittings	Austenitic stainless steel Type 316
Flange gaskets	For less than or equal to ANSI Class 300, flat, non-asbestos type or spiral wound is permitted. For greater than or equal to ANSI Class 600, spiral wound gaskets are required. Spiral-wound gaskets shall have non-asbestos filler, 304 or 316 windings and inner ring; external centering ring may be coated carbon steel.
Flange bolting	Refer to 7.1.34 and 7.1.36.
Valves	Refer to 7.1.27, 7.1.29, 7.1.30, 7.1.31, 7.1.32, 7.3.7, 7.3.9, and 7.3.12.
NOTE This table does not apply to materials used for gases regarded as sour.	

Table 3—Minimum Requirements for Piping Materials—Steam and Air

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Pipe	Seamless, carbon steel (e.g. ASTM A106-B, A53-B or the equivalent material designation located in Annex F)
Pipe fitting	Seamless, carbon steel (e.g. ASTM A234 or the equivalent material designation located in Annex F) Carbon steel (e.g. ASTM A105 Class 3000 or the equivalent material designation located in Annex F)
Flange	Carbon steel (e.g. ASTM A105 or the equivalent material designation located in Annex F), weld neck or slip-on
Tubing	Stainless steel (e.g. ASTM A269 or the equivalent material designation located in Annex F), Type 316
Tube fittings	Stainless steel Type 316
Flange gaskets	For less than or equal to ANSI Class 300, flat, non-asbestos type or spiral wound is permitted. For greater than or equal to ANSI Class 600, spiral wound gaskets are required. Spiral-wound gaskets shall have non-asbestos filler, 304 or 316 windings and inner ring; external centering ring may be coated carbon steel.
Flange bolting	Refer to 7.1.34 and 7.1.36.
Valves	Refer to 7.1.27, 7.1.29, 7.1.30, 7.1.31, 7.1.32, 7.3.7, 7.3.9, and 7.3.12.

Table 4—Minimum Requirements for Piping Materials—Cooling Water

Pipe	Carbon steel (e.g. ASTM A106-B and A53-B or the equivalent material designation located in Annex F), seamless
Pipe fitting	Carbon steel (e.g. ASTM A234 or the equivalent material designation located in Annex F), seamless Carbon steel (e.g. ASTM A105 or the material designation located in Annex F), Class 3000
Flange	Carbon steel (e.g. ASTM A105 or the equivalent material designation located in Annex F), weld neck or slip-on
Tubing	Stainless steel (e.g. ASTM A269 or the equivalent material designation located in Annex F), Type 316
Tube fittings	Stainless steel Type 316
Flange gaskets	Flat, nonasbestos type or spiral wound is permitted.
Flange bolting	Refer to 7.1.34 and 7.1.36.
Valves	Refer to 7.1.27, 7.1.29, 7.1.30, 7.1.31, 7.1.32, 7.3.7, 7.3.9, and 7.3.12.
NOTE Salt or brackish cooling water can require alternative materials.	

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Table 5—Minimum Requirements for Piping Materials—Lubricating, Control, and Seal Oil

Pipe	Stainless steel (e.g. ASTM A312 Type 304 or 316 or the equivalent material designation located in Annex F); seamless, except Schedule 10S and 40S may be electric fusion welded
Pipe fitting	Stainless steel (e.g. ASTM A403 Type 304 or 316 stainless steel or the equivalent material designation located in Annex F); seamless, except Schedule 10S and 40S may be electric fusion welded Stainless steel (e.g. ASTM A182 Type 304 or 316 stainless steel or the equivalent material designation located in Annex F), Class 3000. Socket weld fittings are prohibited.
Flange	Stainless steel (e.g. ASTM A181 Type 304 or 316 stainless steel or the equivalent material designation located in Annex F), weld neck or slip-on. Socket weld flanges are prohibited.
Tubing	Stainless steel (e.g. ASTM A269 316 stainless steel or the equivalent material designation located in Annex F)
Tube fittings	Stainless steel Type 316
Flange gaskets	For less than or equal to ANSI Class 300, flat, non-asbestos type or spiral wound is permitted. Compressed sheet-type gaskets containing graphite are not permitted due to their tendency to contaminate the oil stream by shedding graphite particles. For greater than or equal to ANSI Class 600, spiral wound gaskets are required. All spiral-wound gaskets shall have non-asbestos filler, 304 or 316 windings and inner ring; external centering ring may be coated carbon steel. Graphite is permitted as the filler material on spiral wound gaskets.
Flange bolting	Refer to 7.1.34 and 7.1.36.
Valves	Refer to 7.1.27, 7.1.29, 7.1.30, 7.1.31, 7.1.32, 7.3.7, 7.3.9, and 7.3.12.

Table 6—Minimum Pipe Wall Thicknesses

Materials	Nominal Pipe Size Minimum		
	DN	in.	Schedule
Carbon steel	≤ DN 40	(≤ 1 1/2)	80
Carbon steel	DN 50 to 200	(2 to 8)	40
Carbon steel	≥ DN 250	(≥ 10)	20
Stainless steel	≤ DN 25	(≤ 1)	80S
Stainless steel	DN 40 to 75	(1 1/2 to 3)	40S
Stainless steel	≥ DN 100	(≥ 4)	10S

Table 7—Minimum Tubing Wall Thicknesses

Nominal Tubing Size ^{a,c}		Minimum Wall Thickness	
mm	in.	mm	in.
6	(1/4) ^b	1.0	0.035

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10	$(\frac{3}{8})^b$	1.0	0.035
12	$(\frac{1}{2})$	1.5	0.065
20	$(\frac{3}{4})$	2.5	0.095
25	(1)	2.5	0.109
^a The tubing size is the outside diameter. ^b The sizes 6 mm ($\frac{1}{4}$ in.) and 10 mm ($\frac{3}{8}$ in.) are permitted for instrument and control air only. ^c Refer to 7.1.20.			

7.1.4 Piping systems shall include all components needed, such as piping, tubing where permitted, isolating valves, control valves, relief valves, pressure reducers, orifices, temperature gauges and thermowells, pressure gauges, sight flow indicators, and all related vents and drains.

7.1.5 Welding together of carbon steel and stainless steel pipe materials within the same spool is not permitted.

7.1.6 The vendor shall identify any bimetallic welds to non-pipe components, such as isolating valves, control valves, or relief valves for purchaser approval.

7.1.7 The vendor shall furnish all piping systems, including mounted appurtenances, located within the confines of the main unit's base area, any oil console base area, or any auxiliary base area.

7.1.7.1 The piping shall terminate with flanged connections at the edge of the base.

NOTE Connections for the main or auxiliary turbine are typically exempted from termination at skid edge.

7.1.7.2 The purchaser shall furnish only interconnecting piping between equipment groupings and off-base facilities.

7.1.8 ● The extent of the piping system at the equipment train shall be defined by the purchaser when sole plates are specified..

7.1.9 The design of piping systems, including internal reservoir piping, shall be subject to agreement between the vendor and the purchaser.

7.1.10 The design of piping systems, including internal reservoir piping, shall achieve the following:

- a) proper support and protection to prevent damage from vibration or from shipment, operation, and maintenance;
- b) proper flexibility and normal accessibility for operation, maintenance, and thorough cleaning;
- c) installation in a neat and orderly arrangement adapted to the contour of the machine without obstructing access openings;
- d) To ensure that the function of standby pumps is not impaired due to vapor/air accumulation at a high point in the suction piping, air pockets are to be eliminated by the use of valved vents, continuous recirculation, or nonaccumulating piping arrangements;
- e) complete drainage through valved low points without disassembly of piping;

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- f) adequate space allocation for site-installed interconnecting piping and wiring within the confines of the skid;
- g) vents and drains subject to toxic or flammable fluids, and not connected to a manifolded system, are to be be valved and blinded or plugged;
- h) vents and drains that are connected to pressurized systems are equipped with protection from reverse flow;
- i) piping that is free of pockets, traps, or nondrainable low points that may collect debris and prevent thorough flushing and drainage;
- j) use of hoses or bellows requires purchaser approval.

7.1.11 Piping shall be fabricated by bending and welding to minimize the use of flanges and fittings where practical.

7.1.12 Welded flanges are required at equipment connections, at the edge of any base and for ease of maintenance.

7.1.13 Mitered elbows require purchaser approval.

7.1.14 Welded pipe bushings are acceptable only at the drain connections on pump suction strainers where the strainer cannot be rotated.

NOTE Y strainers have oversized drain connections. If a bushing is not allowed, it is necessary to elevate the entire pipe and system to include a drain valve.

7.1.15 Pipe threads shall be taper threads in accordance with ASME B1.20.1 or ISO 7-1.

NOTE 1 For the purposes of this provision, ASME B1.20.1 is equivalent to ISO 7-1.

NOTE 2 Straight threads are sometimes used for instrument or hydraulic connections and have another sealing method such as O-rings or metal-to-metal seating.

7.1.16 A process-compatible thread sealant/lubricant that meets the proper temperature specification shall be used on all non-seal-welded threaded connections.

7.1.17 Tape shall not be used on threaded connections.

7.1.18 Threaded joints shall not be seal welded.

NOTE 1 Seal welding is not the preferred method to join piping and accessories for a number of reasons including to the potential for crevice corrosion, corrosion from process fluids, residual stresses on the threads, and difficulty of inspecting joints. However, seal welding can be necessary in situations where there are no readily available practical solutions. Some examples are:

- instrument sensing lines connecting tubing to root valves;
- plugged threaded drain and vent valves with seal welding on piping side and bull plugs on atmospheric side, where space is limited;
- smaller strainer drains;
- small components not available with integral flanges; any flanges will be seal welded;

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— orifice flange taps.

NOTE 2 Seal welding is discouraged because of the potential for crevice corrosion, corrosion from process fluids, residual stresses on the threads, or difficulty of inspecting joints.

7.1.19 Flanges shall be in accordance with the pressure design code.

7.1.19.1 The Class system applies and all flanges shall conform to ASME B16.1, B16.5, B16.42 or B16.47 Series B as applicable.

7.1.19.2 ● For the PN system, all flanges shall conform to EN 1092-1 or EN 1092-2 as applicable, except as specified in 7.1.17.3 through 7.1.17.9.

7.1.19.3 Steel flanges shall conform to the dimensional requirements of ASME B16.5 or B16.47 Series B or EN 1092-1 as applicable.

7.1.19.4 ● ASME B16.47 Series A steel flanges shall be provided for Class system flanges.

7.1.19.5 ● Class 125 flanges shall have a minimum thickness equal to Class 250 for sizes NPS 8 and smaller. PN16 flanges shall have a minimum thickness equal to PN25 for sizes DN 200 and smaller.

7.1.19.6 The dimensional requirements of flanges in materials other than those covered in 7.1.17.1 through 7.1.17.5 shall conform to the dimensional requirements of the flanges specified in 7.1.17.1 or 7.1.17.2.

7.1.19.7 Pressure and temperature ratings shall be considered for materials not covered by referenced flange standards.

7.1.19.8 Flanges shall be full faced or spot faced on the back.

7.1.19.9 Flanges shall be designed for through bolting.

7.1.19.10 For all steel flanges, imperfections in the flange facing finish shall not exceed that permitted in ASME B16.5 or ASME B16.47 as applicable.

7.1.19.11 ● Machined and studded connections shall conform to the facing and drilling requirements of ASME B16.1, B16.5, B16.42 or B16.47 or EN 1092-1, EN 1092-2, as specified.

7.1.19.12 Studs and nuts shall be provided installed, and the first 1.5 threads at both ends of each stud shall be removed.

7.1.19.13 Machined and studded connections and flanges not in accordance with ASME B16.1, B16.5, B16.42 or B16.47 or EN 1092-1, EN 1092-2 require purchaser's approval. Unless otherwise specified, the vendor shall supply mating flanges, studs, and nuts for these nonstandard connections.

7.1.19.14 The vendor shall supply mating flanges, studs, and nuts for connections not in accordance with ASME B16.1, B16.5, B16.42 or B16.47 or EN 1092-1, EN 1092-2

7.1.19.15 SAE 4-bolt flanges are only permitted for equipment connections or when space restrictions exist.

7.1.19.16 Proposal shall indicate the location, the design style, and the quantities of SAE J518/ISO 6162 connections.

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NOTE Common configurations of the flange design include a one-piece butt weld connection with or without an integral sealing O-ring, alternatively as a one-piece slip-on flange or as two split halves to clamp the pipe connector.

7.1.20 Since socket welded connections have the potential to trap dirt and debris, Socket welded connections within the lube-, control-, or seal-oil systems are not permitted.

7.1.21 For other services, if socket-welded construction is used, there shall be a 1.5 mm ($1/16$ in.) gap between the pipe end and the bottom of the socket before welding.

NOTE 1 ASME B31.3 includes typical details of socket-weld construction.

7.1.22 Connections, piping, valves, and fittings that are DN 32 (NPS $1\frac{1}{4}$), DN 65 (NPS $2\frac{1}{2}$), DN 90 (NPS $3\frac{1}{2}$), DN 125 (NPS 5), DN 175 (NPS 7), or DN 225 (NPS 9) in size shall not be used.

7.1.23 In lieu of use of piping in sizes DN 15 (NPS $1/2$), DN 20 (NPS $3/4$) or DN 25 (NPS 1) pipe, seamless tubing may be furnished in accordance with Tables 3 to 6 with purchaser approval.

7.1.24 Coupling/unions in tubing systems shall be located at least 1 m (3.28 ft) from equipment components, such as turbine casings and steam piping, where there is a risk of ignition of the fluid (e.g., surface temperatures above the hot-surface ignition temperature).

7.1.25 Tubing sizes larger than 1 in. require purchaser's approval, since special tooling and assembly methods are needed for tubing sizes larger than 1 in. (25 mm).

7.1.26 Minimum piping connection shall be DN 15 (NPS $1/2$). For instrument or valve connections, refer to 7.3.3.

7.1.27 Piping systems furnished by the vendor shall be fabricated, installed in the shop, and properly supported.

7.1.28 Pairs of adjacent bolt holes for flanged connections shall straddle lines parallel to the main horizontal or vertical centerline of the flange.

7.1.29 Tapped openings shall be plugged with solid, round-head, steel plugs furnished in accordance with ASME B16.11.

7.1.29.1 As a minimum, these plugs shall meet the material requirements of the piping system.

7.1.29.2 Plugs that can require later removal shall be of corrosion-resistant material.

7.1.29.3 Plastic plugs are not permitted.

NOTE This section refers to piping only. Plugs on instrument valves and equipment, such as filters, or heat exchangers, are covered in their appropriate sections.

7.1.30 The root pass of all butt welds on stainless steel pipe shall be made by tungsten inert-gas arc welding. Filler passes may be made by tungsten inert-gas arc welding, shielded metal arc, gas metal arc, flux core, or submerged arc welding processes.

7.1.31 ● Special requirements for piping, flanges, gaskets, instruments and O-rings, valves, sight flow indicators, strainers, and other appurtenances in special and/or hazardous service shall be specified by the purchaser.

7.1.32 Hand-operated block and bypass valves shall have bolted bonnets and glands.

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7.1.33 For service ratings greater than or equal to ANSI Class 900, block valves may be of bolted bonnet, welded bonnet, or no-bonnet construction with a bolted gland; these valves shall be suitable for repacking under pressure.

7.1.34 Wafer check valves in sizes DN 50 (NPS 2) and larger shall be in accordance with API 594.

7.1.35 Wafer check valves shall not be used in hazardous process fluid (gas or liquid) or steam service.

7.1.36 Nonmetallic seats shall not be used.

7.1.37 If drilled check valves are provided, they shall be labelled with stainless steel tags stamped indicating that they are drilled and the size of the drilled hole.

7.1.38 Block valves shall be supplied with nominal 13Cr stainless steel trim.

NOTE Certain fluid applications can require alternate trim materials (i.e. H₂S service). See 7.1.2.

7.1.39 • Test valves in oil lines shall be vented back to the reservoir. Test valves may be combined with instrument valves supplied in accordance with 7.3.6.

7.1.40 The bolting for pressure joints, valves and piping shall be in accordance with ASME B31.3 or the appropriate specified code.

7.1.40.1 As a minimum, according to the requirements of ASME B1.1 or the appropriate specified code, this bolting shall be ASTM A193/A193M-07, Grade B7, or the equivalent material.

7.1.40.2 Nuts shall be ASTM A194/A194M-07, Grade 2H nuts, or the equivalent material.

7.1.40.3 Cadmium plated studs, bolts, and nuts shall not be used.

7.1.41 • Flange bolting shall be treated to resist atmospheric corrosion.

7.1.42 Through studs shall be used.

7.1.43 • Each utility such as air and inert-gas supply, cooling water supply and return lines, and others as specified shall be manifolded to a common connection.

NOTE For manifolding of oil drains, see 7.1.40 to clarify that manifolding of utility lines does not refer to oil drain lines.

7.1.44 The manifold shall be sized to handle the maximum flow through all components that can require the simultaneous use of the specified utility.

7.1.45 • Valves shall be in accordance with purchaser-specified standards in addition to the mandated requirements of this standard.

7.1.46 • Flanged gate valves shall be in accordance with API 600, ISO 10434, API 602, or ISO 15761, or API 603 in addition to the mandated requirements of this standard. These standards apply to valve sizes DN 100 (4 NPS) and smaller.

NOTE 1 For the purposes of this provision, API 600 is the equivalent of ISO 10434.

NOTE 2 For the purposes of this provision, API 602 is the equivalent of ISO 15761.

7.1.47 Piping and components between double block valves shall be suitable for the more severe line classification on either side of the double block valve.

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7.1.48 Piping supports for valves shall allow removal of the valve while maintaining support of the piping.

7.1.49 Valves DN 50 (NPS 2) and larger shall be flanged.

7.2 Lubricating, Control, and Seal-oil Piping

7.2.1 Individual gravity-flow oil return drain line(s) and header(s) from equipment housings shall:

- a) run no more than half full if flowing at normal drain operating conditions, at maximum flow conditions (see Annex H);

NOTE 2 Oil drain sizing can be influenced by oil viscosity, slope of the oil drain piping, pitch and roll-of offshore installations, location of the oil reservoir with respect to the serviced equipment, and other site-specific criteria.

- b) have a continuous downward slope of not less than 4 % (40 mm per meter, 1/2 in. per foot) toward the reservoir;
- c) be self-venting;
- d) be equipped with breather(s)/vent(s) at appropriate locations in the system to maintain atmospheric pressure in the oil lines, avoid vacuum or backpressure, and promote free oil flow
- e) maintain the free air space above the liquid level (i.e. avoid hydraulic damming or obstruction of flow);
- f) have lateral branches (not more than one in any transverse plane) enter drain headers at approximate 45° angles in the direction of flow;
- g) be designed such that after the equipment drain connection point, individual return lines have no reduction in pipe diameter between the source and reservoir;

NOTE Some equipment, such as gearboxes, could have oversized oil drain connections. In such cases, reduction from the connection to the oil return header using an eccentric reducer ensures complete drainage.

- h) all drain lines other than inner seal-oil drain lines have a minimum size of DN 25 (NPS 1).

7.2.2 Piping shall be in accordance with Tables 6, 7, and 8.

7.2.3 Nonconsumable backup rings and sleeve-type joints shall not be used.

7.2.4 Pressure piping downstream of oil filters shall be free from internal obstructions that can accumulate debris. (See Table 6)

7.2.5 Piping and tubing, including fittings, shall be made of stainless steel. (See Table 6)

7.2.6 Provision shall be made for bypassing the bearings (and seals if applicable) of equipment during oil system flushing operations.

NOTE 1 The equipment supplier with unit responsibility defines the necessary permanent and temporary accessories required for flushing the bearings.

NOTE 2 Provisions for flushing connections could consist of removable spool pieces, or rotating an elbow, to accommodate the installation and removal of jumper lines for flushing.

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7.3 Instrument Piping and Tubing

7.3.1 The vendor shall supply all necessary piping, valves and fittings for instruments, gauge boards, and instrument panels.

7.3.2 Panels shall be completely assembled, requiring only connection to the purchaser's external piping and wiring circuits.

7.3.3 Instrument piping and tubing shall be in accordance with Table 3 to Table 8.

7.3.4 Initial connections for pressure instruments and test points shall comprise a branch and DN 20 (NPS $\frac{3}{4}$) isolation valve to the same standard as the system to which it is connected.

7.3.4.1 A common initial connection per 7.3.4 may be used for remotely mounted instruments that measure the same pressure.

7.3.4.2 Separate secondary DN 15 (NPS $\frac{1}{2}$) isolating valves shall be provided for each instrument.

7.3.4.3 Where a pressure gauge is used for testing pressure alarm or shutdown devices, common connections shall be provided for the pressure gauge and alarm or shutdown devices.

7.3.4.4 • Separate taps shall be provided for pressure gauges and each pressure transmitter used for an alarm or start permissive. Shutdown transmitters that require multiple transmitters can have one pressure gauge with its own tap.

7.3.4.5 Tubing valves shall be the manufacturer's standard tube-end or instrument valve, as approved by the purchaser.

7.3.5 • ♦ Heads of oil-actuated control valves shall be vented back to the reservoir.

7.3.6 • Sensing lines to safety instruments shall have continuous through flow of oil to purge air from the sensing line, as well as to maintain warm oil at the device.

7.3.7 Instrument valves for oil and gas service located in sensing lines downstream of a primary service block valve may be bar-stock instrument valves, provided the instrument valves are protected against accidental disassembly. Instrument valves shall be stainless steel ASTM A312 Type 316 with stainless steel stems.

7.3.8 Plugs in instrument valves shall be the manufacturer's standard design of stainless steel material.

7.3.9 Bleed valves provided at instruments may be the manufacturer's standard bleed fitting. Where test valves are provided according to 7.3.11, bleed valves may be omitted.

7.3.10 For liquid services of less than or equal to 0.3 bar G. (5 psig), bleed valves may be omitted, except for instrument with continuous bleed lines.

7.3.11 • Test valves shall be supplied adjacent to all of the instruments.

7.3.12 Test valves shall terminate with a plugged DN 15 (NPS $\frac{1}{2}$) connection.

7.3.13 • Instrument manifold valves shall be provided.

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7.4 Process Piping

7.4.1 ● The extent of, and requirements for, process piping to be supplied by the vendor shall be specified.

7.4.2 Piping shall be in accordance with Tables 3, 7, and 8.

7.4.3 ● The vendor shall review the design of all piping, appurtenances, and vessels (e.g. pulsation suppression devices, intercoolers, aftercoolers, separators, knockout drums, air intake filters, expansion joints) and supports immediately upstream and downstream of the equipment.

7.4.4 The purchaser and the vendor shall agree on the scope of this review.

7.5 Steam, Air, and Cooling Water Piping

7.5.1 Steam and air piping shall be in accordance with Tables 4, 7, and 8.

7.5.2 Cooling water piping shall be in accordance with Tables 5, 7, and 8.

7.6 Intercoolers and Aftercoolers

7.6.1 ● The vendor shall furnish intercoolers.

7.6.2 ● Intercoolers and aftercoolers shall be air-cooled or water-cooled as specified.

7.6.3 ● The vendor shall furnish aftercoolers.

7.6.4 Intercoolers and aftercoolers shall be furnished in accordance with the pressure design code.

7.6.5 ● Water-cooled, shell-and-tube intercoolers and aftercoolers shall be designed and constructed in accordance with TEMA Class C or R, as specified. If TEMA Class R is specified, the heat exchanger shall be in accordance with API 660 as specified.

NOTE 1 It is necessary to exercise caution regarding the susceptibility of heat exchangers and their supporting structures to pulsation-induced vibration.

NOTE 2 TEMA R heat exchangers are typically used for hydrocarbon services.

7.6.6 Intercoolers and aftercoolers shall be constructed and arranged to allow removal of tube bundles without dismantling piping or compressor components.

7.6.7 Water shall be on the tube side.

7.6.8 Rupture disks on the shell side of fixed tube sheet heat exchangers (to protect the shell in case of tube failures) shall be used only if specifically approved by the purchaser.

7.6.9 ● Air-cooled heat exchangers shall be in accordance with API 661.

7.6.10 Air-cooled heat exchangers used for intercoolers shall have automatic temperature control.

7.6.10.1 This control shall be accomplished by means of louvers, variable-speed fans, variable-pitch fans, bypass valves, or any combination of these.

7.6.10.2 Proposed control systems shall be reviewed by the purchaser.

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NOTE Temperature control for air-cooled heat exchangers used for intercooling is an external feature and not covered in this standard.

7.6.11 • Water-cooled double-pipe intercoolers and aftercoolers shall be furnished. A finned double-pipe design may be furnished only if specifically approved by the purchaser.

7.6.12 • Intercoolers shall be either integrally mounted on a skid or separately mounted, as specified.

7.6.13 • Materials of construction shall be those specified.

7.6.14 If condensate separation and collection facilities are furnished by the vendor, they shall include the following:

- a) automatic drain trap with a manual bypass;
- b) armored gauge glass with isolation valves and blowdown valves on the collection pot;
- c) separate connections and level instruments for high-level alarm and shutdown on the collection pot;
- d) collection pots sized to provide an agreed-upon holding capacity and a 5-minute interval between high-level alarm and shutdown, based on the expected normal liquid condensate rate.

7.6.15 • The vendor shall furnish the fabricated piping between the compressor stages (or the nozzles of centrifugal compressor bodies) and the intercoolers and aftercoolers.

7.6.16 Interstage piping shall conform to the piping design code.

8 Instrumentation, Control, and Electrical Systems

8.1 General

8.1.1 Systems shall be instrumented and controlled for orderly start-up, stable operation, warning of abnormal conditions, and shutdown of the main equipment in the event of impending damage.

8.1.2 Instrumentation and installation shall conform to the purchaser's specifications and to the requirements of this standard.

8.1.3 Controls and instrumentation, equipment, and wiring shall be designed for outdoor installation.

NOTE Special considerations can be desirable for instrumentation working below -20°C (-4°F), such as heated enclosures, or protection from radiant sources if temperatures are above the certified range of the instruments.

8.1.3.1 Controls, instrumentation, and equipment shall have a minimum ingress protection level of NEMA 4 rating per NEMA 250, or IP 65 per IEC 60529.

NOTE IP 65 is generally considered equal to NEMA 4. IEC addresses environment protection and electrical protection separately. Ingress protection is covered by the IP designation in IEC 60529 and IEC 60034-5. IEC 60034-5 is very similar but not identical to IEC 60529, for definition of IP code. NEMA addresses both environmental and electrical protection (construction features) in one standard NEMA 250.

8.1.3.2 • Controls, instrumentation, and equipment shall be suitable for the area classification (class, group, and division or zone) specified by the purchaser.

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8.1.3.X ● Controls, instrumentation, and equipment shall meet the requirements of the applicable parts of NFPA 70, Articles 500, 501, 502, 504, and 505 (IEC 60079) or alternate electrical codes, as well as any local codes specified and furnished on request by the purchaser.

NOTE Examples of alternate electrical requirements include ATEX, CENELEC, CSA, and GOST.

8.1.4 Terminal boxes shall be metal and shall incorporate low-point breather/drains that maintain the ingress protection rating and hazardous area certification.

8.1.5 ● Instrument and control terminal boxes shall be of bottom entry design.

8.1.6 ● Junction boxes shall have an ingress protection level of NEMA 4X minimum rating per NEMA 250, or IP 66 per IEC 60529.

NOTE 1 IP 66 is generally considered equal to NEMA 4X.

NOTE 2 IEC addresses environment protection and electrical protection separately. Ingress protection is covered by the IP designation in IEC 60529. Electrical protection is covered by IEC 60079.

NOTE 3 The IP code only addresses requirements for protection of people, ingress of solid objects, and ingress of water. There are numerous other requirements covered by the NEMA type designations that are not addressed by the IEC 60529/IP codes. IEC 60529 does not specify the following:

- construction requirements;
- door and cover securement;
- corrosion resistance;
- effects of icing;
- gasket aging and oil resistance;
- coolant effects.

The type designation of NEMA specifies requirements for these additional performance protections. For this reason, the IEC enclosure IP code designations cannot be converted to enclosure NEMA type numbers (see NEMA Publication, *A Brief Comparison of NEMA 250 and IEC 60529*).

NOTE 4 NEMA addresses both environmental and electrical protection (construction features) in one standard NEMA 250.

8.1.7 ● The purchaser shall specify any preferences for protection method of compliance and certification of devices within a hazardous area.

NOTE Examples of protection methods are Ex (d), flameproof, Ex (i) intrinsically safe, Ex (n) nonsparking.

8.1.8 Where applicable, controls and instrumentation shall conform to API 551.

8.1.9 All controls and instruments shall be located and arranged to permit easy visibility for the operators, as well as accessibility for tests, adjustments, and maintenance.

8.1.10 All wetted metallic parts of all instruments shall be made of an austenitic 300 stainless steel.

NOTE Certain fluid applications can require alternate trim materials (i.e., H₂S service). See 7.1.27.

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8.1.11 As a minimum, the vendor shall furnish and mount devices to facilitate the alarm, shutdown, and trip functions specified in Table 9.

8.2 Alarm, Shutdown, and Control Systems

8.2.1 General

8.2.1.1 ● ♦ The necessary valving and other approved protocol shall be provided to enable all instruments and other components except shutdown-sensing devices to be replaced or tested with the equipment in operation.

8.2.1.2 ● Shutdown-sensing and trip-sensing devices shall be provided with valving and other approved protocol to allow testing or replacement with the equipment in operation.

8.2.1.3 If isolation valves for shutdown-sensing devices are provided, they shall be supplied with a means of locking the valves in the open position.

8.2.1.4 ● A hand-auto (HA) or hand-off-auto (HOA) starting switch for the pump motor(s) shall be provided.

8.2.1.4.1 The HA switch shall contain manual-on and automatic-start positions only, with a separate manual reset button.

8.2.1.4.2 If an HOA switch is provided, there shall be a separate set of contacts to indicate or alarm that it is in the off position.

NOTE The manual reset button of the HA control allows the standby pump to be manually shut down while the switch is in the automatic-start position only if the primary pump is providing sufficient pressure [i.e. if the pressure-rising limit relay of the low-pressure device (PSL) has been satisfied].

8.2.1.5 A separate electrical disconnect switch with a lockable off position shall be provided at a remote location, such as the motor control center, and should be used only for pump maintenance or during the time the equipment is shut down.

8.2.2 Alarm, Shutdown, and Trip Systems

8.2.2.1 An alarm/shutdown/trip system shall be provided that initiates an alarm if any one of the specified parameters reaches an alarm point and initiates shutdown/trip of the equipment if any one of the specified parameters reaches the shutdown/trip point.

8.2.2.2 ● The purchaser shall specify the alarms and shutdowns required, which, as a minimum, should include those listed in Table 9.

NOTE Automatic shutdown of some equipment may pose a greater impact on the facility than allowing the equipment to be damaged.

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Table 8—Recommended Alarms, Recommended Shutdowns, and Required Trips for Oil Systems

Condition	Alarm	Shutdown	Trip
Low control oil pressure ^a	x	—	
Low pressure to start standby oil pump	x	—	
Low pressure at lubricated equipment	x	x	
Pump running for each standby and emergency pump ^b	x	—	
High oil temperature leaving heat exchanger	x	—	
Low level for oil reservoir	x	—	
Low level for each seal-oil overhead tank or low seal-oil differential pressure for each seal-oil level ^{a,c}	x		x
High level for overhead seal tank ^a	x	—	
Atmospheric lube-oil rundown tank, low level alarm/high level permissive ^a	x	—	
High differential pressure for each oil-filter set	x	—	
^a If applicable. ^b Not required if the purchaser's alarms are from the motor-control center. ^c Differential pressure between oil and gas is a critical parameter in a seal-oil system. Too low differential pressure may create the risk for gas leakage; too high differential pressure may increase the volume of contaminated oil that requires processing or disposal. Normal operating pressure, alarms and trips should be defined by the equipment vendor taking in account factors such as the operating conditions, the type of seal used.			

8.2.2.3 The vendor shall advise the purchaser of any additional alarms and/or shutdowns considered essential to safeguard the equipment.

8.2.2.4 The vendor shall advise the purchaser of any additional trips considered essential to safeguard personnel.

8.2.2.5 • The purchaser shall specify the extent to which alarm/shutdown systems are supplied and installed by the equipment vendor.

NOTE API 670 provides more information about condition-based monitoring systems, safety instrumented systems (SIS), and emergency shutdown systems (ESD).

8.2.2.6 The alarm/shutdown system shall conform to the following requirements.

NOTE It is accepted that with some systems, particularly those based on conventional direct-acting instruments, complete compliance with the requirements of 8.2.2.6.1 through 8.2.2.6.11 may not be achievable.

8.2.2.6.1 For every shutdown parameter, an alarm shall be provided with the alarm point set at a lesser deviation from the normal condition than the associated shutdown point.

8.2.2.6.2 • Any parameter, reaching the alarm or shutdown or trip point, shall initiate an operations notification consisting of an audible warning, or flashing light or other indication, as specified.

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8.2.2.6.3 It shall be possible to determine which parameter initiated the event.

NOTE Remote monitoring of alarms is more commonly used than only local alarms or flashing lights.

8.2.2.6.4 If any component of the alarm system malfunctions, an alarm shall be initiated that is distinguishable from alarms resulting from deviation from normal operating parameters of the equipment.

8.2.2.6.5 An alarm resulting from malfunction of the monitoring system shall be distinguishable from an alarm resulting from deviation of normal operating conditions.

NOTE To accomplish this, redundant sensors can be required.

8.2.2.6.6 If any malfunction of a component of the shutdown or trip system results in the system being unable to recognize a shutdown condition, the equipment shall automatically shut down and an alarm shall be initiated.

8.2.2.6.6.1 This alarm shall be distinguishable from shutdowns resulting from malfunction of the equipment (fail-safe system).

8.2.2.6.6.2 An alarm resulting from malfunction of the monitoring system shall be distinguishable from an alarm resulting from deviation of normal operating conditions.

8.2.2.6.7 ● If a non-fail-safe system is specified, a failure that results in the system being unable to recognize an alarm condition shall also result in all other alarms and shutdowns remaining functional.

8.2.2.6.7.1 It shall be possible to test each component of every alarm function while the equipment is in operation.

8.2.2.6.7.2 Such testing shall not require the disarming of any shutdown function.

NOTE This requirement cannot be readily achieved for some devices and classes of equipment, such as enclosed gas turbines.

8.2.2.6.8 ● ♦ If specified, with the exception of the final shutdown devices such as driver circuit breaker, trip and throttle valve, fuel valve, it shall be possible to test each component of every alarm, shutdown, and trip function, while the equipment is in operation, without disarming any other function.

NOTE 1 This requirement cannot be readily achieved for some devices and classes of equipment, such as enclosed gas turbines.

NOTE 2 Alarm and shutdown arrangements 2 or 3 (see 8.2.3.1 and 8.2.3.3) enables independent testing of devices.

8.2.2.6.9 If shutdown bypass functions are furnished in a vendor-supplied panel, the vendor shall provide clearly visible indication(s) on the display(s) to indicate if shutdown circuits are in a test bypass mode.

8.2.2.6.10 Shutdown systems shall be provided with key lock switches or another suitable means to permit testing without shutting down the unit.

8.2.2.6.11 Override switches are not acceptable for trips that are used to reduce risk for persons or environment (SIL loops).

8.2.3 Alarm and Shutdown Arrangements

8.2.3.1 ● Alarm and shutdown arrangements shall be one of the following, as specified.

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8.2.3.1.1 Arrangement 1—Both alarm and shutdown devices shall be connected through normally energized, fail-safe circuits (de-energize to alarm/shutdown). The shutdown circuit wiring shall be completely independent from the alarm circuit wiring and shall be mechanically protected.

8.2.3.1.2 Arrangement 2—Shutdown functions shall be initiated by local devices connected in a normally energized (de-energized to alarm/shutdown) circuit. Alarm functions shall be comprised of locally mounted transmitters monitored by a multipoint scanning-type system, such as programmable controllers, PLC or plant DCS. Alarm settings for each function shall be separately and independently adjustable.

8.2.3.1.3 Arrangement 3—Each function for which both an alarm and a shutdown have been specified shall be provided with three separate and independent transmitters. The detail arrangement should be jointly developed between the purchaser and the vendor or vendors of the system and the served equipment. Each transmitter shall be independently connected to one of three independent, multi-point, electronic, scanning-type monitoring systems. The alarm and shutdown function outputs from the three instruments shall be connected as “two-out-of-three” voting logic and:

- a) activation of any one alarm or shutdown function shall initiate an alarm;
- b) activation of any two shutdown functions monitoring the same parameter shall initiate a separate alarm and shall cause the served equipment to shut down;
- c) if any one transmitter is faulty, then the remaining two transmitters shall vote “one-out-of-two” for shutdown;
- d) if a second transmitter becomes faulty, then the system shuts down the served equipment.

8.2.3.2 Alarm functions not associated with a shutdown function shall be provided with one single transmitter.

8.2.3.3 The detailed arrangement shall be jointly developed by the purchaser and the vendor or vendors of the system and the served equipment.

NOTE This arrangement (Arrangement 3) has the following advantages.

- a) Any shutdown or alarm function can be tested at any time with the equipment in service without the need to disarm any part of the system.
- b) Failure of any one component initiates an alarm but does not result in equipment shutdown.
- c) The use of modern, digital instrument technology is facilitated.
- d) If the circuit is normally energized, this would be a fail-safe arrangement to avoid spurious trips (e.g. two-out-of-three voting, DC power supply, UPS).

8.2.4 Annunciators

8.2.4.1 The alarm/shutdown annunciation system shall incorporate a first-out annunciator facility to indicate which parameter first reached the shutdown level.

8.2.4.2 Where this facility is not incorporated as part of an integrated control and monitoring system, a separate annunciator instrument shall be provided (see 8.2.4.6).

NOTE An annunciator can be mounted on either a local or a remote-control panel.

8.2.4.3 The annunciation system shall incorporate the following functions:

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8.2.4.3.1 The first parameter to reach alarm or shutdown shall cause the flashing of a light and the sounding of an audible device.

8.2.4.3.2 The alarm or shutdown condition shall be acknowledged by operating an alarm silencing button, common to all alarms and shutdowns.

8.2.4.3.3 If the alarm or shutdown is acknowledged, the audible device shall be silenced, but the light shall remain steadily lit as long as that alarm or shutdown condition exists.

8.2.4.3.4 If another parameter reaches an alarm or shutdown level, the light shall return to the flashing condition and the audible device shall sound, even if the previous alarm/shutdown condition has been acknowledged but still exists.

NOTE These functions are commonly implemented through the use of a human-machine interface (HMI) or other systems.

8.2.4.4 • The annunciator sequence shall be selected from ISA 18.1 by the purchaser.

8.2.4.5 • A separate first-out indication shall be provided.

8.2.4.6 If alarms are displayed and recorded with time stamp, first-out is not required.

8.2.4.7 If a plant DCS or local panel HMI system is provided, it shall generate an event list (alarms and shutdowns/trips) time stamp entries. .

8.2.4.7.1 The event list shall be stored in the system's nonvolatile memory to preserve the data on loss of power.

8.2.4.7.2 The event list, event time stamp, and scan time of the event logger shall be as described in API 670.

8.3 Instrumentation

8.3.1 Instrument Installation and Gauge Boards

8.3.1.1 • Instruments for the console and equipment may be local or gauge-board mounted as specified.

8.3.1.2 The gauge boards shall have individually labelled instruments.

8.3.1.3 • Purchaser's labelling shall be applied in addition to or in place of the vendor's standard labelling.

8.3.1.4 Gauge boards and panels shall be completely assembled, piped and wired, requiring only connection to the purchaser's external piping and wiring circuits.

8.3.1.5 If more than one wiring point is required on a unit for control or instrumentation, the wiring to each electrical control device or instrument shall be provided from common terminal boxes with terminal posts.

8.3.1.6 Separate terminal boxes are required for segregation of different AC and DC electrical signals.

8.3.1.7 • Signal-segregation requirements in addition to the requirements defined in 8.3.1.6 shall be provided.

8.3.1.8 Each terminal box shall be mounted on the package or console baseplate.

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NOTE Some soleplate-mounted equipment can result in maintenance access problems, which can be addressed by shipping terminal boxes loose for field wiring to a nearby location.

8.3.1.9 For electrical wiring, refer to 8.4.

8.3.1.10 All hand switches and instruments shall be tagged for identification.

8.3.1.11 • Purchaser's tagging shall be applied in addition to or in place of the vendor's standard tagging.

8.3.1.12 Except for instrument-air service, bleed valves are required between instruments and their isolation valves. Combination isolation/bleed valves may be used.

8.3.1.13 The sensing elements of pressure devices shall be of stainless steel (AISI Standard Type 300 stainless steel).

8.3.1.14 Low-pressure devices actuated by falling pressure shall be equipped with a pressure gauge, valved bleed, or vent connection to allow controlled depressurizing during testing.

8.3.1.15 High-pressure devices activated by rising pressure shall be equipped with a valved test connection so that a portable pump can be used to raise the pressure during testing.

8.3.2 Switches

8.3.2.1 The use of switches requires purchaser approval (see 8.3.3.1).

8.3.2.2 Where alarm and/or shutdown functions are initiated by locally mounted switches, such switches shall comply with 8.3.2.3 through 8.3.2.9.

8.3.2.3 If switches are used, each alarm switch and each shutdown switch shall be furnished as separate devices, and located to facilitate inspection and maintenance.

8.3.2.4 Switches shall be hermetically sealed, single-pole, double-throw type with a minimum capacity of 5 A at 120 V AC and 0.5 A at 120 V DC.

8.3.2.5 Mercury switches shall not be used.

8.3.2.6 • The purchaser shall specify whether switches shall be connected to either open (de-energize) or close (energize) to initiate alarms and shutdowns.

8.3.2.7 Alarm and shutdown switch set points shall not be adjustable from outside the housing.

8.3.2.8 • Multi-point instruments may be used

8.3.2.8.1 Alarms and shutdowns shall be connected to separate instruments.

8.3.2.8.2 Separately adjustable alarm or shutdown contacts (switches) shall be provided.

8.3.2.9 Alarm switches and shutdown switches shall be arranged to permit testing of the control circuit without interfering with normal equipment operation.

8.3.2.10 When possible, the actuating element shall also be arranged to permit testing.

NOTE In some installations, the actuating element can require removed for testing whenever there is no method to simulate the signal during operation.

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8.3.3 Transmitters

8.3.3.1 Indicating transmitters shall be provided in lieu of switches.

8.3.3.2 ● The purchaser shall specify housing type and power supply requirements.

8.3.3.3 ● Transmitter output signals shall be of analog and/or digital type, as specified.

8.3.3.4 Analog transmitters shall be two-wire type and have an output of 4 mA to 20 mA.

8.3.3.5 Each transmitter shall be located to facilitate inspection and maintenance.

8.3.3.6 Each indicating transmitter shall be located to facilitate unobstructed viewing.

8.3.3.7 Each transmitter shall be arranged to permit testing of the control circuit, including the actuating element, without interfering with normal equipment operation.

NOTE 1 Testing of transmitters associated with trips have special considerations (see 8.2.2.6.11).

8.3.3.8 Transmitters shall have suitable response time for the service, with regard to the monitoring system.

8.3.4 Temperature Indicators

8.3.4.1 Temperature-sensing elements shall be configured to extend adequately into the measured fluid.

NOTE This is particularly important for lines that can run partially full, such as drain lines.

8.3.4.2 Temperature-sensing elements may be located in oil-flow sight glasses.

8.3.4.3 Dial-type temperature indicators shall be heavy-duty and corrosion-resistant.

8.3.4.3.1 They shall be at least 100 mm (4 in.) in diameter and bimetallic-type, fluid-filled or gas actuated.

8.3.4.3.2 Black printing on a white background is standard for gauges.

8.3.5 Thermowells

8.3.5.1 Temperature indicators or sensing elements that are in contact with process fluids or are located in pressurized or flooded liquid lines shall be furnished with DN 20 (NPS $\frac{3}{4}$), series 300 stainless steel, separable, solid-bar thermowells.

8.3.5.2 Thermowells in flammable or toxic gas service shall use flanged connections.

8.3.5.3 When considering pipe size, larger pipe sizes can be required to compensate for the restriction of flow by the thermowells.

NOTE Atmospheric, partially-full bearing oil drain lines are an example of a service where thermowells may not be required, if the element can be safely removed during operation without leakage.

8.3.6 Thermocouples and Resistance Temperature Detectors

8.3.6.1 The design and location of thermocouples and resistance temperature detectors shall permit replacement while the unit is operating.

8.3.6.2 The lead wires of the thermocouples or resistance temperature detectors shall terminate in the thermocouple or resistance detector conduit head.

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8.3.6.3 The vendor shall install wiring from the temperature detector conduit head to an on-base terminal box.

8.3.6.4 If temperature element heads are exposed to temperatures above 60 °C (140 °F), 20 mm (³/₄ NPT) flexible conduits for rigid conduit systems or cables for cable-gland systems, rated for the hazardous area class in accordance with the specified electrical code, shall be used for connections to the heads.

8.3.6.4.1 Flexible conduits shall be rated for the temperature element head exposure design temperature.

8.3.6.4.2 Flexible conduits shall have an interlocking stainless steel or galvanized steel core with an integral grounding conductor.

NOTE Good design practice incorporates extended lagging on thermowells and/or extension nipples between the thermowells and conduit heads to reduce or limit the exposure temperature of the conduit heads.

8.3.7 Level Instruments

8.3.7.1 Direct-acting level instruments may be operated by displacers, floats, capacitance, ultrasonic, guided wave radar, or other means as approved.

8.3.7.2 Sensing elements shall be made of austenitic stainless steel.

8.3.8 Pressure Indicators

8.3.8.1 Pressure indicators (not including built-in instrument-air indicators) shall be furnished with AISI standard Type 316 stainless steel bourdon tubes and stainless steel movements, 100 mm (4 in.) minimum dials and 15 mm (¹/₂ NPT) male stainless steel connections.

8.3.8.1.1 Black printing on a white background is standard for gauges.

8.3.8.1.2 Pressure-sensing elements shall be made of AISI standard Type 300 stainless steel.

8.3.8.2 ● Liquid-filled gauges or dampened movement gauges shall be furnished in locations subject to vibration or pulsating service.

8.3.8.3 Pressure indicator ranges shall be selected so that the normal operating pressure is in the middle of their range.

8.3.8.4 In no case, however, shall the maximum reading on the dial be less than the applicable relief valve setting plus 10 %.

8.3.8.5 Each pressure indicator shall be provided with a device, such as a disk insert or blowout back, designed to relieve excess case pressure.

8.3.8.6 Local differential pressure indication shall be provided at the filter so that the condition of the filters can be monitored during changeover..

8.3.8.7 Differential pressure indicators shall be furnished with stainless steel pressure-containing housings and stainless steel movements.

8.3.8.8 Differential pressure indicators shall be designed to prevent damage by over-ranging.

8.3.8.9 Dial size shall be minimum 100 mm (4 in.) with black printing on a white background.

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NOTE Direct pressure-sensing, nonmagnetic-drive differential pressure indicators can be damaged by over-ranging. Precautions can be required to prevent damage if they are selected for systems with operating pressures higher than their differential range.

8.3.9 Oil Sight Flow Indicators

8.3.9.1 Flow indicators shall be furnished in the atmospheric oil drain return line from all bearing, gear, and oil seal return lines.

8.3.9.2 Flow indicators shall not be installed in pressurized lines.

NOTE Flow indicators might not be practical for units where the oil reservoir or sump is part of the equipment or part of a compact package.

8.3.9.3 ● To detect excessive oil leakage into the coupling guard, flow indicators shall be installed in the drain lines of totally enclosed, dry coupling guards.

8.3.9.4 The flow indicator shall:

- a) be flanged;
- b) be of the bulls-eye type with glass on both sides;
- c) have the same body material as specified in 7.1.27;
- d) have a diameter of not less than one-half the inside diameter of the oil pipe;
- e) sized so the oil flow is visible at minimum oil flow;
- f) each oil flow indicator shall be installed to ensure viewing of the oil flow through the line.

8.3.9.5 If flow indicators are provided for oil filter and heat exchanger vent tubing, they may utilize screwed connection.

8.3.10 Solenoid Valves

8.3.10.1 Direct solenoid-operated valves shall be used only in clean, dry instrument-air or control-oil service and shall have Class F insulation or better and a continuous service rating.

8.3.10.2 If required for other services, the solenoid shall act as a pilot valve to pneumatic valves, hydraulic valves, and the like.

8.3.10.3 Single-coil solenoid valves shall not be used in continuously energized services that can affect normal operations.

8.3.10.4 Single-coil solenoid valves may be used in intermittent instrument services.

8.3.10.5 ● If continuously energized solenoids are specified for shutdown circuits, the vendor shall provide the purchaser with the coil rating and estimated service life of each solenoid coil based on continuously energized operation.

8.3.10.6 ● Dual-coil solenoids shall be provided for any shutdown function.

8.3.10.6.1 Each coil shall be capable of keeping the solenoid in its energized condition.

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8.3.10.6.2 Separate circuits shall energize each coil.

8.3.11 Pressure-limiting Valves and Pressure Safety Relief Valves

8.3.11.1 The vendor shall furnish the PLVs and pressure safety valves that are installed on components or in piping that is supplied by the vendor.

8.3.11.2 The purchaser shall furnish the PLVs and pressure safety valves that are installed on components or in piping that is supplied by the purchaser.

8.3.11.3 Only pressure safety valves for gas, steam, or thermal relief service are required to meet the pressure-limiting requirements defined in API 520 (all parts) and in API 526.

8.3.11.4 The vendor shall determine the size and set pressure of all PLVs and pressure safety valves associated with the system components.

8.3.11.5 Pressure-limiting settings, including accumulation, shall take into consideration all possible types of equipment and component failures and the protection of oil-system components and piping.

8.3.11.6 Pressure safety valves shall not have an accumulation exceeding 10 % of set pressure.

8.3.11.7 PLVs shall not have an accumulation that results in a pressure exceeding 110 % of the system design pressure.

8.3.11.8 ● Thermal relief valves shall be provided for components that can be blocked in by isolation valves.

NOTE See 6.8.1.7 for thermal protection of heat exchangers.

8.3.11.9 Thermal relief valves are required for water side of oil heat exchangers if water cooling manifolds are included in the scope of supply. See 7.1.37.

8.3.11.10 ● The discharge of oil thermal relief valves shall be routed back to the reservoir.

NOTE These lines are normally run with tubing.

8.3.12 Control Valves and Regulators

8.3.12.1 ASDs shall not be used to control system pressure or regulate flow.

8.3.12.2 Control valve(s) and self-contained regulators shall be sized to maintain the specified conditions during:

- a) pump changeover, i.e. multiple-pump operation;
- b) oil temperature range, i.e. pump start-up through normal operation;
- c) start-up;
- d) gearbox static (zero speed) and dynamic (operational) flows;
- e) control-oil transient conditions.

8.3.12.3 Control valve(s) and self-contained regulators shall have steel bodies with stainless steel trim.

8.3.12.4 Instrument air supply regulators and filters may use aluminum bodies.

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8.3.12.5 The pressure rating of the body and head shall not be less than the maximum pressure to which the component can be exposed in its failed position.

8.3.12.6 Failure modes for control valves and self-contained regulators are the following:

- | | |
|--|---|
| a) back-pressure | fail-closed; |
| b) pressure reducing (except seal oil) | fail-open; |
| c) temperature control valves | fail mode to divert all flow through the heat exchangers; |

NOTE For sites using air-cooled heat exchangers and with wide ambient temperature ranges, the fail mode "fail-locked" can be considered for temperature control valves, to avoid excessive oil cooling on temperature control valve failure.

- | | |
|---------------------------|--------------|
| d) Seal oil system valves | fail-closed. |
|---------------------------|--------------|

8.3.12.7 Direct-acting control valves and self-contained regulators shall be sized to limit proportional offset to 10 % based on steady state and 25 % for maximum transients.

8.3.12.8 Pneumatic-control valves shall be sized to be no less than 10 % open with the minimum flow through the valve and no more than 90 % open with the maximum flow expected through the valve.

8.3.12.8.1 Pneumatic-control valve(s) actuator and spring shall be sized to open or close against the maximum pressure (relief valve plus accumulation) expected in the system.

8.3.12.8.2 Direct-acting control valves shall have an external sensing line.

8.3.12.8.2.1 For systems with multilevel oil pressure control, the back pressure regulator's external sensing line shall include a flow control valve or needle check valve arrangement to provide dampening to control valve instability during transient operation.

8.3.12.8.2.2 Oil pressure sensing line for the back pressure regulator shall be located downstream of the filters.

8.3.12.8.3 Control valves shall have visual valve stem position indication.

NOTE This requirement does not apply to self-contained regulators as described in 8.3.12.1.

8.3.12.9 If a failure or a malfunction of a PCV can create a hazard or result in damage to equipment or components, an additional PLV discharging to the reservoir or drain header shall be furnished. (See Figure C.10 and Figure C.11 for typical arrangements.)

NOTE The design criteria for sizing this additional PLV depend only on the sizing of the PCV in a fail-open mode; fail-open modes include oil starvation, overpressure, and flooding of bearing housings. Other methods for limiting pressure can be employed, e.g. short-stroke valve with a mechanical stop.

8.3.12.10 Bypass valves shall be of globe type.

8.4 Electrical Systems

8.4.1 Motors, electrical instrumentation, components, and electrical installations shall be suitable for the area classification (class, group, and division or zone) specified by the purchaser.

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8.4.2 Motors, electrical instrumentation, components, and electrical installations shall meet the requirements of the applicable parts of IEC 60079 or NFPA 70, Articles 500, 501, 502, 504, and 505 as well as any local codes specified and furnished on request by the purchaser.

8.4.3 ● The characteristics of electrical power supplies for motors, heaters, starting and supervisory controls, and instrumentation shall be specified.

NOTE This information can be provided on the Site and Utility Data Sheet, located in Annex A.1.

8.4.4 Power, control, and instrument wiring within the confines of the baseplate or module shall be flame retardant and resistant to oil, heat, moisture, and abrasion.

8.4.5 Stranded conductors shall be used within the confines of the baseplate and in other areas subject to vibration.

8.4.6 ● Instrument and control wiring may be solid conductors in areas not subject to vibration.

8.4.7 Wiring insulation shall be in accordance with the applicable electrical code and other specified requirements.

8.4.8 All wiring, terminal strips, and electrical components shall be permanently labelled or tagged for identification.

NOTE 1 Bonding ground conductors are typically not labelled.

NOTE 2 Terminals of electrical components utilize manufacturer's standard identification.

8.4.9 All terminal boards in terminal boxes and control panels shall be provided with at least 20 % spare terminal points.

8.4.10 To facilitate maintenance, adequate clearances shall be provided for all energized parts (such as terminal blocks and relays) on all components.

8.4.10.1 The clearances required for 600 V service shall also be provided for lower voltages.

8.4.10.2 Enclosures shall be provided for all energized parts to guard against accidental contact.

8.4.11 Electrical materials, including insulation, shall be corrosion resistant and nonhygroscopic insofar as is possible.

8.4.12 ● If specified for tropical location, materials shall be given the treatments specified as follows.

8.4.12.1 Parts (such as coils and windings) shall be protected from fungus attack.

8.4.12.2 Unpainted surfaces shall be protected from corrosion by plating or another suitable coating.

8.4.13 Segregation for AC and DC wiring circuits is required. Segregation shall be accomplished by separate conduits, separate cables, and terminal blocks in separate terminal boxes.

8.4.14 ● Control, instrumentation, and power wiring, which is not within a fully enclosed panel or other enclosure, shall be in the form of armored cable or shall be run in metal conduit as specified.

8.4.15 Control, instrumentation, and power wiring shall meet the following:

8.4.15.1 cables shall be supported on cable trays;

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8.4.15.2 conduits and cable trays shall be supported to prevent damage from pedestrian traffic;

8.4.15.3 conduit shall be supported to avoid damage caused by vibration;

8.4.15.4 conduit shall be isolated and shielded to prevent interference between different services;

8.4.15.5 conduits may terminate (in the case of the leads to temperature elements, shall terminate) with a length of flexible metal conduit, long enough to facilitate maintenance without removal of the conduit;

8.4.15.6 in applications where conduit temperatures are above 60 °C (140 °F), the flexible conduit shall be 19 mm (3/4 in.) bronze hose with four-wall-interlocking construction and joints with packed-on heatproof couplings shall be used.

8.4.16 Electrical metallic tubing (EMT) is not permitted.

NOTE Rigid metallic conduit has tubing wall sufficiently thick to be threaded.

8.4.17 Conduits shall be arranged to permit removal of devices without conduit removal. Conduits may terminate with a flexible metallic conduit, suitable for the electrical class and long enough to permit access to the unit for maintenance without removal of the conduit.

8.4.18 For Division 2 and Zone 2 locations, flexible metallic conduits shall have a liquid-tight thermosetting or thermoplastic outer jacket and approved fittings.

8.4.19 All conduits shall be grouped and mounted above the console baseplate to promote the free drainage of fluids.

8.4.20 The conduit shall not be located in a maintenance access area.

8.4.21 Conduit drains shall be installed in all conduit low points for outdoor installations.

8.4.22 ● Conduit drains shall be provided in all conduit low points for indoor installations.

8.5 Control Panels

8.5.1 ● A common control panel shall be provided and shall include all panel-mounted instruments for the equipment train.

8.5.2 If a local control panel is provided, power status indicators shall be installed on the control panel.

8.5.3 Indicator lights shall be provided on the incoming side of each supply circuit to monitor circuit power status.

8.5.4 ● Panels shall be designed and fabricated in accordance with the purchaser's specification.

8.5.5 ● The purchaser will specify whether the control panel shall be freestanding, locally mounted, or remote mounted.

NOTE If only minor control equipment is used (e.g. push buttons, lamps) sometimes a small control panel on a metal structure (e.g. gauge board) is utilized.

8.5.6 The control panel shall be fully enclosed.

8.5.7 Panel displays shall be designed to be visible in all conditions, including darkness and direct sunlight.

8.5.8 ● The control panel shall include an external light with on/off switch rated for installation in the specified area.

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8.5.9 Control panels in nonhazardous, climate-controlled rooms shall be NEMA 12 or 13 or IP 52 or 54, respectively, per IEC 60529 rating, and fabricated from painted carbon steel.

8.5.9.1 ● If located outdoors, enclosures shall be watertight (minimum ingress protection level of IP 66 as detailed in IEC 60529, or a NEMA 4X minimum rating per NEMA 250) and fabricated from AISI 300 series stainless steel material.

8.5.9.2 ● Indoor panels subject to fire sprinkler systems shall be watertight (minimum ingress protection level of IP 66 as detailed in IEC 60529, or a NEMA 4X minimum rating per NEMA 250), and fabricated from AISI 300 series stainless steel material.

8.5.10 If purging is specified to meet the area classification, it shall be in accordance with ISA S12.4 or with NFPA 496, Type X, Y, or Z, or with IEC 60079-2, as required to meet the area classification.

8.5.11 A method of disconnecting power for devices inside the control panel shall be provided.

8.5.12 Control panels shall include the following:

- a) thermostatically controlled vortex heat exchangers or air conditioners for devices within the panel if the temperature inside the panel exceeds the electronic hardware temperature rating;

NOTE 1 This is typically of concern for ambient conditions above 40 °C (100 °F).

NOTE 2 Panels located in nonhazardous area classified air-conditioned control rooms sometimes use forced ventilation for cooling.

- b) thermostatically controlled heater if minimum ambient temperature is less than internal equipment design temperature, or to prevent condensation;
- c) wiring segregated by voltage level and signal type within the same cabinet;
- d) drawing pocket inside the control panel.

8.5.13 ● Panel fronts shall be made of steel sheet at least 3 mm (nominal 1/8 in.) thick, reinforced, self-supporting and closed on the top and sides.

8.5.14 ● Tops and sides shall be a minimum thickness of at least 2 mm (0.0787 in.).

NOTE U.S. Standard Gauge is equivalent to Manufacturers' Standard Gauge (MSG); 12 Gauge = 2.657 mm.

8.5.15 All gauges shall be mounted flush on the front of the panel.

8.5.16 All separate fasteners shall be of corrosion-resistant metal.

8.5.17 Nameplates shall be phenolic white with 3/16" minimum black lettering.

8.5.18 Nameplates shall be attached with self-tapping screws or adhesive.

8.5.19 ● Internal light or lights and electrical receptacle shall be provided.

8.5.20 For panels installed in hazardous areas that have electrical receptacles, external warning labels shall be applied as required by electrical codes.

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8.5.21 All control panel interior wiring shall be run in nonmetallic wire ways (cable duct) with snap on or hinged covers.

8.5.22 Control panel wire ways shall have a maximum fill capacity of 50 %.

NOTE 1 Fill capacity is determined by the total combined cross-sectional area of all of the wire cables within the wire way divided by the interior cross-sectional area of the wire way.

NOTE 2 Power carrying conductor wire ways sometimes reduce the maximum fill capacity to account for thermal factors.

NOTE 3 A lower percentage fill capacity can be specified to accommodate future wiring.

NOTE 4 See NFPA 79 for more details.

8.5.23 All wiring shall have different colors or otherwise properly identified in the case of general-purpose wiring and intrinsically safe wiring (IS), which shall be light blue.

8.5.24 Separate and isolated copper grounding bars shall be provided for equipment power, instruments, and intrinsically safe circuits.

8.5.25 Controls panels may also include other components such as electronic controllers, computers, HMIs, and other equipment that shall be mounted, wired, and operated based on manufacturer's requirements.

8.5.26 Except for components incorporate suitable noise immunity, Shielding of the devices in the panel shall be provided for protection from 5 watts radiofrequency interference at 1 m (3 ft) using commercial frequency bandwidths.

8.5.27 Cable and/or conduit entry location to the panel shall be agreed between the purchaser and the manufacturer.

8.5.28 ● Removable gland plates shall be used to allow installation of cable or conduit connection locations.

9 Inspection, Testing, and Preparation for Shipment

9.1 General

9.1.1 The purchaser shall specify the extent of participation in the inspection and testing.

9.1.2 ● The purchaser's representative, the vendor's representative, or both shall indicate conformance in accordance with the inspector's checklist by initialing, dating, and submitting the completed checklist to the purchaser before shipment.

9.1.3 After advance notification to the vendor, the purchaser's representative shall have entry to all vendor and subvendor plants where manufacturing, testing, or inspection of the equipment is in progress.

9.1.4 The vendor shall notify subvendors of the purchaser's inspection and testing requirements.

9.1.5 ● If witnessed or observed shop inspection has been specified, the purchaser and the vendor shall coordinate the scheduling of manufacturing hold points and inspectors' visits.

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9.1.6 The expected dates of testing shall be communicated at least 30 days in advance of testing and the actual dates confirmed as agreed.

9.1.7 The vendor shall give at least 5 working days advanced notification of a witnessed or observed inspection or test.

9.1.8 A witnessed operational test requires confirmation by the supplier of the successful completion of a preliminary test.

9.1.9 Equipment, materials, and utilities for the specified inspections and tests shall be provided by the vendor.

9.1.10 The purchaser's representative shall have access to the vendor's quality program for review.

9.2 Inspection

9.2.1 General

9.2.1.1 The vendor shall keep the following data available for at least 20 years:

- a) necessary or specified certification of materials, such as mill test reports;
- b) test data and results to verify that the requirements of the specification have been met;
- c) fully identified records of all heat treatment, whether performed in the normal course of manufacture or as part of a repair procedure;
- d) results of quality-control tests and inspections;
- e) details of all repairs;
- f) ● other data specified by the purchaser or required by applicable codes and regulations;
- g) purchase specifications for all items on bills of material;
- h) sizing and selection criteria for all major components;
- i) results of documented tests and inspections, including fully identified records of all heat treatment and radiography.

9.2.1.2 Pressure-containing parts shall not be painted until the specified inspection and testing of the parts is complete, except as noted in 9.3.2.

NOTE This refers to individual pressure-containing equipment such as vessels, pumps, and valves for which ASME BPVC Section VIII, Division 1 prohibits painting prior to pressure testing.

9.2.1.3 ● Piping spools shall be hydrotested prior to painting.

9.2.1.4 The assembled piping system hydrostatic test can be performed with painted components if vessels, pumps, and valves have already been individually hydrotested.

NOTE ASME B31.3 allows piping joints to be primed and painted prior to leak testing; see 9.3.2.2 for hydro testing of piping spools.

9.2.1.5 ● In addition to the requirements of the governing piping, pressure vessel, and welding code or standard, the purchaser shall identify the following:

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- a) parts that are to be subjected to surface and subsurface examination;
- b) the type of examination required, such as magnetic particle, liquid penetrant, and radiographic and/or ultrasonic examination.

NOTE ASTM material specifications contain mandated and supplemental inspections.

9.2.2 Material Inspection of Pressure Vessels and Piping Systems

9.2.2.1 General

9.2.2.1.1 If radiographic, ultrasonic, magnetic particle, or liquid penetrant inspection of welds or materials is required or specified, the criteria in 9.2.2.2 to 9.2.3 shall apply unless other criteria are specified by the purchaser.

9.2.2.1.2 Welds, cast steels, and iron materials may be inspected in accordance with 9.2.2.2 and 9.2.2.2.6.

9.2.2.2 Radiography, Ultrasonic Inspection, Magnetic Particle Inspection, Liquid Penetrant Inspection, and Visual Inspection

9.2.2.2.1 NDE and acceptance shall be in accordance with the pressure design code and Tables 10 and 11.

9.2.2.2.2 The acceptance standard used for welded fabrications and castings shall be in accordance with the pressure design code.

Table 9—NDE Testing Acceptance Criteria—ASME

NDE Technique (Abbreviation)	Method	Acceptance Criteria	
		For Fabrication	For Castings
Radiographic testing (RT)	Section V, Articles 2 and 22 of the ASME BPVC	Section VIII, Division 1, UW-51 (for 100 % radiography) and UW-52 (for spot radiography) of the ASME BPVC	Section VIII, Division 1, Appendix 7 of the ASME BPVC
Ultrasonic testing (UT)	Section V, Articles 4, 5, and 23 of the ASME BPVC	Section VIII, Division 1, UW-53 and Appendix 12 of the ASME BPVC	Section VIII, Division 1, Appendix 7 of the ASME BPVC
Liquid penetrant testing (PT)	Section V, Articles 6 and 24 of the ASME BPVC	Section VIII, Division 1, Appendix 8 of the ASME BPVC	Section VIII, Division 1, Appendix 7 of the ASME BPVC
Magnetic particle testing (MT)	Section V, Articles 7 and 25 of the ASME BPVC	Section VIII, Division 1, Appendix 6 of the ASME BPVC	Section VIII, Division 1, Appendix 7 of the ASME BPVC

Table 10—NDE Testing Acceptance Criteria—EN ISO

NDE Technique (Abbreviation)	Method	Acceptance Criteria
Visual examination (VT)	EN ISO 17637	Table 8.4-2
Radiographic testing (RT)	EN ISO 17636-1 and 2, Class B ^{a,b}	EN ISO 10675-1 Acceptance level 2 and additional requirements of Table 8.4-3
Ultrasonic testing (UT)	EN ISO 17640, Class B ^b	EN ISO 11666:2018, ^c

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		Acceptance level 2 ^d
Liquid penetrant testing (PT)	EN ISO 3452-1	EN ISO 23277:2009 Acceptance level 1
Magnetic particle testing (MT)	EN ISO 17368	EN ISO 23278:2009 Acceptance level 1
^a Refer to EN ISO 17636-1 and 2:2013, Class A for acceptance criteria for the maximum area for single exposure. ^b Class A for material group 1.1, 1.2, 8.1 if piping Class is I or II. ^c For the characterization of indications, EN ISO 23279 may be used. ^d Acceptance level 3 for material group 1.1, 1.2, 8.1 if piping Class is I or II.		

NOTE Table 11 is adapted from EN 13480-5 that is a harmonised standard under the EU Pressure Equipment Directive.

9.2.2.2.3 Radiography shall be based upon the procedures of ASTM E94/E94M or appropriate country codes and standards.

9.2.2.2.4 Ultrasonic inspection shall be based upon the procedures ASTM A609/A609M (castings), ASTM A388/A388M (forgings), or ASTM A578/A578M (plate), or appropriate country codes and standards.

9.2.2.2.5 Both wet and dry methods of magnetic particle inspection shall be based upon the procedures of ASTM E709 or appropriate country codes and standards.

9.2.2.2.6 Liquid penetrant inspection shall be based upon the procedures of ASTM E165/E165M or appropriate country codes and standards.

9.2.2.3 Positive Material Identification

9.2.2.3.1 ● Materials, welds, fabrications, and piping shall be PMI tested.

9.2.2.3.2 ● Purchaser shall specify the extent of required testing, including any sampling requirements.

NOTE Additional information on PMI testing can be found in API 578.

9.2.2.3.3 If PMI testing has been specified for a pressurized fabrication, the components comprising the fabrication, including welds, shall be checked after the fabrication is complete. Testing may be performed prior to any heat treatment.

NOTE Pressurized fabrications can include equipment such as accumulators, overhead seal-oil tanks, and certain pressurized rundown tanks.

9.2.2.3.4 If PMI is specified, techniques providing qualitative or quantitative results regarding nominal alloy composition shall be used.

9.2.2.3.5 Mill test reports, material composite certificates, visual stamps, or markings shall not be considered as substitutes for PMI testing, or vice versa.

9.2.2.3.6 PMI results shall be within ASTM governing standard limits with allowance for the accuracy of the PMI device as specified by the device manufacturer.

9.2.3 Mechanical Inspection

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9.2.3.1 During assembly of the system and before testing, each component and all piping and appurtenances shall be inspected to ensure they have been cleaned and are free of foreign materials, corrosion products and mill scale.

9.2.3.2 ● The purchaser may inspect the equipment and all piping and appurtenances for cleanliness before heads are welded onto vessels, openings in vessels or exchangers are closed, or piping is finally assembled.

9.2.3.3 ● The hardness of parts, welds, and heat-affected zones shall be verified as being within the allowable values by testing.

9.2.3.4 The method, extent, documentation, and witnessing of the testing shall be agreed upon by the purchaser and the vendor.

9.3 Testing

9.3.1 General

9.3.1.1 At least 6 weeks prior to the first scheduled test, the vendor shall submit to the purchaser, for review and comment, detailed procedures for all oil system operational tests, and all specified optional tests, including acceptance criteria for all monitored parameters.

9.3.1.2 Notification requirements are covered in 9.1.5 through 9.1.7; however, hydro test and operational test requirements shall not be less than 5 working days before the date the equipment will be ready for testing.

9.3.1.3 If the testing is rescheduled, the vendor shall notify the purchaser not less than 5 working days before the revised test date.

9.3.1.4 ● The purchased oil system and other auxiliary equipment shall be used during the main equipment testing (individual machine or string testing).

9.3.1.5 ● Complete unit tests or other tests of the oil system and the equipment it serves shall be performed by the vendor in place of or in addition to separate tests of the oil system as specified by the purchaser.

9.3.1.6 Details of these tests shall be jointly developed by the purchaser and the vendor.

9.3.2 Hydrostatic Test

9.3.2.1 Pressure-containing parts, including auxiliaries, shall be tested hydrostatically with liquid at a minimum of 1.5 times the MAWP unless limited by the hydrostatic test pressure of a component in the system that has been hydro tested to 1.3 times its MAWP.

9.3.2.1.1 In this case, hydrostatic test shall be a minimum of 1.3 times the MAWP.

NOTE The ASME pressure vessel code and other pressure vessel codes allow hydrostatic testing to 1.3 times MAWP.

9.3.2.1.2 Minimum hydro test pressure shall not be less than 150 kPa (1.5 bar; 20 psi).

NOTE Hydro test can be performed with oil or alternative liquid.

9.3.2.2 The assembled piping system, in each package, shall be hydrostatically tested with compatible oil as per 9.3.2.1. Alternately, by prior agreement, the piping spools may be tested individually instead of an assembled hydrostatic test, using an alternative liquid in accordance with 9.2.3.4. Removal of spools, screens, or the loosening of flanges does not void the original hydrostatic test.

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9.3.2.3 If the part tested is to operate at a temperature at which the strength of a material is below the strength of that material at the testing temperature, the hydrostatic test pressure shall be multiplied by a factor obtained by dividing the allowable working stress for the material at the testing temperature by that at the rated operating temperature.

9.3.2.3.1 The stress values used shall conform to those given in the piping system design code for piping or in the pressure design code for vessels.

9.3.2.3.2 The pressure thus obtained shall then be the minimum pressure at which the hydrostatic test shall be performed.

9.3.2.3.3 The data sheets shall list the minimum hydrostatic test pressures.

9.3.2.4 To reduce the potential for chloride stress corrosion cracking, the chloride content of liquids used to test austenitic stainless steel materials shall not exceed 50 parts per million.

9.3.2.5 All residual liquid shall be removed from tested parts at the conclusion of the test.

NOTE 1 NACE SCC resistances of 304 and 316 at temperatures below 50 °C shows that SCC can be avoided at much higher concentrations than allowed above. The above limit is set based on use of potable water and the requirement to wipe dry, which prevents much higher concentrations of chlorides from forming.

NOTE 2 Preventing evaporative drying also limits the growth of anaerobic bacteria that can produce waste byproducts that foster microbial induced corrosion. Microbial induced corrosion can create pinhole corrosion paths in 300 series stainless steel pipe.

9.3.2.6 Components or assemblies to be tested shall be brought to hydrostatic test pressure for a minimum of 30 minutes after which the inspection shall begin.

9.3.2.6.1 Test pressure shall be maintained for a sufficient period of time to permit complete examination of parts under pressure.

9.3.2.6.2 The hydrostatic test shall be considered satisfactory if the test pressure is maintained and neither leaks nor seepage through the pressure-containing parts or joints is observed.

NOTE Ambient temperature changes (e.g. due to weather, direct sun) during longer hydrotests can cause temporary increases or decreases in test pressure, which can be considered during test evaluation

9.3.2.6.3 ● The hydrostatic test shall be conducted for the duration specified by the user.

9.3.3 Operational Tests

9.3.3.1 The complete oil system shall be run in the vendor's shop to test its operation and cleanliness.

9.3.3.2 The oil used shall be as mutually agreed upon and compatible with the system oil (see 6.2.8).

9.3.3.3 The running tests shall be conducted under normal system operating conditions for at least 2 hours, with system parameters recorded at least every 30 minutes. The operational tests may be done concurrently within the 2 hours.

9.3.3.4 ● ♦ If specified, the running tests shall be conducted under normal system operating conditions for at least 4 hours, with system parameters recorded at least every 30 minutes. The operational tests may be done concurrently within the 4 hours.

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9.3.3.5 If console mounted, the low-oil-pressure alarm, the standby-pump start and the shutdown devices purchased for the project shall be used for the operational tests.

9.3.3.6 If the low-oil-pressure alarm, the standby-pump start and the shutdown devices purchased for the project are not console mounted, the vendor shall provide shop devices for the operational tests.

NOTE Some of these devices are normally mounted near the equipment rather than on the console.

9.3.3.7 All oil pressures, viscosities, and temperatures shall be within the range of operating values recommended in the vendor's operating instructions for the specific unit being tested.

9.3.3.8 All filter elements shall be installed prior to the operational tests.

9.3.3.9 Steam turbine pump drivers shall be mechanically tested. If the turbine has been previously tested, a test motor may be considered to replace the turbine during the console operational tests.

9.3.3.10 The operational testing of the oil system shall include the following.

9.3.3.10.1 The oil system shall be thoroughly checked for leaks; all leaks shall be corrected prior to testing.

9.3.3.10.2 The limiting pressures shall be determined so that the subsequent proper operation of each PLV may be verified.

9.3.3.10.3 A changeover of filters and heat exchangers shall be accomplished without the system delivery pressure dropping to the automatic-start setting of the standby pump.

9.3.3.10.4 If applicable, it shall be demonstrated that the control valve or valves can handle a simulated governor-transient step change on the main equipment drive turbine without the PLVs lifting and without the delivery pressure dropping to the automatic-start setting of the standby pump.

NOTE A shaft-driven main pump can require a string test or field test to verify two-pump operation.

9.3.3.10.5 If applicable, it shall be demonstrated that, after a failure or trip of the main oil pump, the standby pump starts automatically and returns the system to normal operating pressure without the delivery pressure dropping as follows:

- 1) in a single-level oil-pressure system, below the midpoint between the equipment's low oil pressure alarm and the equipment's shutdown pressure;
- 2) in a multi-level oil pressure system, below the midpoint between the equipment's normal operating and shutdown pressures.

NOTE Verification of these criteria requires test instrumentation with a response time adequate to record the transient pressures during pump changeover.

9.3.3.10.6 It shall be demonstrated that the control valve(s) is capable of controlling the oil pressure if only one pump (either the main or the standby pump) is operating at minimum oil requirements and if both pumps are operating at minimum oil requirements, defined as the sum of the normal bearing and seal-oil requirements and the steady-state control-oil requirements. The test shall be considered satisfactory if no abnormal conditions occur during the operational test (see 6.7.23).

NOTE Some typical abnormal conditions encountered are system instability, an excessive drop in delivery pressure, alarm or shutdown signals, or other conditions that require operator attention.

9.3.3.10.7 Correct functioning of temperature control valve(s) shall be demonstrated.

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9.3.3.10.8 All warning, protective, and control devices shall be checked and adjustments shall be made as required.

9.3.3.10.9 While the system is at maximum operating pressure, the internal leakage rate of transfer valves shall be demonstrated to be lower than the drainage capability of the filter housing drains. Leakage shall not exceed the expected or specified rates.

9.3.3.10.10 Sound-level survey.

NOTE Noise levels measured during shop testing may not be indicative of actual field values.

9.3.3.10.11 ● Pump and driver bearing housing vibration levels shall be recorded during the oil system operational test. Acceptance criteria to be agreed between purchaser and vendor.

NOTE Vibration levels measured during shop testing may not be indicative of the actual field values.

9.3.3.11 System cleanliness shall be demonstrated by the vendor after the operational tests.

9.3.3.11.1 The vendor shall take responsibility for a clean system prior to the operational testing by shop flushing the system as required until the cleanliness criteria are achieved.

9.3.3.11.2 Immediately following functional testing at the design flow rate and a temperature of 66 °C to 71 °C (150 °F to 160 °F) or lower, as component design dictates, screens placed at all discharge terminations from the console or the packages and at other strategic points agreed on by the purchaser and the vendor shall be checked for cleanliness.

9.3.3.11.2.1 One (1)-hour minimum oil circulation intervals are required for cleanliness testing for subsequent cleanliness inspection of screens until the system is clean.

9.3.3.11.2.2 Where possible, screens shall be mounted such that the flow entering the screen is in a vertical downward direction to prevent debris from escaping the screen.

9.3.3.11.2.3 Alternate methods of measuring oil cleanliness as referenced in Annex E may be specified by the purchaser.

9.3.3.11.3 The screen mesh shall be No. 100 plain-weave, stainless steel wire with a diameter of 0.1 mm (0.004 in.) and a 0.15 mm (0.006 in.) opening.

9.3.3.11.4 The greatest dimension of the particles shall not exceed 0.25 mm (0.010 in.), and the particles shall be randomly distributed on the screen.

9.3.3.11.5 Piping, heat exchangers, and valves shall be physically impacted with a nonmetallic hammer to aid in particle release or particle movement frequently during the test.

9.3.3.11.6 The system shall be visually inspected at two to six points selected by the inspector.

9.3.3.11.7 The system shall be considered clean if foreign matter, such as scale, rust, metal shavings, and sand, are not visible to the eye and grittiness is not detectable to the touch.

9.3.3.11.8 This verification shall not require a re-hydro test nor necessitate the installation of screens.

9.3.3.12 ● System cleanliness shall be demonstrated prior to as well as after the operational testing.

9.3.3.13 If dismantling of the oil system is required to make modifications to improve operation, the initial running test shall not be conclusive and final tests shall be run only after corrections are made.

9.3.3.14 The demonstration of cleanliness shall be conducted only after the final assembly.

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9.3.3.15 • The vendor, by unbolting and re-bolting pump inlet and discharge piping, shall demonstrate that the pump on its baseplate or sub-base is in compliance with API 686 machinery shaft alignment, pipe alignment, and soft foot requirements.

9.4 Preparation for Shipment

9.4.1 Equipment shall be suitably prepared for the type of shipment specified.

9.4.1.1 The preparation shall make the equipment suitable for 6 months of outdoor storage from the time of shipment, with no disassembly required before operation, except for inspection of pump bearings and seals.

9.4.1.2 If storage for a longer period is contemplated, the purchaser shall consult with the vendor regarding the recommended procedures.

NOTE Some equipment, such as control panels that contain electronic equipment, can benefit from storage in a climate-controlled environment.

9.4.2 The vendor shall provide the purchaser with the instructions necessary to preserve the integrity of the storage preparation after the equipment arrives at the job site and before start-up, as described in API 686.

9.4.3 The equipment shall be prepared for shipment after all testing and inspection have been completed and the equipment has been released by the purchaser.

9.4.4 Except for machined surfaces, all exterior surfaces that can corrode during shipment, storage, or in service, including the underside of baseplates, shall be given at least one coat of the manufacturer's standard paint.

9.4.4.1 The paint shall not contain lead or chromates.

NOTE Austenitic stainless steels are typically not painted for a nonmarine or noncorrosive environment. Depending upon operating temperatures, the environmental setting (marine or nonmarine), and the specific materials stainless steels may require coating to protect them. For insulated stainless, the requirements for coating are increased. Proper review of the need for coating should be reviewed to avoid corrosion.

9.4.4.2 • The purchaser can require a specific painting system.

9.4.5 Exterior machined surfaces except for corrosion-resistant material shall be coated with suitable rust preventive.

9.4.6 The interior of the equipment shall be clean; free from scale, welding spatter, and foreign objects; and sprayed or flushed with rust preventive that can be removed with solvent.

9.4.7 Internal surfaces of bearing housings and carbon steel oil systems' components shall be coated with an oil-soluble rust preventive that is compatible with the lubricating oil.

9.4.8 Flanged openings shall be provided with metal closures at least 5 mm (³/₁₆ in.) thick with elastomer gaskets and at least four full-diameter bolts.

9.4.8.1 Each elastomeric gasket shall be equal to the flange diameter.

9.4.8.2 For studded openings, all nuts required for the intended service shall be used to secure closures.

9.4.8.3 Each opening shall be car sealed so that the protective cover cannot be removed without the seal being broken.

9.4.9 Threaded openings shall be provided with steel caps or round-head steel shipping plugs in accordance with ASME B16.11.

9.4.9.1 The caps or plugs shall be of material equal to or better than that of the pressure casing.

9.4.9.2 Nonmetallic (such as plastic) caps or plugs shall not be used.

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9.4.10 Openings that have been bevelled for welding shall be provided with closures designed to prevent entrance of foreign material and damage to the bevel.

9.4.11 Lifting points and lifting lugs shall be clearly identified on the equipment package.

9.4.12 The recommended lifting arrangement shall be graphically described in the installation manual.

9.4.12 Each package shall be marked with lifting and sling points that will distribute the load equally and keep them in a stable horizontal position.

9.4.13 Each item shall be provided with lashing points to secure the load horizontally and axially during transport.

9.4.14 Equipment shall be identified with item and serial numbers.

9.4.14.1 Material shipped separately shall be identified with securely affixed, corrosion-resistant metal tags indicating the item and serial number of the equipment for which it is intended.

9.4.14.2 Crated equipment shall be shipped with duplicate packing lists, one inside and one on the outside of the shipping container.

9.4.14.3 All instrumentation, whether installed on the equipment or shipped loose, shall be identified with securely affixed, corrosion-resistant tags.

9.4.15 The base and all components and piping of a package or an assembled oil system shall be shipped as a single assembly.

9.4.16 The base and all components and piping of a package or an assembled oil system shall be temporarily braced as necessary to prevent damage during shipment.

9.4.17 No component shall be disassembled for shipment except as required to meet dimensional restrictions for transport or for protection against vibration or other damage during handling and shipment.

9.4.18 pumps and drivers shall be uncoupled except for some coupling types, such as C-flange motors, necessitate pump/motor disassembly.

9.4.18.1 Exposed shafts and coupling fit areas shall be protected with a corrosion barrier followed by a separate barrier material to protect against incidental mechanical damage.

9.4.18.2 The seams shall be sealed with oil-proof adhesive tape.

9.4.19 Each filter shall be shipped with new, clean elements installed and shall carry outside a securely affixed all-weather tag stating "SHIPPED WITH CLEAN ELEMENTS INSTALLED."

9.4.20 Spare parts shall be packaged separately from materials belonging to the main order.

9.4.21 All packing material shall be biologically decomposable or recyclable.

9.4.22 Composition wood products such as particleboard, medium-density fiberboard (MDF), and oriented strand board (OSB) shall not be used.

9.4.23 Wood used in export shipping shall comply with the requirements of ISPM Pub. No.15.

9.4.24 Turbine drivers shall be dried thoroughly and prepared for shipment in accordance with API 611.

9.4.25 Auxiliary piping connections furnished for the purchased equipment shall be impression stamped or permanently tagged to agree with the vendor's connection table or general arrangement drawing.

9.4.26 Service and connection designations shall be indicated.

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9.4.27 Assemblies and components shall be fully protected from entry of moisture and dirt.

9.4.27.1 If vapor-phase inhibitor crystals in bags are installed in large cavities to absorb moisture, the bags shall be attached in an accessible area for ease of removal.

9.4.27.2 When applicable, bags shall be installed in wire cages attached to flanged covers.

9.4.27.3 Bag locations shall be indicated in corrosion-resistant tags attached with stainless steel wire.

9.4.28 Connections on auxiliary piping removed for shipment shall be match-marked or permanently tagged for ease of assembly.

9.4.29 Components to be shipped separately shall be suitably preserved or placed in plastic bags and contained by cardboard boxes.

9.4.30 Individual boxes shall be securely blocked or braced in the shipping container.

9.5 Package Markings and Shipping Documentation

9.5.1 ● All markings shall be in English and other specified language.

9.5.2 Shipping marks shall be stenciled on two opposite sides of the shipping unit. A shipping unit may be a box, carton, bundle, crate, drum, loose self-supported piece of equipment, etc.

NOTE Some equipment, especially smaller pieces or those prepared for domestic shipment, may not have adequate surfaces for stenciling of shipping marks. In those instances, see 9.5.4.

9.5.3 Lettering shall be between 3 in. to 5 in. (7.6 cm and 12.7 cm) high in weatherproof black ink to ensure visibility.

9.5.4 Shipping units that cannot be stenciled directly shall have attached corrosion resistant metal tags with raised markings.

9.5.5 Shipping units shall be marked with industry standard cautionary symbols indicating center of gravity, sling or lifting points, top heavy packages, fragile and liquid contents, moisture sensitive contents, and other issues per ASTM D5445-15.

9.5.6 Package markings shall include:

- a) purchaser's purchase order number and tag number;
- b) shipping unit piece number;
- c) gross weight;
- d) dimensions;
- e) purchaser's project name.

9.5.7 Packaged equipment shall be shipped with duplicate packing lists—one inside and the other on the outside of the shipping container, as well as a paper copy of package markings inside each container.

9.5.8 ● One copy of the manufacturer's standard installation instructions shall be packed and shipped with the equipment.

9.5.9 Equipment or materials that contain or are coated with chemical substances shall be prominently tagged at openings to indicate the nature of contents and precautions for shipping, storage, and handling.

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NOTE Some examples include oils, corrosion inhibitors, antifreeze solutions, desiccants, hydrocarbon substances, and unused paint.

9.5.9.1 Substances that are supplied with the shipment shall have a safety data sheet (SDS).

9.5.9.2 If a substance is exempt from regulation, a statement to that effect shall be included.

9.5.9.3 At least 2 weeks before shipment, SDSs shall be forwarded to the receiving facility, to allow planning for handling of any regulated substances.

9.5.9.4 SDSs in protective envelopes shall be affixed to the outside of the shipping package.

10 Vendor's Data

10.1 General

10.1.1 The purchaser may specify the content of proposals, meeting frequency, and vendor data content/format identified in Annex D. Annex D provides a general outline of information that potentially may be requested by the purchaser.

10.1.2 ● The information specified in Annex D shall be provided.

10.2 Documentation

10.2.1 The information to be furnished by the vendors is specified in 10.3 and 10.4.

10.2.1.1 The vendor shall complete and forward the vendor drawing and data requirements (VDDR) form (see Annex D) to the address or addresses noted on the inquiry or order.

10.2.1.2 This form shall detail the schedule for transmission of drawings, curves, and data as agreed to at the time of the order, as well as the number and type of copies required by the purchaser.

10.2.2 The data shall be identified on transmittal (cover) letters, in title blocks and title pages or other prominent position on drawings, with the following information:

- a) purchaser's/owner's corporate name;
- b) job/project number;
- c) equipment item number and service name;
- d) inquiry or purchase order number;
- e) any other identification specified in the inquiry or purchase order;
- f) vendor's identifying proposal number, shop order number, serial number, or other reference required to completely identify return correspondence.

10.2.3 A coordination meeting shall be held, preferably at the vendor's plant, within 4 to 6 weeks after order commitment.

10.2.4 Unless otherwise specified, the vendor shall prepare and distribute an agenda prior to this meeting, which, as a minimum, includes a review of the following items:

- a) purchase order, scope of supply, unit responsibility, subvendor items, and lines of communication;
- b) data sheets;
- c) applicable specifications and previously agreed exceptions;

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- d) schedules for transmittal of data, production, and testing;
- e) quality assurance program and procedures;
- f) inspection, related acceptance criteria, expediting, and testing;

NOTE See Table I.1 for an inspector's checklist to assist in defining inspection requirements.

- g) schematics and bills of materials;
- h) instrumentation and controls;
- i) physical orientation of the equipment and piping, including access for operation and maintenance;
- j) any site erection, commissioning, or location issues;
- k) other technical items.

10.3 Proposals

10.3.1 General

10.3.1.1 The vendor shall forward the original proposal, with the specified number of copies, to the addressee specified in the inquiry documents.

10.3.1.1.1 As a minimum, the proposal shall include the data specified in 10.4 and 10.4.3, as well as a specific statement that the system and all its components are in strict accordance with API 614.

10.3.1.1.2 If the system and components are not in strict accordance, the vendor shall include a list that details and explains each deviation.

10.3.1.1.3 The vendor shall provide sufficient detail to enable the purchaser to evaluate any proposed alternative designs.

10.3.1.1.4 All correspondence shall be clearly identified in accordance with 10.2.2.

10.3.1.2 The materials of construction of all major components shall be clearly stated in the vendor's proposal.

10.3.1.2.1 Materials shall be identified by reference to applicable International Standards, including the material grade.

10.3.1.2.2 If no such designation is available, the vendor's material specification, giving physical properties and chemical composition, and test requirements shall be included in the proposal. Where International Standards are not available, internationally recognized national or other standards may be used.

10.3.2 Drawings

10.3.2.1 Drawings indicated on the VDDR form (see Annex D) shall be included in the proposal and, as a minimum, will include the following:

- a) general arrangement or outline drawing for skid-mounted package, showing overall dimensions, maintenance clearance or removal dimensions, overall masses, erection masses and the largest maintenance mass for each item, as well as the size and location of major purchaser connections;
- b) cross-sectional drawings showing the details of the proposed equipment, when available;
- c) schematics of all auxiliary systems, including the fuel, lube-oil, control, and electrical systems, as well as bills of material;
- d) sketches that show methods of lifting and major components and auxiliaries; this information may be included on the drawings specified in item a) above or may be depicted in instruction manuals.

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10.3.2.2 If “typical” drawings, schematics, and bills of material are used, they shall be marked up to show the correct mass and dimension data and to reflect the actual equipment and scope proposed.

10.3.2.3 Technical Data

10.3.2.3.1 The following data shall be included in the proposal:

- a) purchaser’s data sheets, with complete vendor’s information about the proposed equipment entered thereon and literature to fully describe details of the offering;
- b) predicted noise data;
- c) VDDR form (see Annex D), indicating the schedule according to which the vendor agrees to transmit all the data specified as part of the contract;
- d) schedule for shipment of the equipment, in weeks after receipt of the order;
- e) list of spare parts recommended for start-up and normal maintenance purposes;
- f) list of the special tools furnished for maintenance;
- g) description of any special weather protection and winterization required for start-up, operation, and periods of idleness under the site conditions specified on the data sheets (the list shall clearly indicate the protection to be furnished by the purchaser, as well as that included in the vendor’s scope of supply);
- h) complete tabulation of utility requirements, e.g. steam, water, electricity, air, gas, lube oil (including the quantity and supply pressure of the oil required and the heat load to be removed by the oil), and the nameplate power rating and operating power requirements of auxiliary drivers (approximate data shall be defined and clearly identified as such);
- i) description of any special requirements specified in the purchaser’s inquiry;
- j) any start-up, shutdown, or operating restrictions required to protect the integrity of the equipment;
- k) list of components that can be construed as being of alternative design, hence requiring the purchaser’s acceptance;
- l) description of inspection procedures for materials.

10.3.2.3.2 ● Procurement of components shall not proceed without the purchaser’s review and acceptance of the components selected.

10.3.2.3.3 ● The manufacture of the console shall not proceed without the purchaser’s review of the layout of components and piping.

10.3.2.3.4 ● The vendor shall furnish an outline of the procedures used for each of the special or optional tests that have been specified by the purchaser or proposed by the vendor.

10.4 Contract Data

10.4.1 General

10.4.1.1 The contract data shall be furnished by the vendor in accordance with the agreed VDDR form.

10.4.1.1.1 Each drawing shall have a title block in its lower right-hand corner with the date of certification, identification data specified in 10.2.2, the revision number and date, and the title.

10.4.1.1.2 Similar information shall be provided on all other documents including subvendor items.

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10.4.1.2 The purchaser will promptly review the vendor's data when received; however, this review shall not constitute permission to deviate from any requirements in the order unless specifically agreed upon in writing.

10.4.1.3 After the data have been reviewed and accepted, the vendor shall furnish certified and as-built copies in the quantity specified.

10.4.1.4 A complete list of vendor data shall be included with the first issue of the major drawings.

10.4.1.4.1 This list shall contain titles, drawing numbers, and a schedule for transmission of each item listed.

10.4.1.4.2 This list shall cross-reference data with respect to the VDDR form in Annex D.

10.4.2 Drawings

10.4.2.1 The drawings furnished shall contain sufficient information so that, with the drawings and the manuals specified in 10.4.6, the purchaser can properly install, operate, and maintain the ordered equipment.

10.4.2.2 Drawings shall be clearly legible (8-point minimum font size even if reduced from a larger-size drawing).

10.4.2.2.1 Drawings shall be identified in accordance with 10.4.1.1.1.

10.4.2.2.2 Drawings shall be in accordance with ASME Y14.2.

10.4.2.2.3 As a minimum, each drawing shall include the details for that drawing listed in Annex D.

10.4.3 Technical Data

10.4.3.1 The data shall be submitted in accordance with Annex D and identified in accordance with 10.4.1.1.1.

10.4.3.1.1 Any comments on the drawings or revisions of specifications that necessitate a change in the data shall be noted by the vendor.

10.4.3.1.2 These notations shall result in the purchaser's issue of completed, corrected data sheets as part of the order specifications.

10.4.3.2 ● The vendor shall submit certified copies of the test data to the purchaser for approval before shipment.

10.4.4 Progress Reports

● The vendor shall submit progress reports to the purchaser at the intervals specified.

NOTE Refer to the description of item m) in Table D.1 of Annex D for the content of these reports.

10.4.5 Parts Lists and Recommended Spares

10.4.5.1 The vendor shall submit complete parts lists for all equipment and accessories supplied.

10.4.5.1.1 These lists shall include part names, manufacturer's unique part numbers, and materials of construction (identified by applicable International Standards).

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10.4.5.1.2 Each part shall be completely identified and shown on appropriate cross-sectional, assembly-type cutaway, or exploded-view isometric drawings.

10.4.5.1.3 Interchangeable parts shall be identified as such.

10.4.5.1.4 Parts that have been modified from standard dimensions or finish to satisfy specific performance requirements shall be uniquely identified by part number.

10.4.5.1.5 Standard purchased items shall be identified by the original manufacturer's name and part number.

10.4.5.2 The vendor shall indicate on each of these complete parts lists all those parts that are recommended as start-up or maintenance spares, and the recommended stocking quantities of each.

10.4.5.2.1 These shall include spare parts recommendations of subsuppliers that were not available for inclusion in the vendor's original proposal.

10.4.5.2.2 The vendor shall forward the lists to the purchaser promptly after receipt of the reviewed drawings and in time to permit order and delivery of the parts before field start-up.

10.4.5.2.3 The transmittal letter shall be identified with the data specified in 10.2.2.

10.4.6 Installation, Operation, Maintenance, and Technical Data Manuals

10.4.6.1 General

10.4.6.1.1 The vendor shall provide sufficient written instructions and all necessary drawings to enable the purchaser to install, operate, and maintain all of the equipment covered by the purchase order.

10.4.6.1.2 This information shall meet the following requirements:

- a) compiled in a manual or manuals with a cover sheet showing the information listed in 10.2.2;
- b) an index sheet and a complete list of the enclosed drawings by title and drawing number;
- c) the manual pages and drawings shall be sequentially numbered;
- d) the manual or manuals shall be prepared specifically for the equipment covered by the purchase order; "typical" manuals are unacceptable.

10.4.6.2 Installation Manual

10.4.6.2.1 All information required for the proper installation of the equipment shall be compiled in a manual.

10.4.6.2.1.2 This manual shall be issued no later than the time of issue of final certified drawings. For this reason, it may be separate from the operating and maintenance instructions.

10.4.6.2.3 This manual shall contain information on:

- a) alignment and grouting procedures;
- b) normal and maximum utility requirements;
- c) centers of mass;

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- d) rigging provisions and procedures;
- e) all other installation data;
- f) all drawings and data specified in 10.4.2 and 10.4.3 that are pertinent to proper installation are to be included as part of this manual;
- g) one extra manual, over and above the specified quantity, are to be included with the first equipment delivered.

10.4.6.3 Operation and Maintenance Manual

A manual shall be supplied at shipment containing:

- a) all required operating and maintenance instructions;
- b) operation at all specified process conditions;
- c) separate sections covering operation under any specified extreme environmental conditions.

NOTE VDDR allows for input of required document dates.

10.4.6.4 Technical Data Manual

10.4.6.4.1 The oil system technical data manual contents shall be available for review before shipment of the oil system.

10.4.6.4.2 ● The vendor shall provide the purchaser with a technical data manual at shipment.

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Annex A

(informative)

Data Sheets

A.1 Site and Utility Data Sheet

DRAFT - FOR COMMITTEE REVIEW

Project/Design/Data				DOCUMENT NUMBER:					
PROJECT DESIGN DATA SHEET U.S. CUSTOMARY				REVISION	0	1	2	3	4
				DATE					
				BY					
				REV/APPR					
				JOB NO.	PAGE 1 OF 1				
				CLIENT					
				LOCATION					
				UNIT NO.					
				ITEM NO.					
				SERVICE					
APPLICABLE TO: ☒ PROPOSAL ☐ PURCHASE ☐ AS BUILT				REQ'N NO.					
ATMOSPHERIC AND WEATHER									
AMBIENT DRY BULB TEMPERATURE				RAINFALL / SNOWFALL (in)					
Average Annual (Summer / Winter) (°F)				Average, Annual Rainfall Max 24 Hour Period					
Site Maximum (Design) (°F)				Average, Annual Snowfall					
Site Minimum (Design) (°F)				SNOW AND ICE LOADING					
Design Basis - Air Cooled Exchangers (°F)				Ground Snow Load (in)					
RELATIVE HUMIDITY (%)				RAW WATER SOURCE:					
Average @ (°F)				Temperature: (min/max/design) (°F)					
Maximum @ (°F)				EARTHQUAKE LOADING:					
Minimum @ (°F)				Design Code:					
BAROMETRIC PRESSURE (MAX/MIN) (psig)				Seismic Zone: Importance Factor:					
SOLAR RADIATION (Heat Flux Intensity) (BTU/ft²)				Short Period Acceleration (S _s) in %g:					
SITE ELEVATION (ft)				DESIGN WIND SPEED, 3 sec gust: (mph)					
SITE CONDITIONS:				Wind Design Code: Site Class:					
				Exposure Category:					
UTILITIES									
STEAM					ELECTRICAL POWER				
Pressure (psig)	Rated	Max/Min	Mech Design	MOTORS		Voltage	Phase	Hertz	
High-high				Low Volt: <=	(HP)				
High				Med Volt: > & ·	(HP)				
Medium				High Volt: > & ·	(HP)				
Low				High-High Volt: >	(HP)				
Temperature (°F)	Rated	Max/Min	Mech Design	Fractional <=	(HP)				
High-high									
High				HEATERS (incl Lube Oil):					
Medium				> (kW)					
Low				<= (kW)					
AIR & NITROGEN				Motor Space Htrs > (kW)					
				Motor Space Htrs < (kW)					
	Pressure (psig)	Temperature (°F)		Heaters for panels					
	Min	Normal	Design	Normal	Design				
Instrument									
Plant Air						MISCELLANEOUS ELECTRICAL			
Nitrogen (LP)						Normal Lighting			
Nitrogen (HP)						U.P.S. - Controls			
Remarks						U.P.S. - Critical Equip			
COOLING WATER				Instrument Circuits					
		Press (psig)	Temp (°F)	Shutdown / Alarm - Instr.					
Maximum (Supply/Return)				Emergency Generator					
Minimum (Supply/Return)				Other					
Max. Differential Temperature									
Allowable Differential Pressure				Digital I/O Signals:					
System Mech Design				Analog I/O Signals:					
Source									
REMARKS:									

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ProjectDesignData

DOCUMENT NUMBER:

	REVISION	0	1	2	3	4
	DATE					
	BY					
	REV/APPR					
PROJECT DESIGN DATA SHEET SI UNITS (bar)	JOB NO.	PAGE 1 OF 1				
	CLIENT					
	LOCATION					
	UNIT NO.					
	ITEM NO.					
	SERVICE					
APPLICABLE TO: ☐ PROPOSAL ☐ PURCHASE ☐ AS BUILT						
REQ'N NO.						

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ATMOSPHERIC AND WEATHER

AMBIENT DRY BULB TEMPERATURE				RAINFALL / SNOWFALL (mm)			
Average Annual (Summer / Winter) (°C)				Average, Annual Rainfall Max 24 Hour Period			
Site Maximum (Design) (°C)				Average, Annual Snowfall			
Site Minimum (Design) (°C)				SNOW AND ICE LOADING			
Design Basis - Air Cooled Exchangers (°C)				Ground Snow Load (mm)			
RELATIVE HUMIDITY (%)				RAW WATER SOURCE:			
Average @ (°C)				Temperature: (min/max/design) (°C)			
Maximum @ (°C)				EARTHQUAKE LOADING:			
Minimum @ (°C)				Design Code:			
BAROMETRIC PRESSURE (MAX/MIN) (barG)				Seismic Zone: Importance Factor:			
SOLAR RADIATION (Heat Flux Intensity) (W/m²)				Short Period Acceleration (S _s) in %g:			
SITE ELEVATION (m)				DESIGN WIND SPEED, 3 sec gust: (km/h)			
SITE CONDITIONS:				Wind Design Code: Site Class:			
				Exposure Category:			

UTILITIES

STEAM				ELECTRICAL POWER			
Pressure (barG)	Rated	Max/Min	Mech Design	MOTORS	Voltage	Phase	Hertz
High-high				Low Volt: <= (kW)			
High				Med Volt: > & · (kW)			
Medium				High Volt: > & · (kW)			
Low				High-High Volt: > (kW)			
Temperature (°C)	Rated	Max/Min	Mech Design	Fractional <= (kW)			
High-high							
High				HEATERS (incl Lube Oil):			
Medium				> (kW)			
Low				<= (kW)			
AIR & NITROGEN				Motor Space Htrs > (kW)			
	Pressure (barG)		Temperature (°C)		Motor Space Htrs < (kW)		
	Min	Normal	Design	Normal	Design		
Instrument						Heaters for panels	
Plant Air						MISCELLANEOUS ELECTRICAL	
Nitrogen (LP)						Normal Lighting	
Nitrogen (HP)						U.P.S. - Controls	
Remarks				U.P.S. - Critical Equip			
COOLING WATER				Instrument Circuits			
	Press (barG)	Temp (°C)		Shutdown / Alarm - Instr.			
Maximum (Supply/Return)				Emergency Generator			
Minimum (Supply/Return)				Other			
Max. Differential Temperature							
Allowable Differential Pressure				Digital I/O Signals:			
System Mech Design				Analog I/O Signals:			
Source							

REMARKS:

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A.2 Data Sheets—USC Units

DATA SHEET — SCOPE AND ATTACHMENTS

U.S. CUSTOMARY

API 614, 6th Ed. DATA SHEET SCOPE AND ATTACHMENTS U.S. CUSTOMARY		Job No.: _____ Page: 1 of 15 Date: _____	Item No.: _____ By: _____ Revision: _____	Rev
1	Apply to: ☐ Proposal ☐ Purchase ☐ As Built			
2	For _____ Site _____			
3	Oil System for _____			
4	Supplier _____ Manufacturer _____			
5	Purchase Order No. _____ Date _____ Inquiry No. _____ Requisition No. _____			
6				
7	Explanations:			
8	— The party to complete the information is indicated as follows:			
9	☐ Purchaser ☐ Unspared or critical service (by purchaser) ☐ Vendor ☐ Either, but by vendor if not by purchaser.			
10	— An asterisk * specifies a requirement, value, or criterion.			
11	— Designations in parentheses () are explained in the standard;			
12	numbers refer to paragraphs.			
13				
14	Applicable documents:			
15	☐ Local instruments and panel items	☐ Pump Drivers (Motor)		
16	☐ Instrument suppliers	☐ Pump Drivers (Turbine)		
17	☐ Additional documents	☐ Referenced standards		
18	☐ Additional documents	☐ Additional documents		
19	☐ Additional documents	☐ Additional documents		
20	☐ Additional documents	☐ Additional documents		
21	☐ Additional documents	☐ Additional documents		
22				
23	Installation data:			
24	☐ Space available for oil system: L _____ W _____ H _____ (ft)			
25	☐ Plot plan showing console location in relation to main equipment:			
26	(Sketch the equipment plot plan with relation to the console location here)			
27	☐ Maximum allowable noise level not to exceed _____ dB or see _____			
28	☐ Additional requirements _____			
29	☐ Additional requirements _____			
30				
31	☐ Winterize ☐ Tropicalize ☐ Minimum clearance and access to components required (6.2.13) _____ (ft)			
32	☐ Area classification (8.1.3.2): Class _____ Group _____ Division _____ or see _____			
33				
34	Equipment oil required:			
35	☐ Oil type / viscosity (6.2.8): _____			
36	☐ Required heat load (BTU/hr) _____			
37				
38	☐ Lube oil (6.2.6):	Normal	After trip	Pressure
39	☐	(gpm)	(gpm)	(psig)
40	☐ Driven equipment			
41	☐ Driven equipment			
42	☐ Driven equipment			
43	☐ Prime mover			
44	☐ Gears			
45	☐ Couplings			
46	☐ Total:			
47	☐ Control oil (normal)			
48	☐ Control oil (transient)			
49	☐			
50				

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DATA SHEET — SCOPE AND ATTACHMENTS

U.S. CUSTOMARY

API 614, 6th Ed. DATA SHEET SCOPE AND ATTACHMENTS U.S. CUSTOMARY		Job No.: _____ Page: <u>2</u> of <u>15</u> Date: _____	Item No.: _____ By: _____ Revision: _____
1	* Site data:		
2	☐ Ambient conditions		
3	☐ Min/max temperature (°F) _____ / _____		
4	☐ Relative humidity _____		
5			
6			
7			
8	☐ Steam		
9	Drivers (6.7.7.3):		
10	Pressure _____	Temperature _____	
11	Pressure _____	Temperature _____	
12	Pressure _____	Temperature _____	
13	Pressure _____	Temperature _____	
14	Pressure _____	Temperature _____	
15	Location (6.1.6):		
16	☐ Indoor		
17	☐ Outdoor		
18	☐ Heated		
19	☐ Unheated		
20	☐ Under roof		
21	Painting:		
22	☐ Component supplier standard		
23	☐ Unified per system supplier standard		
24	☐ Purchaser's paint system (9.4.4.2):		
25	☐ _____		
26	☐ _____		
27	☐ _____		
28	☐ _____		
29	☐ _____		
30	☐ _____		
31	☐ _____		
32	☐ _____		
33	Preparation for shipment		
34	☐ Domestic		
35	☐ Export		
36	☐ Extended Storage _____ months		
37	☐ Include _____ sets of extra filter elements		
38	☐ _____		
39	☐ _____		
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DATA SHEET — BASIC DESIGN U.S. CUSTOMARY

API 614, 6th Ed. DATA SHEET BASIC DESIGN U.S. CUSTOMARY				Job No.: _____	Item No.: _____
				Page: 3 of 15	By: _____
				Date: _____	Revision: _____
1	APPLICABLE TO: ☐ Proposal ☐ Purchase ☐ As built				Rev
2	For _____ Site _____				
3	Oil System for _____				
4	Supplier _____		Manufacturer _____		
5	Purchase Order No. _____	Date _____	Inquiry No. _____	Requisition No. _____	
6	Basic Design (4.2.a) Configuration Code: _____				
7	Design goal for uninterrupted operation (mission time) of the equipment (6.1.2): _____ months				
8	☐ Purchaser and the vendor shall agree upon an acceptable system before the order is released (4.8).				
9	☒ If selected here, all diamond options are invoked (4.5).				
10	Overall system selection (6.2)	Figure No	Option Nos	Comments	
11	☐ Combined lube, seal & control system				
12	☐ Separate seal oil system				
13	☐ Seal module at equipment				
14	☐ Lube / control oil system				
15	☐ Basic oil supply module				
16	☐ Lube module at equipment				
17	☐ Drawing requirements				
18	☐ Component review				
19	Supply arrangement (6.2.7):	Lube oil	Seal oil	Combined	Baseplates:
20	☐ Separate console	☐	☐	☐	☐ Point support (6.5.13)
21	☐ Multiple package	☐	☐	☐	☐ Grout holes / vent holes (6.5.7)
22	☐ Combined with equipment base				☐ Epoxy grout precoat (6.5.8)
23	☒ All oil system components mounted on common baseplate (6.5.2)				☐ Nonskid decking required (6.5.4)
24	☐ Special provisions needed for backup oil supply upon primary system failure (6.2.21)				☐ Sloped decking required (6.5.5)
25	☐ Lifting attachments furnished with material and load test certifications (6.5.6.6)				☐ Lifting lugs 100% NDE tested (6.5.6.3)
26	Basic System Details:				
27	☐ Compressor block-in time (6.2.21.2) _____ (min)				☐ Process relief valve setting _____ (psig)
28	☐ Sound level _____ dB max. (6.1.12)				☐ Shop test conditions
29	☐ Equipment coast-down time _____ (min)				☐ Field start-up / run-in conditions
30	Equipment cool off time:				☐ Other special conditions
31	☐ Driver _____ (min)				☐ Welding & special fabrication requirements (6.4.2)
32	☐ _____ (min)				☐ Additional radiography
33	☐ Minimum start up oil temperature _____ (°F)				☐ Magnetic particle
34	Other :				☐ Liquid penetrant
35	☐ Settling out pressure _____ (psig) (6.2.5 a)				☐ Heat loss analysis of system and interconnecting piping (6.6.8.8)
36	☐ Standby pump (6.7.1.3) _____				☐ Only field-proven equipment, defined by Purchaser, accepted (6.1.3)
37	☐ Rundown tank (6.12.2.1) _____				☐ Documentation to demonstrate field-proven equipment (6.1.3.1)
38	atmospheric (Fig. C.15) pressurized (Fig. C.16)				☐ Dynamic simulation of the oil system required (6.2.24)
39					☐ Pressure vessel design code: ASME Section VIII (6.3.1)
40	Piping, Tubing & Valves:				
41	☐ Test valves in oil lines vented back to reservoir (7.1.33)				☐ Utilities manifolded to common connections (7.1.37)
42	☐ Double block & bleeds required (6.2.18)				☐ Air ☐ Cooling water ☐ Other
43	☐ Instrument test valves required (7.3.11)				☐ PLV to be tight shutoff, design code compliant (6.7.22.6)
44	☐ Instrument manifold valves required (7.3.13)				☐ PLV not used for continuous pressure regulation (6.7.22.4)
45	☒ Tubing fitting - Mfg _____ Model _____				☐ Manual bypass valves required around PLV (6.7.22.7)
46	☐ Flange bolting treated to resist atmospheric corrosion (7.1.35)				☒ Control valve heads vented to reservoir (7.3.5)
47	☐ Through studs required (7.1.36)				☐ Continuous oil flow for sensing lines of safety instruments (7.3.6)
48	☐ PN designated flanges required (7.1.16.2)				☐ Special requirements for hazardous service specified (7.1.27)
49	☐ ASME B16.47 Series A steel flanges required (7.1.16.4)				☐ Additional purchaser specification for valves (7.1.39)
50	☐ ASME B16.1 or B16.42 iron flanges accepted (7.1.16.5)				☐ Flanged gate valves required per API 601, API 602 (7.1.40)
51	☐ Machined and studded connections per ASME B16.1 (7.1.16.11)				☐ All stainless steel materials of the oil system to be 316 (6.2.14)
52	☐ Heat tracing reqd by ☐ Purchaser ☐ Vendor				☐ Piping design in accordance with ASME B31.3 (6.2.15)
					☐ Supplementary piping requirements (6.3.5)

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DATA SHEET — INSTRUMENT SUPPLIERS

U.S. CUSTOMARY

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			Date: _____	Revision: _____																																																																																																										
1	APPLICABLE TO: ☐ Proposal ☐ Purchase ☐ As Built				Rev																																																																																																									
2	For _____ Site _____																																																																																																													
3	Oil System for _____																																																																																																													
4	Supplier _____		Manufacturer _____																																																																																																											
5	Purchase Order No. _____ Date _____		Inquiry No. _____ Requisition No. _____																																																																																																											
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7	<table border="1"> <thead> <tr> <th>Instrument suppliers:</th> <th>Manufacturer</th> <th>Description</th> </tr> </thead> <tbody> <tr><td>8</td><td>Pressure gauges</td><td></td></tr> <tr><td>9</td><td>Temperature gauges</td><td></td></tr> <tr><td>10</td><td>Level gauges</td><td></td></tr> <tr><td>11</td><td>Differential pressure gauges</td><td></td></tr> <tr><td>12</td><td>Pressure switches</td><td></td></tr> <tr><td>13</td><td>Differential pressure switches</td><td></td></tr> <tr><td>14</td><td>Temperature switches</td><td></td></tr> <tr><td>15</td><td>Level switches</td><td></td></tr> <tr><td>16</td><td>Control valves</td><td></td></tr> <tr><td>17</td><td>Pressure relief valve</td><td></td></tr> <tr><td>18</td><td>Thermal relief valve</td><td></td></tr> <tr><td>19</td><td>Sight flow indicators</td><td></td></tr> <tr><td>20</td><td>Pressure transmitter</td><td></td></tr> <tr><td>21</td><td>Vibration equipment</td><td></td></tr> <tr><td>22</td><td>Tachometer</td><td></td></tr> <tr><td>23</td><td>Solenoid valves</td><td></td></tr> <tr><td>24</td><td>Annunciator</td><td></td></tr> <tr><td>25</td><td>Thermocouples</td><td></td></tr> <tr><td>26</td><td>Resistance temperature detectors (RTDs)</td><td></td></tr> <tr><td>27</td><td>Thermowells</td><td></td></tr> <tr><td>28</td><td></td><td></td></tr> <tr><td>29</td><td></td><td></td></tr> <tr><td>30</td><td></td><td></td></tr> <tr><td>31</td><td></td><td></td></tr> <tr><td>32</td><td></td><td></td></tr> <tr><td>33</td><td></td><td></td></tr> <tr><td>34</td><td></td><td></td></tr> <tr><td>35</td><td></td><td></td></tr> <tr><td>36</td><td></td><td></td></tr> <tr><td>37</td><td></td><td></td></tr> <tr><td>38</td><td></td><td></td></tr> <tr><td>39</td><td></td><td></td></tr> <tr><td>40</td><td></td><td></td></tr> <tr><td>41</td><td></td><td></td></tr> </tbody> </table>				Instrument suppliers:	Manufacturer	Description	8	Pressure gauges		9	Temperature gauges		10	Level gauges		11	Differential pressure gauges		12	Pressure switches		13	Differential pressure switches		14	Temperature switches		15	Level switches		16	Control valves		17	Pressure relief valve		18	Thermal relief valve		19	Sight flow indicators		20	Pressure transmitter		21	Vibration equipment		22	Tachometer		23	Solenoid valves		24	Annunciator		25	Thermocouples		26	Resistance temperature detectors (RTDs)		27	Thermowells		28			29			30			31			32			33			34			35			36			37			38			39			40			41			
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42	☐ Purchaser's review and acceptance of components prior to purchase (10.3.2.3.2)																																																																																																													
43	☐ Purchaser's review and acceptance of layout of components and piping prior to purchase (10.3.2.3.3)																																																																																																													
44	☐ Furnish outline of procedures of special tests specified by the purchaser (10.3.2.3.4)																																																																																																													
45	Comments:																																																																																																													
46	_____																																																																																																													
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DATA SHEET — RESERVOIR

U.S. CUSTOMARY

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2	Supplier _____	Manufacturer _____		
3	Purchase Order No. _____ Date _____	Inquiry No. _____	Requisition No. _____	
4	Service application: ☐ Separate lube ☐ Lube/seal combined ☐ Separate seal			
5	Purch. item no. _____			
6	☐ Figures no. _____			
7	☐ Include options no. _____			
8	☐ Heater steam/electric (6.6.8.2) _____			
9	☐ Heater removable element (6.6.8.2.3, 6.6.8.2.4) _____			
10	☒ Temp. device for remote monitoring and control (6.6.8.5) _____			
11	☐ Heater element removable during operation (6.6.8.7) _____			
12	☐ Heater installed in oil-filled pipe well (6.6.8.7.2) _____			
13	☐ Material _____			
14	☐ Normal flow (gpm) _____			
15	☐ Free surface (ft ²) _____			
16	☒ Free surface minimum specified (6.6.7.12) _____			
17	☐ Working capacity (gal) _____			
18	☐ Working capacity at least 5 min. of normal flow (6.6.7.4) _____			
19	☐ Retention capacity (gal) _____			
20	☒ Minimum retention capacity 8 min. of normal flow (6.6.7.5) _____			
21	☐ Rundown capacity (gal) _____			
22	☐ Normal operating range (gpm) _____			
23	☐ Charge capacity (gal) _____			
24	☒ Reflex-type oil level glass (6.6.4.3.1) _____			
25	☐ Alternate means of level indication (6.6.4.3.2) _____			
26	☒ Low-level alarm (6.6.7.11) _____			
27	☐ Insulation clips (6.6.9.1) ☐	☐	☐	
28	☐ Ladder with handrail (6.6.13.1) ☐	☐	☐	
29	☐ Handrails on reservoir top (6.6.13.2) ☐	☐	☐	
30	☐ Nonskid decking on reservoir top (6.6.13.3) ☐	☐	☐	
31	☒ Flanged reservoir pipe connections (6.6.2.10) ☐	☐	☐	
32	☒ Vent connection with blind flange (6.6.4.6) ☐	☐	☐	
33	☒ Flanged vent drain connection w/valve & blind flange (6.6.3.3) ☐	☐	☐	
34	☒ Threaded plugged connection above rundown level (6.6.10.1) ☐	☐	☐	
35	☐ Designed for overpressurization or negative pressure (6.6.1.4, 6.6.1.5) _____			
36	☐ Siphon breaker ☐	☐	☐	
37	☒ Top mounted components prohibited (6.6.1.9) ☐	☐	☐	
38	☐ Top mounted components are: _____			
39	☐ Submerged components & materials _____			
40	☐ Dimension of tank L x W x H (ft) _____			
41	☐ Separate connection for seal oil return line (6.6.4.8) ☐	☐	☐	
42	☒ Connections for oil conditioner (6.6.11.1) ☐	☐	☐	
43	☐ Sample points required (6.9.14) _____			
44	☒ Top of reservoir shall slope at least 10 mm/m (1/8 in./ft) (6.6.1.11) _____			
45	☐ Other criteria for reservoir top (6.6.13.6) _____			
46	☒ Bottom of reservoir sloped continuously (6.6.3.1) _____			
47	☒ Fill opening, spring closed, with ss mesh strainer (6.6.4.5) _____			
48	☐ Flame arrestors required (6.6.6.1), Locations (6.6.6.2) _____	Special requirements (6.6.6.3) _____		

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DATA SHEET — ACCESSORIES

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2	Supplier _____	Manufacturer _____	
3	Purchase Order No. _____ Date _____	Inquiry No. _____ Requisition No. _____	
4			
5	Oil Conditioner (6.6.11.1):	Degassing Drum (6.14.1):	
6	☐ Purch. item no. _____	☐ Purchaser's item no. _____	☐ Service used in _____
7	☐ Service used in _____	☐ Type in accordance with Figure 4 or other spec	☐ Flow control
8	☐ Type _____	Operating temp. _____ (°F)	☐ Thermostat control
9	☐ Portable / fixed _____	(gpm) normal/max. _____ / _____	☐ Material _____
10	☐ Rated flow (gpm) _____	Normal retention _____ minutes	☐ Interior coating
11	☐ Manufacturer _____	Norm/max. capacity _____ / _____ (gpm)	☐ Oversized vent
12	☐ Model _____	☐ Purge gas type	☐ Vent relief device
13	☐ Driver for _____	☐ (scfm) required _____	☐ Omit breather
14	☐ HP & enclosure	☐ Type heating device (6.14.4) _____	☐ Code construction (6.3.1)
15	☐ Volts / PH / Hz	☐ Corrosion allowance _____ (in)	☐ Code stamp (6.3.3)
16	_____ / _____ / _____	☐ Design/test _____ / _____ (psig)	☐ Other _____
17	☐ Water removal rate _____	☐ Pressurized service (6.14.9) _____	☐ Other _____
18	☐ Mat'l of construction _____	☐ Other _____	☐ Other _____
19	Extraction and Static Oil Mist Eliminator Systems (6.6.5):		
20	☐ Extraction or static oil mist eliminator in place of the breather cap (6.6.5.1)		
21	☐ Vacuum relief device provided for extraction oil vent mist eliminator (6.6.5.8)		
22	☐ Oil mist eliminator arrangements fitted with suitable isolation and bypass valves to enable maintenance while in operation (6.6.5.13)		
23	☐ 100 % capacity standby extraction oil mist eliminator system with online transfer capability shall be supplied (6.6.5.14)		
24	☐ Other oil mist eliminator system arrangements supplied (6.6.5.15) _____		
25	☐ Extraction/Static		
26	☐ Vacuum / dP level _____	(in H ₂ O)	
27	☐ Oily mist flow _____	(scfm)	
28	☐ Manufacturer _____		
29	☐ Model _____		
30	☐ Materials _____		
31	☐ Design / test pressure _____	(psig)	
32	☐ Eductor / Blower _____		
33	☐ HP & enclosure		
34	Volts / Phase / Hz _____ / _____ / _____		
35	Eductor motive gas:		
36	☐ Type		
37	☐ Pressure _____	(psig)	
38	☐ Flow _____	(scfm)	
39	☐ Mist eliminator efficiency		
40	Furnish _____ extra sets of cartridges ☐ per service ☐ per filter (in addition to other spares)		
41			
42	Comments:		
43	_____		
44	_____		
45	_____		
46	_____		
47	_____		
48	_____		
49	_____		
50	_____		

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DATA SHEET — PUMPS

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2	Supplier _____	Manufacturer _____			
3	Purchase Order No. _____ Date _____	Inquiry No. _____ Requisition No. _____			
4					
5	Pumps and Drivers (6.7):	Lube	Lube / seal	Separate seal oil	Booster seal oil
6	☐ Service application				
7	☐ Figures no.				
8	☐ Include options no.				
9	☐ Booster pumps required				
10	☐ Emergency oil pump (6.7.3)	☐	☐	☐	☐
11	Pump Service:	Main / stby	Emergency	Main / stby	Emergency
12	☐ Pump item no.				
13	☐ Pump type (6.7.1.1)				
14	☐ Pumps external to reservoir (6.7.2)				
15	☐ Submerged pump materials				
16	☐ Pump data sheet				
17	☐ Additional pump standard (6.7.1.2)				
18	☐ Horizontal or vertical (H or V)				
19	☐ Mounting pads (6.7.45.1)				
20	☐ Jackscrews (6.7.45.5)				
21	☐ Driver item no.				
22	☐ Turbine driver (6.7.7)				
23	☐ Turbine data sheet (6.7.7.3)				
24	☐ Electric motor driver				
25	☐ Motor standard applies (6.7.12)				
26	☐ Electric motor data sheet				
27	☐ Driver sized for min. ambient (6.7.16)				
28	☐ Reverse rotation provisions (6.7.18)				
29	☐ Other driver				
30	☐ Other driver data sheet				
31	☐ Coupling type (6.7.35)				
32	☐ Coupling balance to G6.3 (6.7.37)				
33	☐ Coupling S.F. minimum 1.15 (6.7.41)				
34	☐ Coupling guard type (6.7.33.4)				
35	☐ Strainer spool pieces req'd (6.7.27.4)				
36	☐ Strainer pressure gage req'd (6.7.30)				
37	☐ Solenoid trip valve				
38	☐ Rotary pump relief valve by				
39	(purchaser / vendor)				
40					
41	Comments:				
42					
43					
44					
45					
46					
47					
48					
49					
50					

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DATA SHEET — FILTERS

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2	Supplier _____	Manufacturer _____	
3	Purchase Order No. _____ Date _____	Inquiry No. _____ Requisition No. _____	
4			
5	Filters (6.9):		
6	☐ Service application:	☐ Lube ☐ Lube & seal ☐ Control	☐ Separate control oil ☐ Separate seal oil ☐ Booster pump discharge oil ☐ Separate coupling oil
7			
8			
9	☐ Filter item no.		
10	☐ Dual (6.9.1) ☐ Single (6.9.1.2)	☐	☐
11	☐ Flanged filter housings (6.9.1.8)		
12	☐ Valved vent, drain connections (6.9.1.10)		
13	☐ Specific element manufacturer (6.9.8.1)		
14	☐ Specific element model		
15	☐ Code design (6.3.1) / Code stamp (6.3.3)	☐ / ☐	☐ / ☐
16	☐ Special control-oil filtration req'd (6.9.13)		
17	☐ Thermal overpressure protection of offline filter (6.9.2)		
18			
19	☐ Thermal relief valves routed to reservoir (6.9.3)		
20			
21	☐ Manifolder dual filter drains (6.9.4)		
22	☐ Filter vents routed to reservoir through sight flow glass (6.9.6)		
23			
24	☐ Filters grounded to baseplate (6.9.1.12)		
25	☐ Material: case & top		
26	☐ Furnish extra sets of cartridges	☐ per service ☐ per filter (extra over other spares)	
27	Continuous flow transfer valve:		
28	☐ Service application:	☐ Lube oil, ☐ seal oil & ☐ control oil	☐ Separate control oil ☐ Separate seal oil ☐ Booster pump discharge oil ☐ Separate coupling oil
29			
30			
31	☐ Common for coolers & filters	☐	☐
32	☐ Spectacle blinds required (6.10.6)	☐	☐
33	☐ Type (single 6-port or two 3-way) (6.10.2)		
34	☐ Manufacturer		
35	☐ Model		
36	☐ With lifting jack	☐	☐
37	Rating: (psig)		
38	☐ Materials: body		
39	☐ Plug or ball		
40	☐ Trim		
41			
42	Comments:		
43			
44			
45			
46			
47			
48			
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DATA SHEET — LUBE-OIL HEAT EXCHANGERS

U.S. CUSTOMARY

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2	Supplier _____	Manufacturer _____	
3	Purchase Order No. _____ Date _____	Inquiry No. _____ Requisition No. _____	
4			
5	Lube-oil Heat Exchangers: (6.8)		
6	Service application	☐ Lube	☐ Lube/seal ☐ Separate seal
7	☐ Item no(s).		
8	☐ Dual units including transfer valve (6.8.1.2)	☐	☐
9	☐ Include option nos.		
10	☐ Air-cooled heat exchangers required (6.8.4.1)	☐	
11	☐ Multi-plate frame or air-cooled heat exchangers required (6.8.1.4)		
12	☐ Details on ISO data sheet		
13	☐ Water side corrosion allowance (6.8.1.9)		
14	☐ Manufacturer		
15	☐ Model		
16	☐ TEMA class (6.8.2.2.2)		
17	☐ Fouling factor water/oil side (6.8.1.9)		
18	☐ Duty: (BTU/hr)		
19	☐ Tube: L / OD / BWG (6.8.2.2.3)		
20	☐ Design / test pressure shell side (psig)		
21	☐ Design / test pressure tube side (psig)		
22	☐ Construction code / Code stamp (6.3.1. / 6.3.3)	☐ / ☐	☐ / ☐
23	☐ Header plug of nongalling material (6.8.4.4.4)		
24	☐ Connections for purchaser's cooler (6.8.1.6 or 6.8.4.3)		
25	☐ Two or more fans for air-cooled heat exchangers (6.8.4.4.1)		
26	☐ Vibration transducers for each fan (6.8.4.4.5)		
27	☐ Hail guards required (6.8.4.4.8)		
28	☐ Adjustable louvers for temperature control required (6.8.4.4.10)		
29	☐ Tube water flow rate (gpm) (6.8.1.9)		
30	☐ Tube water velocity (fps) (6.8.1.9)		
31	☐ Material: shell, channels, and covers (6.8.2.6)		
32	☐ Tube sheets & tubes (6.8.2.6.1, 6.8.2.6.2)		
33	☐ Removable tube bundle (6.8.2.2.1)	☐	☐
34	☐ Nonrepairable heat exchangers permitted (6.8.2.2.5)		
35	☐ Fabricated with flanged vent and drain nozzles (6.8.1.20)	☐	☐
36	☐ Oil side vents piped to reservoir through F.I. (6.8.1.22)	☐	☐
37	☐ Cooler drains manifolded but not with filter clean oil drains (6.8.1.21)	☐	☐
38	☐ Oil bypass line with temperature control valve (6.8.1.15)	☐	☐
39	☐ 3-port valve with internal thermostat (6.8.1.15.5)	☐	☐
40	☐ Flanged, pneumatically operated 2- or 3-port valve (6.8.1.15.3)	☐	☐
41	☐ Manual override of temperature control valve (6.8.1.15.6)	☐	☐
42	☐ Separate oil side thermal relief valves, each cooler (6.8.1.8)	☐	☐
43	☐ Suitable for use with 150 °C (300 °F) medium (6.8.1.16)	☐	☐
44	☐ Tube O.D. at least 5/8 in., tube wall at least 18 BWG (6.8.2.4)	☐	☐
45	☐ Oil-side lower than the water-side operating pressure (6.8.1.25)	☐	☐
46	Comments:		
47			
48			
49			
50			

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DATA SHEET — OVERHEAD TANKS U.S. CUSTOMARY

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1	APPLICABLE TO: ☐ Proposal ☐ Purchase ☐ As built	Rev	
2	Supplier _____ Manufacturer _____		
3	Purchase Order No. _____ Date _____ Inquiry No. _____ Requisition No. _____		
4	Accumulators (6.11):		
5	Service application	Lube oil	Control oil
6	☐ Required, yes or no, and quantity		
7	☐ Purchaser's item No.		
8	☐ Service combined with		
9	☐ Direct contact type (6.11.3) (Fig. C.19)	☐	☐
10	☐ Bladder type (Fig. C.18)	☐	☐
11	☐ Include option nos. (Fig. C.18, C.19)		
12	☐ Rundown time (min)		
13	☐ Provisions for heat trace, insulation (6.11.13)	☐	☐
14	☐ Constant pressure regulator (6.11.3)	☐	☐
15	☐ Manufacturer		
16	☐ Model		
17	☐ Nominal / usable capacity (gal)		
18	☐ Material: Austenitic ss vessel (6.11.9)		
19	☐ Bladder		
20	☐ Corrosion allowance (in)		
21	☐ Design / test pressure (psig)		
22	☐ Construction code / Code stamp	☐ / ☐	☐ / ☐
23	☐ Accumulator valve locked open (6.11.18)	☐	☐
24	Include:		
25	☐ charge pressure gauge:	☐	☐
26	☐ manual precharge valve (6.11.3)	☐	☐
27	☐ gas supply regulator	☐	☐
28	☐ bleed-down line sight glass (6.11.17)	☐	☐
29	Overhead tanks (6.12)		
30	Service application	Rundown lube oil	Low-pressure seal oil
31			
32	Lube-oil rundown tanks (6.12.2)		
33	☐ Required, yes or no (6.12.2.1)		
34	☐ Purchaser's item no.		
35	☐ Service combined with		
36	☐ Includes options no. (Fig. C.15 or C.16)		
37	☐ Capacity (min) or (gal)		
38	☐ Bypass orifice (6.12.2.6) (Fig. C.16)		
39	☐ Interconnecting piping volume		
40	Seal-oil tanks (6.12.3)		
41	☐ Required, yes or no (6.12.3.1)		
42	☐ Purchaser's item No.		
43	☐ Total capacity (gal)		
44	☐ Design / test pressure (psig)	/	/
45	☐ Additional coastdown time (min) (6.12.3.2.1)		
46	☐ Level transmitter (6.12.3.4 g)		
47	☐ Valved blowdown connection (6.12.3.4 f)	☐	☐
48	☐ Bladder (6.12.3.5)	☐	☐
49	☐ Connection location specified (6.6.4.12)		
50	☐ Code design / Code stamp (6.3.1–6.3.3)	☐ / ☐	☐ / ☐

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DATA SHEET — SEAL-OIL DRAIN TRAPS U.S. CUSTOMARY

API 614, 6th Ed. DATA SHEET SEAL-OIL DRAIN TRAPS U.S. CUSTOMARY		Job No.: _____	Item No.: _____
		Page: 11 of 15	By: _____
		Date: _____	Revision: _____
1	APPLICABLE TO: ☐ Proposal ☐ Purchase ☐ As built		Rev
2	Supplier _____	Manufacturer _____	
3	Purchase Order No. _____ Date _____	Inquiry No. _____ Requisition No. _____	
4			
5	Traps for inner seal oil: (oil seals) (6.13)		
6	Service application		
7	☐ Purchaser's item no.		
8	☐ Seal gas vent piping arrangement (6.13.12)		
9	☐ Drain piped to specified location (6.13.13)		
10	☐ Each drain piped separately (6.13.14)		
11	☐ Spectacle blinds provided (6.13.2)		
12	☐ Float controlled	☐	☐
13	☐ Transmitter controlled (6.13.6)	☐	☐
14	☐ Pots only, for manual drain	☐	☐
15	☐ with valving	☐	☐
16	☐ Flush level glass	☐	☐
17	☐ High level switch	☐	☐
18	☐ Include option nos.		
19	☐ Retention (hr) / (gal)		
20	☐ Code construction (6.3.1)	☐	☐
21	☐ Code stamp (6.3.3)	☐	☐
22	Float traps		
23	☐ Manufacturer		
24	☐ Model		
25	☐ Pressure rating (psig)		
26	☐ Materials: body		
27	float / trim		
28	☐ Drain line piped to		
29	☐ Code construction (6.3.1)	☐	☐
30	☐ Code stamp (6.3.3)	☐	☐
31	Drain pot		
32	☐ Corrosion allowance		
33	☐ Material		
34	☐ Design / test pressure (psig)		
35	☐ Code construction (6.3.1)	☐	☐
36	☐ Code stamp (6.3.3)	☐	☐
37	Mist eliminator		
38	☐ Corrosion allowance (in)		
39	☐ Material: shell		
40	☐ Demisting mesh		
41	☐ Design / test pressure (psig)		
42	☐ Code construction (6.3.1)	☐	☐
43	☐ Code stamp (6.3.3)	☐	☐
44			
45	Comments:		
46			
47			
48			
49			
50			

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DATA SHEET — GAUGE BOARD AND PANELS

U.S. CUSTOMARY

API 614, 6th Ed. DATA SHEET GAUGE BOARD AND PANELS U.S. CUSTOMARY		Job No.: _____	Item No.: _____
		Page: 12 of 15	By: _____
		Date: _____	Revision: _____

1	APPLICABLE TO: ☐ Proposal ☐ Purchase ☐ As Built			Rev
2	For _____ Site _____			
3	Oil System for _____			
4	Supplier _____	Manufacturer _____		
5	Purchase Order No. _____ Date _____	Inquiry No. _____	Requisition No. _____	
6				
7	Explanations:			
8	— The party to complete the information is indicated as follows:			
9	☐ Purchaser ☐ Vendor ☐ Either, but by vendor if not by purchaser.			
10	— An asterisk * specifies a requirement, value, or criterion.			
11	— Designations in parentheses () are explained in the standard;			
12	numbers refer to paragraphs.			
13	Service	Console gauge board	Local equipment panel	Remote equipment panel
14				
15	☐ Panel identification			
16	☐ Supplied by (8.5.1)			
17	☐ Type: (8.5.5) free standing			
18	locally mounted			
19	remote mounted			
20	☐ Per purchaser's specification (8.5.4)			
21	☐ Water tight enclosure (8.5.9.1, 8.5.9.2)			
22	☐ Purged or pressurized			
23	☐ Purge or pressure gas			
24	☐ Shutoff valves for shutdown			
25	sensing devices (8.2.1.2)			
26	☐ Rear access doors			
27	☐ Walk-in facility			
28	☐ Sun and weather roof extension			
29	☐ External light with on/off switch (8.5.8)			
30	☐ Internal light and receptacle (8.5.19)			
31	☐ Limits: max or min height above floor			
32	☐ Removable gland plates (8.5.28)			
33	☐ Spare terminals required			
34	☐ Signal-segregation requirements (8.3.1.7)			
35	☐ Reinforced panel front (8.5.13)			
36	☐ Top and sides specified thickness (8.5.14)			
37	☐ Material: front panel			
38	☐ Other panels and doors			
39	☐ Chassis			
40	☐ Vibration isolator			
41	☐ Electrical area classification			
42	☐ Panel power supply (8.4.2)			
43	☐ Tropicalization (8.4.11)			
44	☐ Common panel for driver and driven			
45	equipment (8.5.1)			
46				
47				
48				
49				
50				

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DATA SHEET — INSTRUMENTATION

U.S. CUSTOMARY

API 614, 6th Ed. DATA SHEET		Job No.: _____		Item No.: _____		
INSTRUMENTATION		Page: 13 of 15		By: _____		
U.S. CUSTOMARY		Date: _____		Revision: _____		
1	APPLICABLE TO: ☐ Proposal ☐ Purchase ☐ As Built					Rev
2	For _____ Site _____					
3	Oil System for _____					
4	Supplier _____		Manufacturer _____			
5	Purchase Order No. _____ Date _____		Inquiry No. _____		Requisition No. _____	
6						
7	Explanations:					
8	— The party to complete the information is indicated as follows:					
9	☐ Purchaser ☐ Vendor ☐ Either, but by vendor if not by purchaser.					
10	— An asterisk * specifies a requirement, value, or criterion.					
11	— Designations in parentheses () are explained in the standard; numbers refer to paragraphs.					
12						
13	Use the following code letters for details of panel mounted items:					
14	L - Locally mount on piping		B - Local equipment panel		C - Remote equipment panel	
15	F - Flush mount on front		H - Purchaser remote mount (control room)		CP - Cutout for purchaser item	
16	S - Surface mount on front		P - Purchaser supply and mount		M - Mount by vendor of purchaser item	
17	R - Rear of panel mount		V - Vendor supply and mount			
18	Instrumentation (8.3)					
19	Instrument location (8.3.1.1)		L	B	C	Instrument location (8.3.1.1)
20	Pressure indicators (8.3.8)					Push button stations
21	☐ Main turbine inlet					☐ Main equipment start
22	☐ Main turbine first stage					☐ Main equipment stop
23	☐ Main turbine extraction					☐ Compressor block in
24	☐ Main turbine exhaust					☐ Compressor unblock
25	☐ Steam chest					Miscellaneous
26	☐ First stage after extraction					☐ Equipment tachometer
27	☐ Nozzle bowl					☐ Equipment speed control
28	☐ Steam seal					☐ Equipment ammeter
29	☐ Ejector/Eductor steam					☐ Compressor inlet controller
30	☐ Compressor suction					☐ Annunciation system (8.2.4.1)
31	☐ Compressor discharge					☐ ISA 18.1 sequence specified (8.2.4.4)
32	☐ Each compressor section					☐ Separate first our indication (8.2.4.5)
33	☐ Balance chamber					☐ Equipment flow meter
34	Differential pressure gauges					☐ Guide vane positioner
35	☐ Compressor air filter					☐ Suction throttle valve
36	☐ Buffer gas					☐ Anti-surge equipment
37	☐ Balance chamber					☐ Capacity control equipment
38	☐ Other					☐ Hand-auto (HA) or Hand-off-auto starting switch for pump motor(s) (8.2.1.4)
39	Temperature gauges					☐ Other
40	☐ Main turbine inlet steam					☐ Other
41	☐ Main turbine exhaust					☐ Other
42	☐ Main turbine extraction/induction					☐ Other
43	☐ Compressor suction (each section)					Monitors
44	☐ Compressor discharge (each section)					☐ Vibration
45	☐ Other					☐ Axial position
46	☐ Level indicators/controllers					☐ Thrust bearing metal temp
47	☐ Suction separator					☐ Journal bearing metal temp
48	☐ Interstage separator					
49	☐ Discharge separator					
50						

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DATA SHEET — INSTRUMENTATION

U.S. CUSTOMARY

API 614, 6th Ed. DATA SHEET INSTRUMENTATION U.S. CUSTOMARY		Job No.: _____ Page: 14 of 15 Date: _____	Item No.: _____ By: _____ Revision: _____	Rev
1	APPLICABLE TO: ☐ Proposal ☐ Purchase ☐ As Built			
2	For _____ Site _____			
3	Oil System for _____			
4	Supplier _____ Manufacturer _____			
5	Purchase Order No. _____ Date _____ Inquiry No. _____ Requisition No. _____			
6				
7	Instrumentation			
8	☐ Additional signal-segregation requirements specified by purchaser (8.3.1.7)			
9	☐ Wiring to be installed in (8.4.13): ☐ Metal conduit ☐ Cable trays ☐ Enclosures			
10	☐ Switches shall be wired to: ☐ open (de-energize) or ☐ close (energize) to initiate alarms and shutdowns (8.3.2.6)			
11	☐ Transmitters (8.3.3.2): ☐ indicating type ☐ nonindicating (blind) type			
12	☐ housing type _____			
13	☐ power supply _____			
14	☐ Transmitter output signal type (8.3.3.3): ☐ analog ☐ digital			
15	☐ Nonhazardous ☐ Nonincendive ☐ Explosion proof			
16	☐ Multi-point instruments may be used (8.3.2.8)			
17	☐ NEMA 4X junction boxes required (8.1.5)			
18	☐ Protection method of compliance and certification of devices within a hazardous area (8.1.6): _____			
19	☐ Liquid-filled or dampened movement gauges shall be furnished (8.3.8.2)			
20	☐ Sight flow indicators installed in the drain lines of totally enclosed dry coupling guards (8.3.9.3)			
21	☐ Continuously energized solenoids required for shutdown circuits (8.3.10.4)			
22	☐ Dual-coil solenoids required for shutdown functions (8.3.10.5)			
23	☐ Thermal relief valves provided for components that may be blocked in by isolation valves (8.3.11.8)			
24	☐ Discharge of oil thermal relief valves routed back to reservoir (8.3.11.10)			
25	☐ Purchaser's labeling in addition to manufacturer's standard labeling (8.3.1.3)			
26	☐ Purchaser's tagging in addition to manufacturer's standard tagging (8.3.1.11)			
27	Electrical Systems			
28	☐ Characteristics of electrical power supplies for motors, heater and instruments shall be specified (8.4.2)			
29	☐ Instrument and control wiring may be solid conductors in areas not subject to vibration (8.4.5)			
30	Wiring installed in (8.4.13): ☐ Metal conduit ☐ Cable trays			
31	☐ Conduit drains provided in all conduit low points for indoor installations (8.4.20)			
32	☐ Tropical location treatment (8.4.11)			
33	☐ Enable all instruments and other components (except shutdown devices) to be replaced or tested during equipment operation (8.2.1.1)			
34	☐ Enable all shutdown devices to be replaced or tested with the equipment in operation (8.2.1.2)			
35	☐ Purchaser specified alarms and shutdowns required — see Table 9 (8.2.2.2)			
36	☐ Purchaser specified alarm/shutdown systems to be supplied and installed by the equipment vendor (8.2.2.5)			
37	Alarm/Trip wiring per Arrangement (8.2.3.1): ☐ 1 ☐ 2 ☐ 3			
38	Any alarm shall initiate: ☐ Audible warning ☐ Flashing light ☐ Both audible warning and flashing light (8.2.2.6.2)			
39	Any shutdown shall initiate: ☐ Audible warning ☐ Flashing light ☐ Both audible warning and flashing light (8.2.2.6.2)			
40	☐ For non-fail-safe systems, a failure that results in the system being unable to recognize an alarm condition shall also result in all other alarms and shutdowns remaining functional (8.2.2.6.7)			
41				
42	☐ Test each component of every alarm, shutdown and trip function, while the equipment is in operation, without disarming any other function (8.2.2.6.8)			
43				
44	Comments:			
45				
46				
47				
48				
49				
50				

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DATA SHEET — INSPECTION AND TESTING

U.S. CUSTOMARY

API 614, 6th Ed. DATA SHEET INSPECTION AND TESTING U.S. CUSTOMARY		Job No.: _____	Item No.: _____
		Page: 15 of 15	By: _____
		Date: _____	Revision: _____
1	APPLICABLE TO: ☐ Proposal ☐ Purchase ☐ As built		Rev
2	Supplier _____ Manufacturer _____		
3	Purchase Order No. _____ Date _____ Inquiry No. _____ Requisition No. _____		
4			
5	Shop inspection (9.1.1)	Required	Witnessed
6	☐ Compliance with inspector's checklist (9.1.2)	☐	☐
7	☐ Required for system assemblies	☐	☐
8	☐ Cleanliness inspection before vessel heads are welded, or exchangers or piping assembly (9.2.3.2)	☐	☐
9	☐ Required for major components:	☐	☐
10	☐ Material certification to be furnished	☐	☐
11	☐ Special examinations	☐	☐
12	☐ Construction code (6.3.1)	☐	☐
13	☐ Code stamp (6.3.3)	☐	☐
14	☐ Certified copies of all test logs and data for approval before shipment (10.4.3.2)	☐	☐
15	☐ Demonstrate pump alignment by unbolting pump inlet and discharge piping (9.3.3.14)	☐	☐
16	☐ Additional radiography, magnetic particle inspection, or liquid penetrant inspections (6.4.2)	☐	☐
17	☐ Hardness testing (9.2.3.3)	☐	☐
18	Shop testing (9.3)	Required	Witnessed
19	☒ Cleanliness demonstrated prior to as well as after operational testing (9.3.3.12)	☐	☐
20	☒ Four-hour running test, with system parameters recorded at least every 30 minutes (9.3.3.4)	☐	☐
21	☐ Check controls	☐	☐
22	☐ Changeover filters/coolers	☐	☐
23	☐ One- and two-pump operation	☐	☐
24	☐ Sound level survey	☐	☐
25	☐ Hydro test assembled system	☐	☐
26	☐ Use during shop test of served equipment (9.3.1.5)	☐	☐
27	☐ Use for complete unit system test (9.3.1.6)	☐	☐
28	☐ Piping spools hydrotested prior to painting (9.2.1.3)	☐	☐
29	☐ PMI testing required (9.2.2.3.1) ☐ Extent of required PMI testing, including sampling, is specified (9.2.2.3.2)		
30	☐ Schedule of manufacturing hold points and inspector's visits (9.1.5)		
31	☐ Amount of advance notification required before a witnessed or observed inspection (9.1.6, 9.1.7): _____ working days		
32	☐ Other records or data to be kept by vendor for at least 20 years, in addition to the requirements of 9.2.1.1 f)		
33	☐ Surface and subsurface examination required (9.2.1.5), examination type:		
34	☐ magnetic particle ☐ liquid penetrant ☐ radiographic ☐ ultrasonic		
35	☐ parts requiring examination:		
36	☐ All markings shall be in English and other specified language (9.5.1)		
37	☐ One copy of manufacturer's standard instruction manual packed and shipped with equipment (9.5.8)		
38	☐ Purchaser's review and acceptance of the components selected, before purchase (10.3.2.3.2)		
39	☐ Purchaser's acceptance of layout of components and piping before manufacture (10.3.2.3.3)		
40	☐ Vendor to furnish outline of procedures used for each of special or optional test (10.3.2.3.4)		
41	Information specified in Annex D - Contract Documents and Engineering Design Data shall be provided (10.1.2)		
42	Comments:		
43			
44			
45			
46			
47			
48			
49			
50			

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A.3 Data Sheets—SI Units

DATA SHEET — SCOPE AND ATTACHMENTS

SI UNITS (bar)

API 614, 6th Ed. DATA SHEET SCOPE AND ATTACHMENTS SI UNITS (bar)		Job No.: _____ Page: <u>1</u> of <u>15</u> Date: _____	Item No.: _____ By: _____ Revision: _____
1	Apply to: ☐ Proposal ☐ Purchase ☐ As Built		
2	For _____ Site _____		
3	Oil System for _____		
4	Supplier _____ Manufacturer _____		
5	Purchase Order No. _____ Date _____ Inquiry No. _____ Requisition No. _____		
6			
7	Explanations:		
8	— The party to complete the information is indicated as follows:		
9	☐ Purchaser ☐ Unspared or critical service (by purchaser) ☐ Vendor ☐ Either, but by vendor if not by purchaser.		
10	— An asterisk * specifies a requirement, value, or criterion.		
11	— Designations in parentheses () are explained in the standard;		
12	numbers refer to paragraphs.		
13			
14	Applicable documents:		
15	☐ Local instruments and panel items ☐ Pump Drivers (Motor) _____		
16	☐ Instrument suppliers ☐ Pump Drivers (Turbine) _____		
17	☐ Additional documents _____ ☐ Referenced standards _____		
18	☐ Additional documents _____ ☐ Additional documents _____		
19	☐ Additional documents _____ ☐ Additional documents _____		
20	☐ Additional documents _____ ☐ Additional documents _____		
21	☐ Additional documents _____ ☐ Additional documents _____		
22			
23	Installation data:		
24	☐ Space available for oil system: L _____ W _____ H _____ (m)		
25	☐ Plot plan showing console location in relation to main equipment:		
26	(Sketch the equipment plot plan with relation to the console location here)		
27	☐ Maximum allowable noise level not to exceed _____ dB or see _____		
28	☐ Additional requirements _____		
29	☐ Additional requirements _____		
30			
31	☐ Winterize ☐ Tropicalize ☐ Minimum clearance and access to components required (6.2.13) _____ (m)		
32	☐ Area classification (8.1.3.2): Zone _____ Group _____ Temp Class _____ or see _____		
33			
34	Equipment oil required:		
35	☐ Oil type / viscosity (6.2.8): _____		
36	☐ Required heat load _____ (kJ/hr)		
37			
38	☐ Lube oil (6.2.6): Normal After trip Pressure Seal oil - Range of operating conditions (6.2.5):		
39	☐ (m³/h) (m³/h) (barG) (m³/h) (barG)		
40	☐ Driven equipment _____ ☐ Normal operation _____ / _____		
41	☐ Driven equipment _____ ☐ Settling-out pressure _____ / _____		
42	☐ Driven equipment _____ ☐ Process relief-valve setting _____ / _____		
43	☐ Prime mover _____ ☐ Shop test and field run-in _____ / _____		
44	☐ Gears _____ ☐ Startup _____ / _____		
45	☐ Couplings _____ ☐ Other _____ / _____		
46	☐ Total: _____ ☐ Other _____ / _____		
47	☐ Control oil (normal) _____ ☐ Other _____ / _____		
48	☐ Control oil (transient) _____ ☐ _____ / _____		
49	☐ _____ ☐ _____ / _____		
50			

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DATA SHEET — SCOPE AND ATTACHMENTS

SI UNITS (bar)

API 614, 6th Ed. DATA SHEET SCOPE AND ATTACHMENTS		Job No.: _____	Item No.: _____
SI UNITS (bar)		Page: 2 of 15	By: _____
		Date: _____	Revision: _____
1	* Site data:		
2	☐ Ambient conditions	☐ Utility data:	☐ Cooling water: water source
3	☐ Min/max temperature (°C) _____ / _____	☐ Electrical	☐ Inlet temperature (°C) _____
4	☐ Relative humidity _____	Volts _____	Maximum return (°C) _____
5		Hertz _____	Design pressure (barG) _____
6		Phase _____	Normal pressure (barG) _____
7			Min. return (barG) _____
8	☐ Steam	Drivers (6.7.7.3):	Heating:
9	Pressure _____	Temperature _____	Pressure _____
10	Pressure _____	Temperature _____	Temperature _____
11	Pressure _____	Temperature _____	Pressure _____
12	Pressure _____	Temperature _____	Temperature _____
13	Pressure _____	Temperature _____	Pressure _____
14	Pressure _____	Temperature _____	Temperature _____
15	Location (6.1.6):		
16	☐ Indoor	☐ Heated	☐ Under roof
17	☐ Outdoor	☐ Unheated	☐ _____
18	Painting:	☐ Weights	☐ Dimensions: L W H
19	☐ Component supplier standard	(kg)	(m)
20	☐ Unified per system supplier standard	Console	Console
21	☐ Purchaser's paint system (9.4.4.2):	Panel	Panel
22	_____	_____	_____
23	☐ _____	_____	_____
24	Preparation for shipment		
25	☐ Domestic	Miscellaneous documentation	
26	☐ Export	☐ Spare parts quotation with proposal	
27	☐ Extended Storage _____ months	☐ Spare parts quotation after contract	
28	☐ Include _____ sets of extra filter elements	☐ Above based on normal supply for _____ months.	
29	☐ _____	☐ Complete inspector's checklist (Annex J)	
30	☐ _____	☐ Progress reports (10.4.4)	
31	☐ _____	☐ Technical data manual provided at shipment (10.4.6.4.2)	
32	☐ _____	☐ Units of measurement for drawings, documentation and maintenance dimensions (5.2): ☐ U.S. Customary ☐ International System of Units (SI)	
33	Spare parts		
34	Vendor Std. Purchasers requirements		
35	☐ _____		
36	☐ _____		
37	☐ _____		
38	Process piping, intercoolers, aftercoolers (7.4, 7.6)		
39	☐ If soleplates are specified for the equipment train, Purchaser to define extent of train lube oil piping system to be included (7.1.7)		
40	☐ Extent of, and requirements for process piping supplied by vendor (7.4.1)		
41	☐ Driven equipment vendor to review design of piping, appurtenances, and vessels and supports immediately upstream and downstream		
42	☐ of the equipment (7.4.3)		
43	☐ Intercoolers furnished by driven equipment vendor (7.6.1)		
44	☐ Aftercoolers furnished by driven equipment vendor (7.6.3)		
45	☐ Fabricated piping between compressor stages and coolers furnished by driven equipment vendor (7.6.15)		
46	☐ Intercoolers and aftercoolers to be: ☐ water-cooled ☐ air-cooled (7.6.2)		
47	☐ TEMA class for water-cooled intercoolers and aftercoolers: ☐ TEMA C ☐ TEMA R (7.6.5)		
48	☐ Water-cooled intercoolers and aftercoolers with double-pipe design (7.6.11)		
49	☐ Intercoolers skid-mounted (7.6.12)		
50	☐ Air-cooled intercoolers and aftercoolers in accordance with API 661 (7.6.9)		
51	☐ Special materials for intercoolers and aftercoolers (7.6.13)		

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DATA SHEET — BASIC DESIGN SI UNITS (bar)

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1	APPLICABLE TO: ☐ Proposal ☐ Purchase ☐ As built			
2	For _____	Site _____		
3	Oil System for _____			
4	Supplier _____	Manufacturer _____		
5	Purchase Order No. _____ Date _____	Inquiry No. _____ Requisition No. _____		
6	Basic Design (4.2.a) Configuration Code: _____			
7	Design goal for uninterrupted operation (mission time) of the equipment (6.1.2): _____ months			
8	☐ Purchaser and the vendor shall agree upon an acceptable system before the order is released (4.8).			
9	☒ If selected here, all diamond options are invoked (4.5).			
10	Overall system selection (6.2)	Figure No	Option Nos	Comments
11	☐ Combined lube, seal & control system			
12	☐ Separate seal oil system			
13	☐ Seal module at equipment			
14	☐ Lube / control oil system			
15	☐ Basic oil supply module			
16	☐ Lube module at equipment			
17	☐ Drawing requirements			
18	☐ Component review			
19	Supply arrangement (6.2.7):	Lube oil	Seal oil	Combined
20	☐ Separate console	☐	☐	☐
21	☐ Multiple package	☐	☐	☐
22	☐ Combined with equipment base			
23	☒ All oil system components mounted on common baseplate (6.5.2)			
24	☐ Special provisions needed for backup oil supply upon primary system failure (6.2.21)			
25	☐ Lifting attachments furnished with material and load test certifications (6.5.6.6)			
26	Baseplates:			
27	☐ Point support (6.5.13)			
28	☐ Grout holes / vent holes (6.5.7)			
29	☐ Epoxy grout precoat (6.5.8)			
30	☐ Nonskid decking required (6.5.4)			
31	☐ Sloped decking required (6.5.5)			
32	☐ Lifting lugs 100% NDE tested (6.5.6.3)			
33	Basic System Details:			
34	☐ Compressor block-in time (6.2.21.2) _____ (min)			
35	☐ Sound level _____ dB max. (6.1.12)			
36	☐ Equipment coast-down time _____ (min)			
37	☐ Driver _____ (min)			
38	☐ _____ (min)			
39	☐ Minimum start up oil temperature _____ (°C)			
40	Other :			
41	☐ Settling out pressure _____ (barG) (6.2.5 a)			
42	☐ Standby pump (6.7.1.3)			
43	☐ Rundown tank (6.12.2.1)			
44	☐ _____ atmospheric (Fig. C.15) _____ pressurized (Fig. C.16)			
45				
46	☐ Process relief valve setting _____ (barG)			
47	☐ Shop test conditions			
48	☐ Field start-up / run-in conditions			
49	☐ Other special conditions			
50	☐ Welding & special fabrication requirements (6.4.2)			
51	☐ Additional radiography			
52	☐ Magnetic particle			
53	☐ Liquid penetrant			
54	☐ Heat loss analysis of system and interconnecting piping (6.6.8.8)			
55	☐ Only field-proven equipment, defined by Purchaser, accepted (6.1.3)			
56	☐ Documentation to demonstrate field-proven equipment (6.1.3.1)			
57	☐ Dynamic simulation of the oil system required (6.2.24)			
58	☐ Pressure vessel design code: ASME Section VIII (6.3.1)			
59	☐ Utilities manifolded to common connections (7.1.37)			
60	☐ Air ☐ Cooling water ☐ Other			
61	☐ PLV to be tight shutoff, design code compliant (6.7.22.6)			
62	☐ PLV not used for continuous pressure regulation (6.7.22.4)			
63	☐ Manual bypass valves required around PLV (6.7.22.7)			
64	☒ Control valve heads vented to reservoir (7.3.5)			
65	☐ Continuous oil flow for sensing lines of safety instruments (7.3.6)			
66	☐ Special requirements for hazardous service specified (7.1.27)			
67	☐ Additional purchaser specification for valves (7.1.39)			
68	☐ Flanged gate valves required per API 601, API 602 (7.1.40)			
69	☐ All stainless steel materials of the oil system to be 316 (6.2.14)			
70	☐ Piping design in accordance with ASME B31.3 (6.2.15)			
71	☐ Supplementary piping requirements (6.3.5)			
72	☐ Piping tracing reqd by ☐ Purchaser ☐ Vendor			

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DATA SHEET — INSTRUMENT SUPPLIERS

SI UNITS (bar)

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42	☐ Purchaser's review and acceptance of components prior to purchase (10.3.2.3.2)																																																																																																													
43	☐ Purchaser's review and acceptance of layout of components and piping prior to purchase (10.3.2.3.3)																																																																																																													
44	☐ Furnish outline of procedures of special tests specified by the purchaser (10.3.2.3.4)																																																																																																													
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DRAFT - FOR COMMITTEE REVIEW

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DATA SHEET — RESERVOIR

SI UNITS (bar)

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1	APPLICABLE TO: ☐ Proposal ☐ Purchase ☐ As built			
2	Supplier _____	Manufacturer _____		
3	Purchase Order No. _____ Date _____	Inquiry No. _____	Requisition No. _____	
4	Service application: ☐ Separate lube ☐ Lube/seal combined ☐ Separate seal			
5	Purch. item no. _____			
6	☐ Figures no. _____			
7	☐ Include options no. _____			
8	☐ Heater steam/electric (6.6.8.2)			
9	☐ Heater removable element (6.6.8.2.3, 6.6.8.2.4)			
10	☐ Temp. device for remote monitoring and control (6.6.8.5)			
11	☐ Heater element removable during operation (6.6.8.7)			
12	☐ Heater installed in oil-filled pipe well (6.6.8.7.2)			
13	☐ Material _____			
14	☐ Normal flow (L/min) _____			
15	☐ Free surface (m ²) _____			
16	☐ Free surface minimum specified (6.6.7.12)			
17	☐ Working capacity (l) _____			
18	☐ Working capacity at least 5 min. of normal flow (6.6.7.4)			
19	☐ Retention capacity (l) _____			
20	☐ Minimum retention capacity 8 min. of normal flow (6.6.7.5)			
21	☐ Rundown capacity (l) _____			
22	☐ Normal operating range (L/min) _____			
23	☐ Charge capacity (l) _____			
24	☐ Reflex-type oil level glass (6.6.4.3.1)			
25	☐ Alternate means of level indication (6.6.4.3.2)			
26	☐ Low-level alarm (6.6.7.11)			
27	☐ Insulation clips (6.6.9.1)	☐	☐	☐
28	☐ Ladder with handrail (6.6.13.1)	☐	☐	☐
29	☐ Handrails on reservoir top (6.6.13.2)	☐	☐	☐
30	☐ Nonskid decking on reservoir top (6.6.13.3)	☐	☐	☐
31	☐ Flanged reservoir pipe connections (6.6.2.10)	☐	☐	☐
32	☐ Vent connection with blind flange (6.6.4.6)			
33	☐ Flanged vent drain connection w/valve & blind flange (6.6.3.3)	☐	☐	☐
34	☐ Threaded plugged connection above rundown level (6.6.10.1)	☐	☐	☐
35	☐ Designed for overpressurization or negative pressure (6.6.1.4, 6.6.1.5)			
36	☐ Siphon breaker	☐	☐	☐
37	☐ Top mounted components prohibited (6.6.1.9)	☐	☐	☐
38	☐ Top mounted components are:			
39	☐ Submerged components & materials			
40	☐ Dimension of tank L x W x H (m) _____			
41	☐ Separate connection for seal oil return line (6.6.4.8)		☐	
42	☐ Connections for oil conditioner (6.6.11.1)	☐	☐	☐
43	☐ Sample points required (6.9.14)			
44	☐ Top of reservoir shall slope at least 10 mm/m (1/8 in./ft) (6.6.1.11)			
45	☐ Other criteria for reservoir top (6.6.13.6)			
46	☐ Bottom of reservoir sloped continuously (6.6.3.1)			
47	☐ Fill opening, spring closed, with ss mesh strainer (6.6.4.5)			
48	☐ Flame arrestors required (6.6.6.1), Locations (6.6.6.2)			
49	Special requirements (6.6.6.3) _____			

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DATA SHEET — ACCESSORIES

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		Date: _____	Revision: _____
1	APPLICABLE TO: ☐ Proposal ☐ Purchase ☐ As built		Rev
2	Supplier _____ Manufacturer _____		
3	Purchase Order No. _____ Date _____ Inquiry No. _____ Requisition No. _____		
4			
5	Oil Conditioner (6.6.11.1):	Degassing Drum (6.14.1):	
6	☐ Purch. item no. _____	☐ Purchaser's item no. _____	☐ Service used in _____
7	☐ Service used in _____	☐ Type in accordance with Figure 4 or other spec	☐ Flow control
8	☐ Type _____	Operating temp. _____ (°C)	☐ Thermostat control
9	☐ Portable / fixed _____	(m³/h) normal/max. _____ / _____	☐ Material _____
10	☐ Rated flow (L/min) _____	Normal retention _____ minutes	☐ Interior coating
11	☐ Manufacturer _____	Norm/max. capacity _____ / _____ (m³/h)	☐ Oversized vent
12	☐ Model _____	☐ Purge gas type	☐ Vent relief device
13	☐ Driver for _____	☐ (m³/h) required _____	☐ Omit breather
14	☐ HP & enclosure _____	☐ Type heating device (6.14.4) _____	☐ Code construction (6.3.1)
15	☐ Volts / PH / Hz _____	☐ Corrosion allowance _____ (mm)	☐ Code stamp (6.3.3)
16	_____ / _____ / _____	☐ Design/test _____ / _____ (barG)	☐ Other _____
17	☐ Water removal rate _____	☐ Pressurized service (6.14.9) _____	☐ Other _____
18	☐ Mat'l of construction _____	☐ Other _____	☐ Other _____
19	Extraction and Static Oil Mist Eliminator Systems (6.6.5):		
20	☐ Extraction or static oil mist eliminator in place of the breather cap (6.6.5.1)		
21	☐ Vacuum relief device provided for extraction oil vent mist eliminator (6.6.5.8)		
22	☐ Oil mist eliminator arrangements fitted with suitable isolation and bypass valves to enable maintenance while in operation (6.6.5.13)		
23	☐ 100 % capacity standby extraction oil mist eliminator system with online transfer capability shall be supplied (6.6.5.14)		
24	☐ Other oil mist eliminator system arrangements supplied (6.6.5.15)		
25	☐ Extraction/Static _____		
26	☐ Vacuum / dP level _____	(mm H2O)	
27	☐ Oily mist flow _____	(m³/h)	
28	☐ Manufacturer _____		
29	☐ Model _____		
30	☐ Materials _____		
31	☐ Design / test pressure _____	(barG)	
32	☐ Eductor / Blower _____		
33	☐ HP & enclosure _____		
34	Volts / Phase / Hz _____ / _____ / _____		
35	Eductor motive gas:		
36	☐ Type _____		
37	☐ Pressure _____	(barG)	
38	☐ Flow _____	(m³/h)	
39	☐ Mist eliminator efficiency _____		
40	Furnish _____ extra sets of cartridges	☐ per service	☐ per filter (in addition to other spares)
41			
42	Comments:		
43	_____		
44	_____		
45	_____		
46	_____		
47	_____		
48	_____		
49	_____		
50	_____		

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DATA SHEET — PUMPS

SI UNITS (bar)

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1	APPLICABLE TO: ☐ Proposal ☐ Purchase ☐ As built					Rev
2	Supplier _____	Manufacturer _____				
3	Purchase Order No. _____ Date _____	Inquiry No. _____ Requisition No. _____				
4						
5	Pumps and Drivers (6.7):	Lube	Lube / seal	Separate seal oil	Booster seal oil	
6	☐ Service application					
7	☐ Figures no.					
8	☐ Include options no.					
9	☐ Booster pumps required					
10	☐ Emergency oil pump (6.7.3)	☐	☐	☐	☐	
11	Pump Service:	Main / stby	Emergency	Main / stby	Emergency	
12	☐ Pump item no.					
13	☐ Pump type (6.7.1.1)					
14	☒ Pumps external to reservoir (6.7.2)					
15	☐ Submerged pump materials					
16	☐ Pump data sheet					
17	☐ Additional pump standard (6.7.1.2)					
18	☐ Horizontal or vertical (H or V)					
19	☒ Mounting pads (6.7.45.1)					
20	☒ Jackscrews (6.7.45.5)					
21	☐ Driver item no.					
22	☐ Turbine driver (6.7.7)					
23	☐ Turbine data sheet (6.7.7.3)					
24	☒ Electric motor driver					
25	☐ Motor standard applies (6.7.12)					
26	☐ Electric motor data sheet					
27	☐ Driver sized for min. ambient (6.7.16)					
28	☒ Reverse rotation provisions (6.7.18)					
29	☐ Other driver					
30	☐ Other driver data sheet					
31	☐ Coupling type (6.7.35)					
32	☐ Coupling balance to G6.3 (6.7.37)					
33	☒ Coupling S.F. minimum 1.15 (6.7.41)					
34	☐ Coupling guard type (6.7.33.4)					
35	☒ Strainer spool pieces req'd (6.7.27.4)					
36	☒ Strainer pressure gage req'd (6.7.30)					
37	☐ Solenoid trip valve					
38	☐ Rotary pump relief valve by					
39	(purchaser / vendor)					
40						
41	Comments:					
42						
43						
44						
45						
46						
47						
48						
49						
50						

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DATA SHEET — FILTERS

SI UNITS (bar)

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2	Supplier _____	Manufacturer _____	
3	Purchase Order No. _____ Date _____	Inquiry No. _____ Requisition No. _____	
4			
5	Filters (6.9):		
6	☐ Service application:	☐ Lube ☐ Lube & seal ☐ Control	☐ Separate control oil ☐ Separate seal oil ☐ Booster pump discharge oil ☐ Separate coupling oil
7			
8			
9	☐ Filter item no.		
10	☐ Dual (6.9.1) ☐ Single (6.9.1.2)	☐	☐
11	☐ Flanged filter housings (6.9.1.8)		
12	☐ Valved vent, drain connections (6.9.1.10)		
13	☐ Specific element manufacturer (6.9.8.1)		
14	☐ Specific element model		
15	☐ Code design (6.3.1) / Code stamp (6.3.3)	☐ / ☐	☐ / ☐
16	☐ Special control-oil filtration req'd (6.9.13)		
17	☐ Thermal overpressure protection of offline filter (6.9.2)		
18			
19	☐ Thermal relief valves routed to reservoir (6.9.3)		
20			
21	☐ Manifolded dual filter drains (6.9.4)		
22	☐ Filter vents routed to reservoir through sight flow glass (6.9.6)		
23	☐ Filters grounded to baseplate (6.9.1.12)		
24			
25	☐ Material: case & top		
26	☐ Furnish extra sets of cartridges	☐ per service ☐ per filter (extra over other spares)	
27	Continuous flow transfer valve:		
28		☐ Lube oil, seal oil & control oil ☐ Separate control oil ☐ Separate seal oil ☐ Booster pump discharge oil ☐ Separate coupling oil	
29	Service application:		
30			
31	☐ Common for coolers & filters	☐	☐
32	☐ Spectacle blinds required (6.10.6)	☐	☐
33	☐ Type (single 6-port or two 3-way) (6.10.2)		
34	☐ Manufacturer		
35	☐ Model		
36	☐ With lifting jack	☐	☐
37	Rating: (barG)		
38	☐ Materials: body		
39	☐ Plug or ball		
40	☐ Trim		
41			
42	Comments:		
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DATA SHEET — LUBE-OIL HEAT EXCHANGERS

SI UNITS (bar)

API 614, 6th Ed. DATA SHEET LUBE-OIL HEAT EXCHANGERS SI UNITS (bar)		Job No.: _____	Item No.: _____
		Page: 9 of 15	By: _____
		Date: _____	Revision: _____
1	APPLICABLE TO: ☐ Proposal ☐ Purchase ☐ As built		Rev
2	Supplier _____	Manufacturer _____	
3	Purchase Order No. _____ Date _____	Inquiry No. _____ Requisition No. _____	
4			
5	Lube-oil Heat Exchangers: (6.8)		
6	Service application	☐ Lube	☐ Lube/seal
7	☐ Item no(s).		☐ Separate seal
8	☐ Dual units including transfer valve (6.8.1.2)	☐	☐
9	☐ Include option nos.		
10	☐ Air-cooled heat exchangers required (6.8.4.1)	☐	
11	☐ Multi-plate frame or air-cooled heat exchangers required (6.8.1.4)		
12	☐ Details on ISO data sheet		
13	☐ Water side corrosion allowance (6.8.1.9)		
14	☐ Manufacturer		
15	☐ Model		
16	☐ TEMA class (6.8.2.2.2)		
17	☐ Fouling factor water/oil side (6.8.1.9)		
18	☐ Duty: (kJ/hr)		
19	☐ Tube: L / OD / BWG (6.8.2.2.3)		
20	☐ Design / test pressure shell side (barG)		
21	☐ Design / test pressure tube side (barG)		
22	☐ Construction code / Code stamp (6.3.1. / 6.3.3)	☐ / ☐	☐ / ☐
23	☐ Header plug of nongalling material (6.8.4.4.4)		☐ / ☐
24	☐ Connections for purchaser's cooler (6.8.1.6 or 6.8.4.3)		
25	☐ Two or more fans for air-cooled heat exchangers (6.8.4.4.1)		
26	☐ Vibration transducers for each fan (6.8.4.4.5)		
27	☐ Hail guards required (6.8.4.4.8)		
28	☐ Adjustable louvers for temperature control required (6.8.4.4.10)		
29	☐ Tube water flow rate (L/min) (6.8.1.9)		
30	☐ Tube water velocity (m/s) (6.8.1.9)		
31	☐ Material: shell, channels, and covers (6.8.2.6)		
32	☐ Tube sheets & tubes (6.8.2.6.1, 6.8.2.6.2)		
33	☐ Removable tube bundle (6.8.2.2.1)	☐	☐
34	☐ Nonrepairable heat exchangers permitted (6.8.2.2.5)		
35	☐ Fabricated with flanged vent and drain nozzles (6.8.1.20)	☐	☐
36	☐ Oil side vents piped to reservoir through F.I. (6.8.1.22)	☐	☐
37	☐ Cooler drains manifolded but not with filter clean oil drains (6.8.1.21)	☐	☐
38	☐ Oil bypass line with temperature control valve (6.8.1.15)	☐	☐
39	☐ 3-port valve with internal thermostat (6.8.1.15.5)	☐	☐
40	☐ Flanged, pneumatically operated 2- or 3-port valve (6.8.1.15.3)	☐	☐
41	☐ Manual override of temperature control valve (6.8.1.15.6)	☐	☐
42	☐ Separate oil side thermal relief valves, each cooler (6.8.1.8)	☐	☐
43	☐ Suitable for use with 150 °C (300 °F) medium (6.8.1.16)	☐	☐
44	☐ Tube O.D. at least 5/8 in., tube wall at least 18 BWG (6.8.2.4)	☐	☐
45	☐ Oil-side lower than the water-side operating pressure (6.8.1.25)	☐	☐
46	Comments:		
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DATA SHEET — OVERHEAD TANKS SI UNITS (bar)

API 614, 6th Ed. DATA SHEET OVERHEAD TANKS SI UNITS (bar)		Job No.: Page: 10 of 15 Date:	Item No.: By: Revision:	Rev	
1	APPLICABLE TO: ☐ Proposal ☐ Purchase ☐ As built				
2	Supplier	Manufacturer			
3	Purchase Order No. Date	Inquiry No.	Requisition No.		
4	Accumulators (6.11):				
5	Service application	Lube oil	Control oil	Seal oil	Seal oil booster
6	☐ Required, yes or no, and quantity				
7	☐ Purchaser's item No.				
8	☐ Service combined with				
9	☐ Direct contact type (6.11.3) (Fig. C.19)	☐	☐	☐	☐
10	☐ Bladder type (Fig. C.18)	☐	☐	☐	☐
11	☐ Include option nos. (Fig. C.18, C.19)				
12	☐ Rundown time (min)				
13	☐ Provisions for heat trace, insulation (6.11.13)	☐	☐	☐	☐
14	☐ Constant pressure regulator (6.11.3)	☐	☐	☐	☐
15	☐ Manufacturer				
16	☐ Model				
17	☐ Nominal / usable capacity (l)				
18	☐ Material: Austenitic ss vessel (6.11.9)				
19	☐ Bladder				
20	☐ Corrosion allowance (mm)				
21	☐ Design / test pressure (barG)				
22	☐ Construction code / Code stamp	☐ / ☐	☐ / ☐	☐ / ☐	☐ / ☐
23	☐ Accumulator valve locked open (6.11.18)	☐	☐	☐	☐
24	Include:				
25	☐ charge pressure gauge:	☐	☐	☐	☐
26	☐ manual precharge valve (6.11.3)	☐	☐	☐	☐
27	☐ gas supply regulator	☐	☐	☐	☐
28	☐ bleed-down line sight glass (6.11.17)	☐	☐	☐	☐
29	Overhead tanks (6.12)				
30	Service application	Rundown lube oil	Low-pressure seal oil	Medium-pressure seal oil	High-pressure seal oil
31					
32	Lube-oil rundown tanks (6.12.2)				
33	☐ Required, yes or no (6.12.2.1)				
34	☐ Purchaser's item no.				
35	☐ Service combined with				
36	☐ Includes options no. (Fig. C.15 or C.16)				
37	☐ Capacity (min) or (l)				
38	☐ Bypass orifice (6.12.2.6) (Fig. C.16)				
39	☐ Interconnecting piping volume				
40	Seal-oil tanks (6.12.3)				
41	☐ Required, yes or no (6.12.3.1)				
42	☐ Purchaser's item No.				
43	☐ Total capacity (l)				
44	☐ Design / test pressure (barG)	/	/	/	/
45	☐ Additional coastdown time (min) (6.12.3.2.1)				
46	☐ Level transmitter (6.12.3.4 g)				
47	☐ Valved blowdown connection (6.12.3.4 f)	☐	☐	☐	☐
48	☐ Bladder (6.12.3.5)	☐	☐	☐	☐
49	☐ Connection location specified (6.6.4.12)				
50	☐ Code design / Code stamp (6.3.1–6.3.3)	☐ / ☐	☐ / ☐	☐ / ☐	☐ / ☐

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DATA SHEET — SEAL-OIL DRAIN TRAPS SI UNITS (bar)

API 614, 6th Ed. DATA SHEET SEAL-OIL DRAIN TRAPS SI UNITS (bar)		Job No.: _____ Page: 11 of 15 Date: _____	Item No.: _____ By: _____ Revision: _____	Rev
1	APPLICABLE TO: ☐ Proposal ☐ Purchase ☐ As built			
2	Supplier _____	Manufacturer _____		
3	Purchase Order No. _____ Date _____	Inquiry No. _____	Requisition No. _____	
4				
5	Traps for inner seal oil: (oil seals) (6.13)			
6	Service application			
7	☐ Purchaser's item no.			
8	☐ Seal gas vent piping arrangement (6.13.12)			
9	☐ Drain piped to specified location (6.13.13)			
10	☐ Each drain piped separately (6.13.14)			
11	☐ Spectacle blinds provided (6.13.2)			
12	☐ Float controlled	☐	☐	☐
13	☐ Transmitter controlled (6.13.6)	☐	☐	☐
14	☐ Pots only, for manual drain	☐	☐	☐
15	☐ with valving	☐	☐	☐
16	☐ Flush level glass	☐	☐	☐
17	☐ High level switch	☐	☐	☐
18	☐ Include option nos.			
19	☐ Retention (hr) / (l) _____			
20	☐ Code construction (6.3.1)	☐	☐	☐
21	☐ Code stamp (6.3.3)	☐	☐	☐
22	Float traps			
23	☐ Manufacturer			
24	☐ Model			
25	☐ Pressure rating (barG)			
26	☐ Materials: body			
27	float / trim			
28	☐ Drain line piped to			
29	☐ Code construction (6.3.1)	☐	☐	☐
30	☐ Code stamp (6.3.3)	☐	☐	☐
31	Drain pot			
32	☐ Corrosion allowance			
33	☐ Material			
34	☐ Design / test pressure (barG)			
35	☐ Code construction (6.3.1)	☐	☐	☐
36	☐ Code stamp (6.3.3)	☐	☐	☐
37	Mist eliminator			
38	☐ Corrosion allowance (mm)			
39	☐ Material: shell			
40	☐ Demisting mesh			
41	☐ Design / test pressure (barG)			
42	☐ Code construction (6.3.1)	☐	☐	☐
43	☐ Code stamp (6.3.3)	☐	☐	☐
44				
45	Comments:			
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DRAFT - FOR COMMITTEE REVIEW

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DATA SHEET — GAUGE BOARD AND PANELS

SI UNITS (bar)

API 614, 6th Ed. DATA SHEET GAUGE BOARD AND PANELS SI UNITS (bar)		Job No.: _____	Item No.: _____
		Page: 12 of 15	By: _____
		Date: _____	Revision: _____

1	APPLICABLE TO: ☐ Proposal ☐ Purchase ☐ As Built		Rev
2	For _____ Site _____		
3	Oil System for _____		
4	Supplier _____ Manufacturer _____		
5	Purchase Order No. _____ Date _____ Inquiry No. _____ Requisition No. _____		
6			
7	Explanations:		
8	— The party to complete the information is indicated as follows:		
9	☐ Purchaser ☐ Vendor ☐ Either, but by vendor if not by purchaser.		
10	— An asterisk * specifies a requirement, value, or criterion.		
11	— Designations in parentheses () are explained in the standard;		
12	numbers refer to paragraphs.		
13	Service	Console gauge board	Local equipment panel
14		board	panel
15	☐ Panel identification		
16	☐ Supplied by (8.5.1)		
17	☐ Type: (8.5.5) free standing		
18	locally mounted		
19	remote mounted		
20	☐ Per purchaser's specification (8.5.4)		
21	☐ Water tight enclosure (8.5.9.1, 8.5.9.2)		
22	☐ Purged or pressurized		
23	☐ Purge or pressure gas		
24	☐ Shutoff valves for shutdown		
25	sensing devices (8.2.1.2)		
26	☐ Rear access doors		
27	☐ Walk-in facility		
28	☐ Sun and weather roof extension		
29	☐ External light with on/off switch (8.5.8)		
30	☐ Internal light and receptacle (8.5.19)		
31	☐ Limits: max or min height above floor		
32	☐ Removable gland plates (8.5.28)		
33	☐ Spare terminals required		
34	☐ Signal-segregation requirements (8.3.1.7)		
35	☐ Reinforced panel front (8.5.13)		
36	☐ Top and sides specified thickness (8.5.14)		
37	☐ Material: front panel		
38	☐ Other panels and doors		
39	☐ Chassis		
40	☐ Vibration isolator		
41	☐ Electrical area classification		
42	☐ Panel power supply (8.4.2)		
43	☐ Tropicalization (8.4.11)		
44	☐ Common panel for driver and driven		
45	equipment (8.5.1)		
46			
47			
48			
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DATA SHEET — INSTRUMENTATION

SI UNITS (bar)

API 614, 6th Ed. DATA SHEET INSTRUMENTATION SI UNITS (bar)		Job No.: _____ Page: 13 of 15 Date: _____		Item No.: _____ By: _____ Revision: _____		Rev			
1	APPLICABLE TO: ☐ Proposal ☐ Purchase ☐ As Built								
2	For _____ Site _____								
3	Oil System for _____								
4	Supplier _____		Manufacturer _____						
5	Purchase Order No. _____ Date _____		Inquiry No. _____		Requisition No. _____				
6									
7	Explanations:								
8	— The party to complete the information is indicated as follows:								
9	☐ Purchaser ☐ Vendor ☐ Either, but by vendor if not by purchaser.								
10	— An asterisk * specifies a requirement, value, or criterion.								
11	— Designations in parentheses () are explained in the standard; numbers refer to paragraphs.								
12									
13	Use the following code letters for details of panel mounted items:								
14	L - Locally mount on piping		B - Local equipment panel		C - Remote equipment panel				
15	F - Flush mount on front		H - Purchaser remote mount (control room)		CP - Cutout for purchaser item				
16	S - Surface mount on front		P - Purchaser supply and mount		M - Mount by vendor of purchaser item				
17	R - Rear of panel mount		V - Vendor supply and mount						
18	Instrumentation (8.3)								
19	Instrument location (8.3.1.1)		L	B	C	Instrument location (8.3.1.1)	L	B	C
20	Pressure indicators (8.3.8)					Push button stations			
21	☐ Main turbine inlet					☐ Main equipment start			
22	☐ Main turbine first stage					☐ Main equipment stop			
23	☐ Main turbine extraction					☐ Compressor block in			
24	☐ Main turbine exhaust					☐ Compressor unblock			
25	☐ Steam chest					Miscellaneous			
26	☐ First stage after extraction					☐ Equipment tachometer			
27	☐ Nozzle bowl					☐ Equipment speed control			
28	☐ Steam seal					☐ Equipment ammeter			
29	☐ Ejector/Eductor steam					☐ Compressor inlet controller			
30	☐ Compressor suction					☐ Annunciation system (8.2.4.1)			
31	☐ Compressor discharge					☐ ISA 18.1 sequence specified (8.2.4.4)			
32	☐ Each compressor section					☐ Separate first our indication (8.2.4.5)			
33	☐ Balance chamber					☐ Equipment flow meter			
34	Differential pressure gauges					☐ Guide vane positioner			
35	☐ Compressor air filter					☐ Suction throttle valve			
36	☐ Buffer gas					☐ Anti-surge equipment			
37	☐ Balance chamber					☐ Capacity control equipment			
38	☐ Other					☐ Hand-auto (HA) or Hand-off-auto starting switch for pump motor(s) (8.2.1.4)			
39	Temperature gauges					☐ Other			
40	☐ Main turbine inlet steam					☐ Other			
41	☐ Main turbine exhaust					☐ Other			
42	☐ Main turbine extraction/induction					☐ Other			
43	☐ Compressor suction (each section)					Monitors			
44	☐ Compressor discharge (each section)					☐ Vibration			
45	☐ Other					☐ Axial position			
46	☐ Level indicators/controllers					☐ Thrust bearing metal temp			
47	☐ Suction separator					☐ Journal bearing metal temp			
48	☐ Interstage separator								
49	☐ Discharge separator								
50									

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DATA SHEET — INSTRUMENTATION

SI UNITS (bar)

API 614, 6th Ed. DATA SHEET INSTRUMENTATION SI UNITS (bar)		Job No.: _____ Page: 14 of 15 Date: _____	Item No.: _____ By: _____ Revision: _____	Rev
1	APPLICABLE TO: ☐ Proposal ☐ Purchase ☐ As Built			
2	For _____ Site _____			
3	Oil System for _____			
4	Supplier _____ Manufacturer _____			
5	Purchase Order No. _____ Date _____ Inquiry No. _____ Requisition No. _____			
6				
7	Instrumentation			
8	☐ Additional signal-segregation requirements specified by purchaser (8.3.1.7)			
9	☐ Wiring to be installed in (8.4.13): ☐ Metal conduit ☐ Cable trays ☐ Enclosures			
10	☐ Switches shall be wired to: ☐ open (de-energize) or ☐ close (energize) to initiate alarms and shutdowns (8.3.2.6)			
11	☐ Transmitters (8.3.3.2): ☐ indicating type ☐ nonindicating (blind) type			
12	☐ housing type _____			
13	☐ power supply _____			
14	☐ Transmitter output signal type (8.3.3.3): ☐ analog ☐ digital			
15	☐ Nonhazardous ☐ Nonincendive ☐ Explosion proof			
16	☐ Multi-point instruments may be used (8.3.2.8)			
17	☐ NEMA 4X junction boxes required (8.1.5)			
18	☐ Protection method of compliance and certification of devices within a hazardous area (8.1.6): _____			
19	☐ Liquid-filled or dampened movement gauges shall be furnished (8.3.8.2)			
20	☐ Sight flow indicators installed in the drain lines of totally enclosed dry coupling guards (8.3.9.3)			
21	☐ Continuously energized solenoids required for shutdown circuits (8.3.10.4)			
22	☐ Dual-coil solenoids required for shutdown functions (8.3.10.5)			
23	☐ Thermal relief valves provided for components that may be blocked in by isolation valves (8.3.11.8)			
24	☐ Discharge of oil thermal relief valves routed back to reservoir (8.3.11.10)			
25	☐ Purchaser's labeling in addition to manufacturer's standard labeling (8.3.1.3)			
26	☐ Purchaser's tagging in addition to manufacturer's standard tagging (8.3.1.11)			
27	Electrical Systems			
28	☐ Characteristics of electrical power supplies for motors, heater and instruments shall be specified (8.4.2)			
29	☐ Instrument and control wiring may be solid conductors in areas not subject to vibration (8.4.5)			
30	Wiring installed in (8.4.13): ☐ Metal conduit ☐ Cable trays			
31	☐ Conduit drains provided in all conduit low points for indoor installations (8.4.20)			
32	☐ Tropical location treatment (8.4.11)			
33	☒ Enable all instruments and other components (except shutdown devices) to be replaced or tested during equipment operation (8.2.1.1)			
34	☐ Enable all shutdown devices to be replaced or tested with the equipment in operation (8.2.1.2)			
35	☐ Purchaser specified alarms and shutdowns required — see Table 9 (8.2.2.2)			
36	☐ Purchaser specified alarm/shutdown systems to be supplied and installed by the equipment vendor (8.2.2.5)			
37	Alarm/Trip wiring per Arrangement (8.2.3.1): ☐ 1 ☐ 2 ☐ 3			
38	Any alarm shall initiate: ☐ Audible warning ☐ Flashing light ☐ Both audible warning and flashing light (8.2.2.6.2)			
39	Any shutdown shall initiate: ☐ Audible warning ☐ Flashing light ☐ Both audible warning and flashing light (8.2.2.6.2)			
40	☐ For non-fail-safe systems, a failure that results in the system being unable to recognize an alarm condition shall also result in all other			
41	alarms and shutdowns remaining functional (8.2.2.6.7)			
42	☒ Test each component of every alarm, shutdown and trip function, while the equipment is in operation, without disarming any			
43	other function (8.2.2.6.8)			
44	Comments:			
45	_____			
46	_____			
47	_____			
48	_____			
49	_____			
50	_____			

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DATA SHEET — INSPECTION AND TESTING

SI UNITS (bar)

API 614, 6th Ed. DATA SHEET INSPECTION AND TESTING SI UNITS (bar)		Job No.: _____	Item No.: _____
		Page: 15 of 15	By: _____
		Date: _____	Revision: _____
1	APPLICABLE TO: ☐ Proposal ☐ Purchase ☐ As built		Rev
2	Supplier _____ Manufacturer _____		
3	Purchase Order No. _____ Date _____ Inquiry No. _____ Requisition No. _____		
4			
5	Shop inspection (9.1.1)	Required	Witnessed
6	☐ Compliance with inspector's checklist (9.1.2)	☐	☐
7	☐ Required for system assemblies	☐	☐
8	☐ Cleanliness inspection before vessel heads are welded, or exchangers or piping assembly (9.2.3.2)	☐	☐
9	☐ Required for major components:	☐	☐
10	☐ Material certification to be furnished	☐	☐
11	☐ Special examinations	☐	☐
12	☐ Construction code (6.3.1)	☐	☐
13	☐ Code stamp (6.3.3)	☐	☐
14	☐ Certified copies of all test logs and data for approval before shipment (10.4.3.2)	☐	☐
15	☐ Demonstrate pump alignment by unbolting pump inlet and discharge piping (9.3.3.14)	☐	☐
16	☐ Additional radiography, magnetic particle inspection, or liquid penetrant inspections (6.4.2)	☐	☐
17	☐ Hardness testing (9.2.3.3)	☐	☐
18	Shop testing (9.3)	Required	Witnessed
19	☐ Cleanliness demonstrated prior to as well as after operational testing (9.3.3.12)	☐	☐
20	☐ Four-hour running test, with system parameters recorded at least every 30 minutes (9.3.3.4)	☐	☐
21	☐ Check controls	☐	☐
22	☐ Changeover filters/coolers	☐	☐
23	☐ One- and two-pump operation	☐	☐
24	☐ Sound level survey	☐	☐
25	☐ Hydro test assembled system	☐	☐
26	☐ Use during shop test of served equipment (9.3.1.5)	☐	☐
27	☐ Use for complete unit system test (9.3.1.6)	☐	☐
28	☐ Piping spools hydrotested prior to painting (9.2.1.3)	☐	☐
29	☐ PMI testing required (9.2.2.3.1) ☐ Extent of required PMI testing, including sampling, is specified (9.2.2.3.2)		
30	☐ Schedule of manufacturing hold points and inspector's visits (9.1.5)		
31	☐ Amount of advance notification required before a witnessed or observed inspection (9.1.6, 9.1.7): _____ working days		
32	☐ Other records or data to be kept by vendor for at least 20 years, in addition to the requirements of 9.2.1.1 f)		
33	☐ Surface and subsurface examination required (9.2.1.5), examination type:		
34	☐ magnetic particle ☐ liquid penetrant ☐ radiographic ☐ ultrasonic		
35	☐ parts requiring examination:		
36	☐ All markings shall be in English and other specified language (9.5.1)		
37	☐ One copy of manufacturer's standard instruction manual packed and shipped with equipment (9.5.8)		
38	☐ Purchaser's review and acceptance of the components selected, before purchase (10.3.2.3.2)		
39	☐ Purchaser's acceptance of layout of components and piping before manufacture (10.3.2.3.3)		
40	☐ Vendor to furnish outline of procedures used for each of special or optional test (10.3.2.3.4)		
41	Information specified in Annex D - Contract Documents and Engineering Design Data shall be provided (10.1.2)		
42	Comments:		
43			
44			
45			
46			
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Annex B (informative)

Symbols

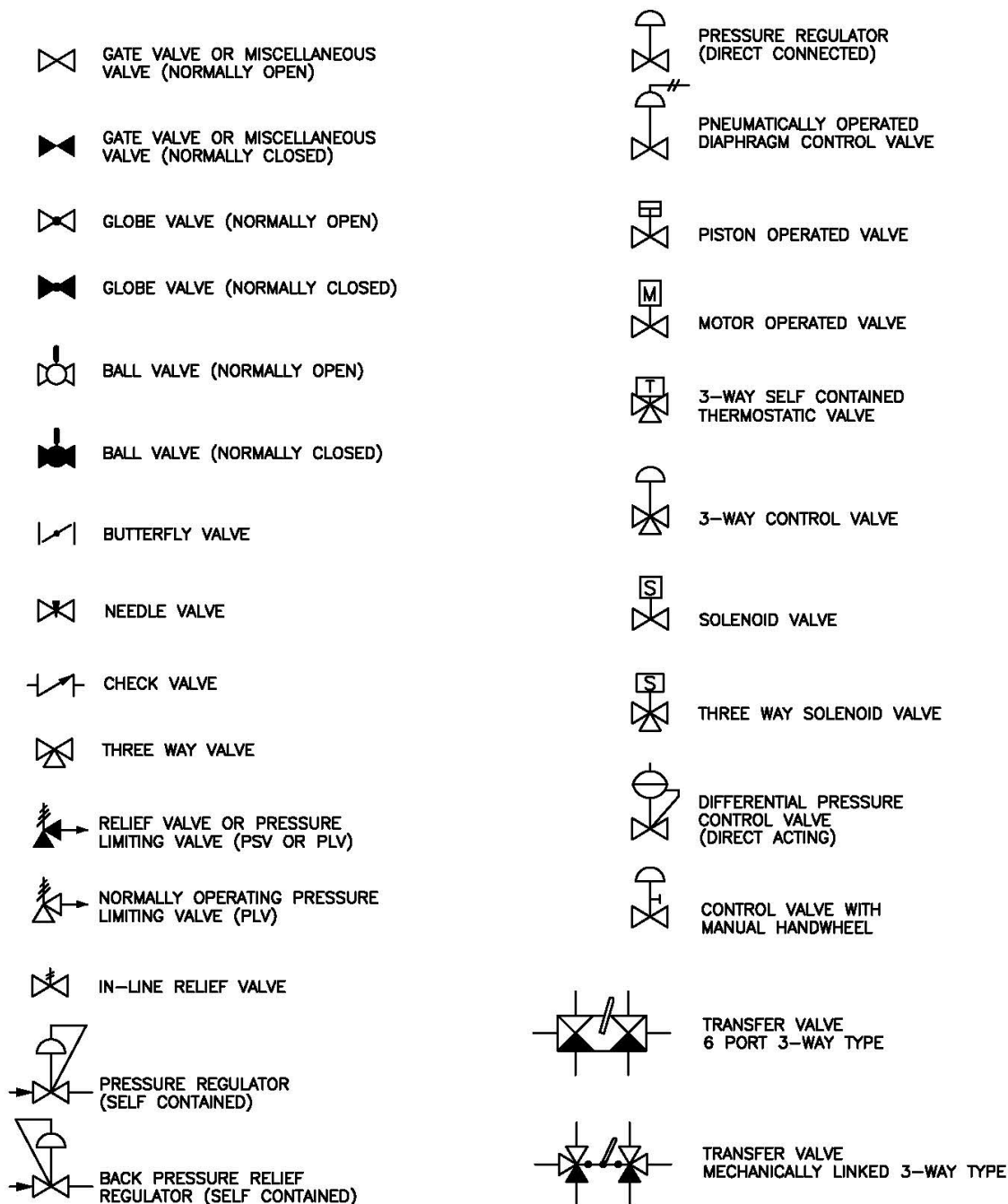


Figure B.1—Symbols

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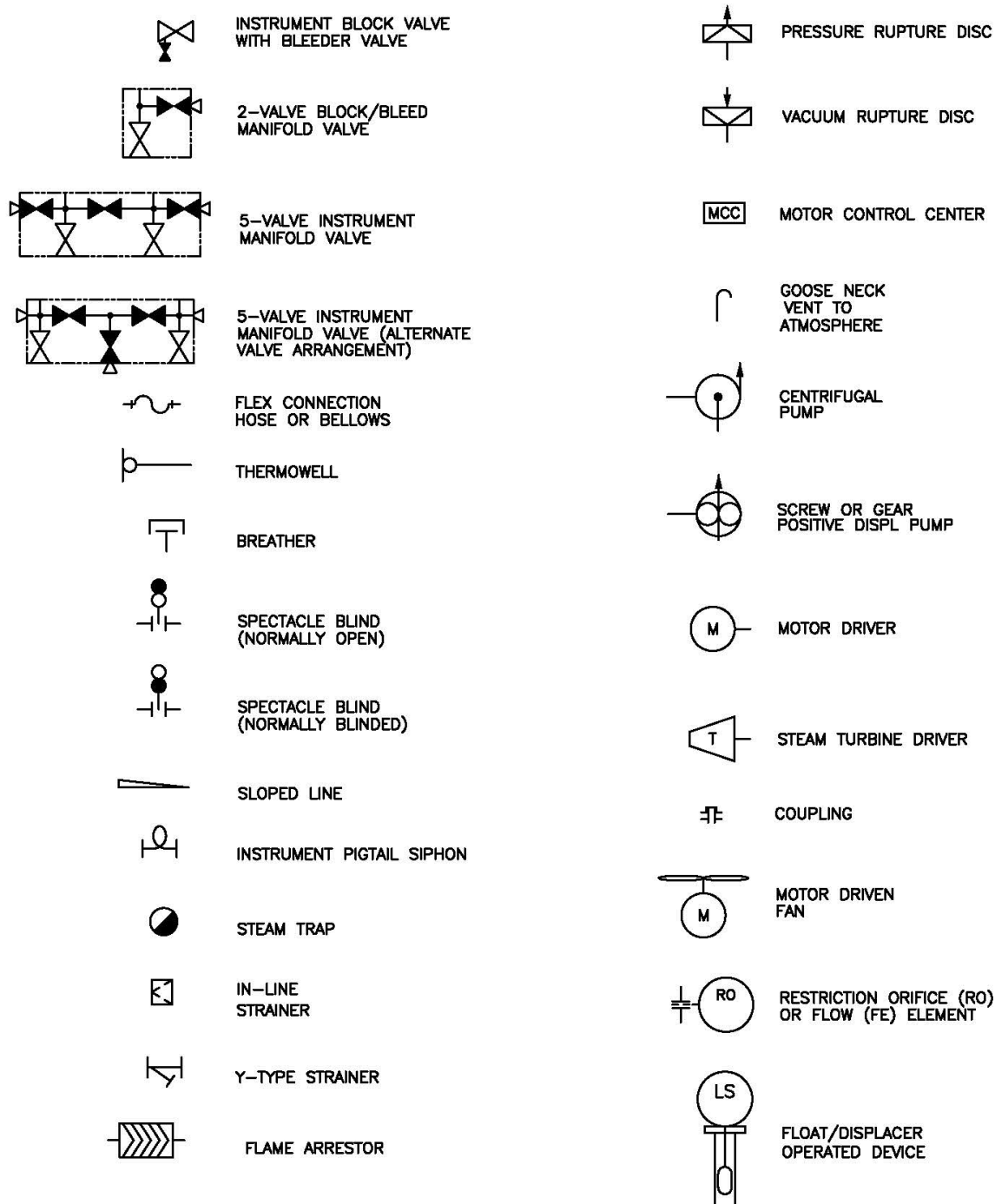


Figure B.2—Symbols *(continued)*

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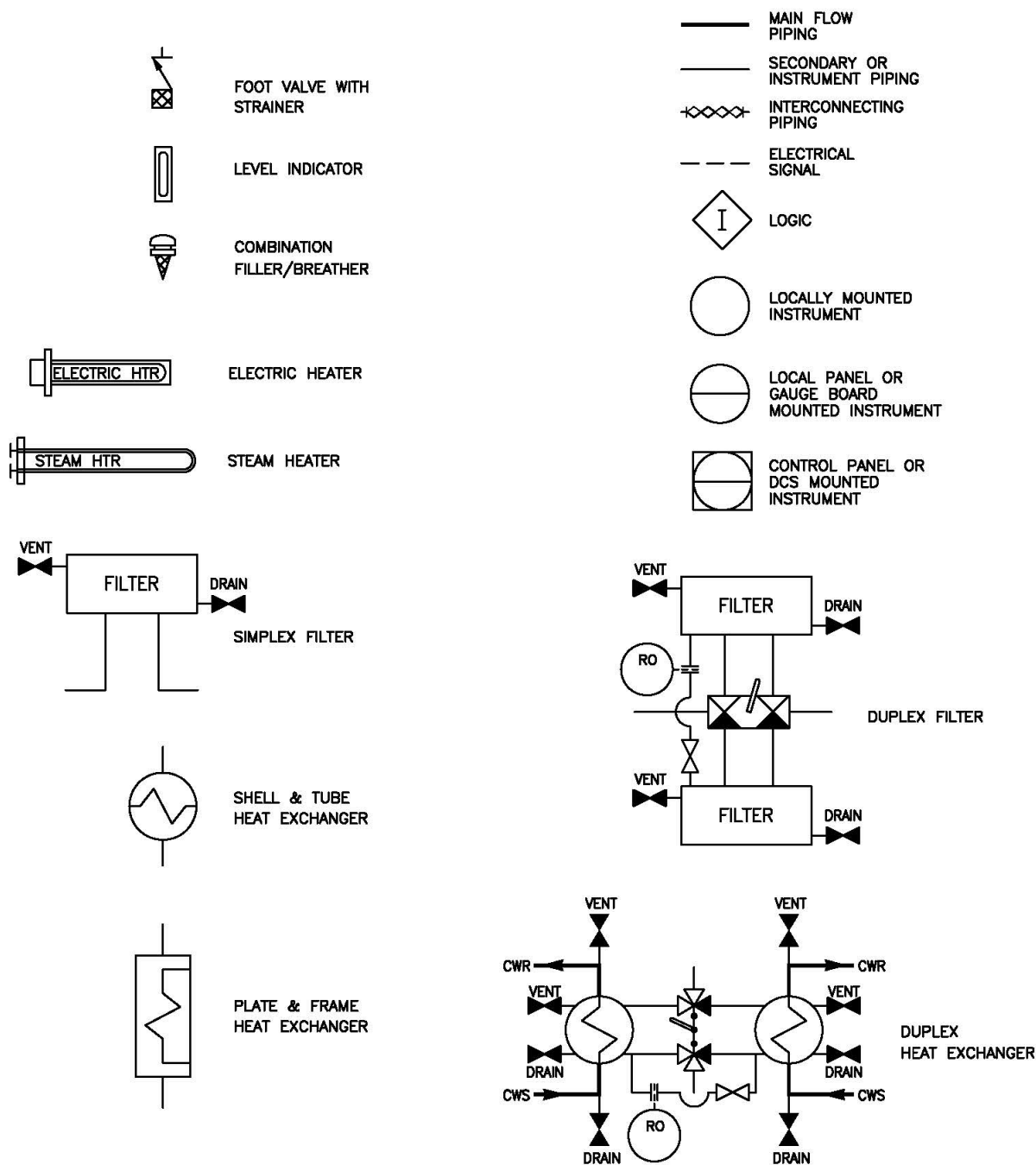


Figure B.3—Symbols *(continued)*

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	INSTRUMENT FUNCTION													
	ALARM HIGH	ALARM HIGH HIGH	ALARM LOW	ALARM LOW LOW	BLIND CONTROLLER	CONTROL VALVE, MANUAL	CONTROL VALVE	ELEMENT	INDICATOR	INDICATING CONTROLLER	RELAY OR CONVERTER	SAFETY VALVE	SWITCH	TRANSMITTER NON-INDICATING
MEASURED VARIABLE														
ANALYSIS	AAH	AAHH	AAL	AALL	AC	AV	ACV	AE	AI	AIC	AY			AT
FLOW	FAH	FAHH	FAL	FALL	FC	FV	FCV	FE	FI	FIC	FY	FSV	FS	FT
HAND					HC	HV	HCV			HIC	HY		HS	
LEVEL	LAH	LAHH	LAL	LALL	LC	LV	LCV	LE	LI	LIC	LY		LS	LT
PRESSURE OR VACUUM	PAH	PAHH	PAL	PALL	PC	PV	PCV	PE	PI	PIC	PY	PSV	PS	PT
PRESSURE DIFFERENTIAL	PDAH	PDAHH	PDAL	PDALL	PDC	PDV	PDCV	PDE	PDI	PDIC	PDY		PDS	PDT
SPEED OR FREQUENCY	SAH	SAHH	SAL	SALL	SC	SV	SCV	SE	SI	SIC	SY		SS	ST
TEMPERATURE	TAH	TAHH	TAL	TALL	TC	TV	TCV	TE	TI	TIC	TY		TS	TT
POSITION	ZAH	ZAHH	ZAL	ZALL	ZC	ZV	ZCV	ZE	ZI	ZIC	ZY		ZS	ZT
VIBRATION	XAH	XAHH						XE	XI		XY		XS	XT

DIAGRAM ABBREVIATIONS

A/M	AUTO MANUAL	HOA	HAND-OFF AUTO
AS	AIR SUPPLY	NC	NORMALLY CLOSED
CSO	CAR SEAL OPEN	NO	NORMALLY OPEN
CSC	CAR SEAL CLOSE	PLV	PRESSURE LIMITING VALVE
CWR	COOLING WATER RETURN	RO	RESTRICTION ORIFICE
CWS	COOLING WATER SUPPLY	RTD	RESISTANCE TEMP. DETECTOR
ESD	EMERGENCY SHUTDOWN	SL	SHIP LOOSE
FC	FAIL CLOSED	TW	THERMOWELL
FO	FAIL OPEN		
FL	FAIL IN LOCKED IN POSITION		
FE	FLOW ORIFICE ELEMENT		

Figure B.4—Instrumentation Symbol Code Table

Annex C

(informative)

Figure C.17 is a schematic diagram of the oil supply system, showing the integration of several modules and their internal components. The diagram is divided into three main sections: (a), (b), and (c).

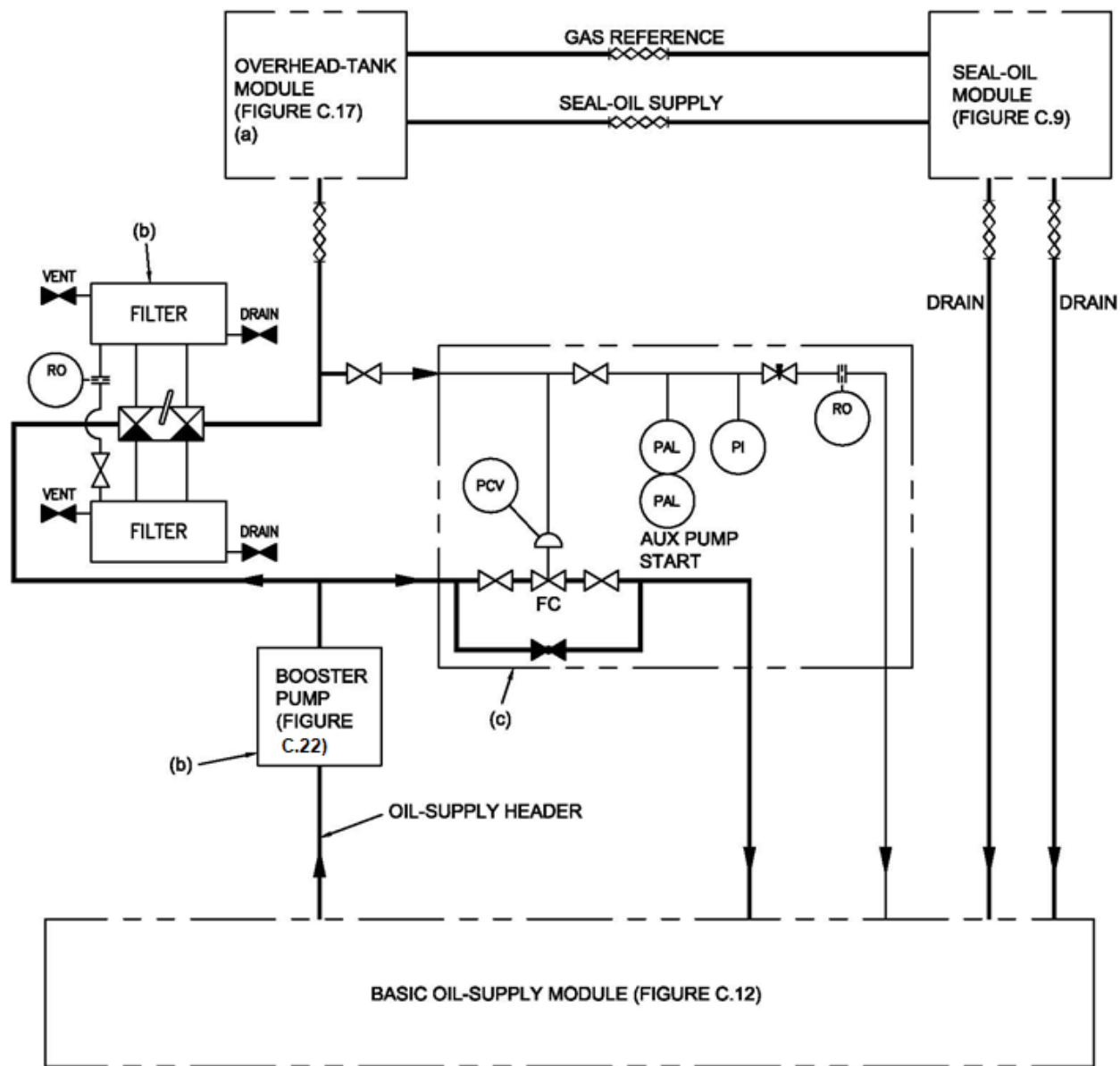
- Section (a):** Shows the **OVERHEAD-TANK MODULE (FIGURE C.17) (b)** connected to the **SEAL-OIL SYSTEM MODULE (FIGURE C.9)** via a **GAS REFERENCE (a)** and **SEAL-OIL SUPPLY** lines. The **SEAL-OIL SYSTEM MODULE** is connected to the **OIL-RETURN HEADER**.
- Section (b):** Shows the **MAIN EQUIPMENT LUBE AND CONTROL OIL MODULE (FIGURE C.13)** and the **CONTROL SYSTEM (FIGURE C.10)**. The **MAIN EQUIPMENT LUBE AND CONTROL OIL MODULE** is connected to the **OIL-RETURN HEADER** and the **OIL-SUPPLY HEADER**. It includes a **BLEED OIL RETURN TO OIL DRAIN OR RESERVOIR** line, a **LUBE OIL SUPPLY** line, and a **PCV** (Pressure Control Valve) line. The **CONTROL SYSTEM** is connected to the **CONTROL OIL SUPPLY** line and the **OIL-SUPPLY HEADER**. It includes a **BLEED OIL RETURN TO OIL DRAIN OR RESERVOIR** line, a **PCV** line, and a **FO** (Flow Orifice) line.
- Section (c):** Shows the **BASIC OIL-SUPPLY MODULE (FIGURE C.12)**. It includes an **ALTERNATIVE CONTROL-OIL FLOW** section with two **FILTER** units, each with a **VENT** and a **DRAIN** line. The **ALTERNATIVE CONTROL-OIL FLOW** section is connected to the **OIL-SUPPLY HEADER** and the **CONTROL OIL SUPPLY** line.

The diagram illustrates the complex interconnections between these modules, ensuring proper oil supply and return for the system.

- a For systems without overhead seal-oil tanks, the gas reference is connected to a direct-acting differential PCV. The alternative arrangement is shown in Figure C.8.
- b The overhead tank module may be either upstream (Figure C.4) or downstream (Figure C.5) of the seal-oil system module.
- c This arrangement is valid only when the minimum seal-oil supply pressure is higher than the control-oil pressure.

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Figure C.1—Combined Seal-oil, Lube-oil, and Control-oil System

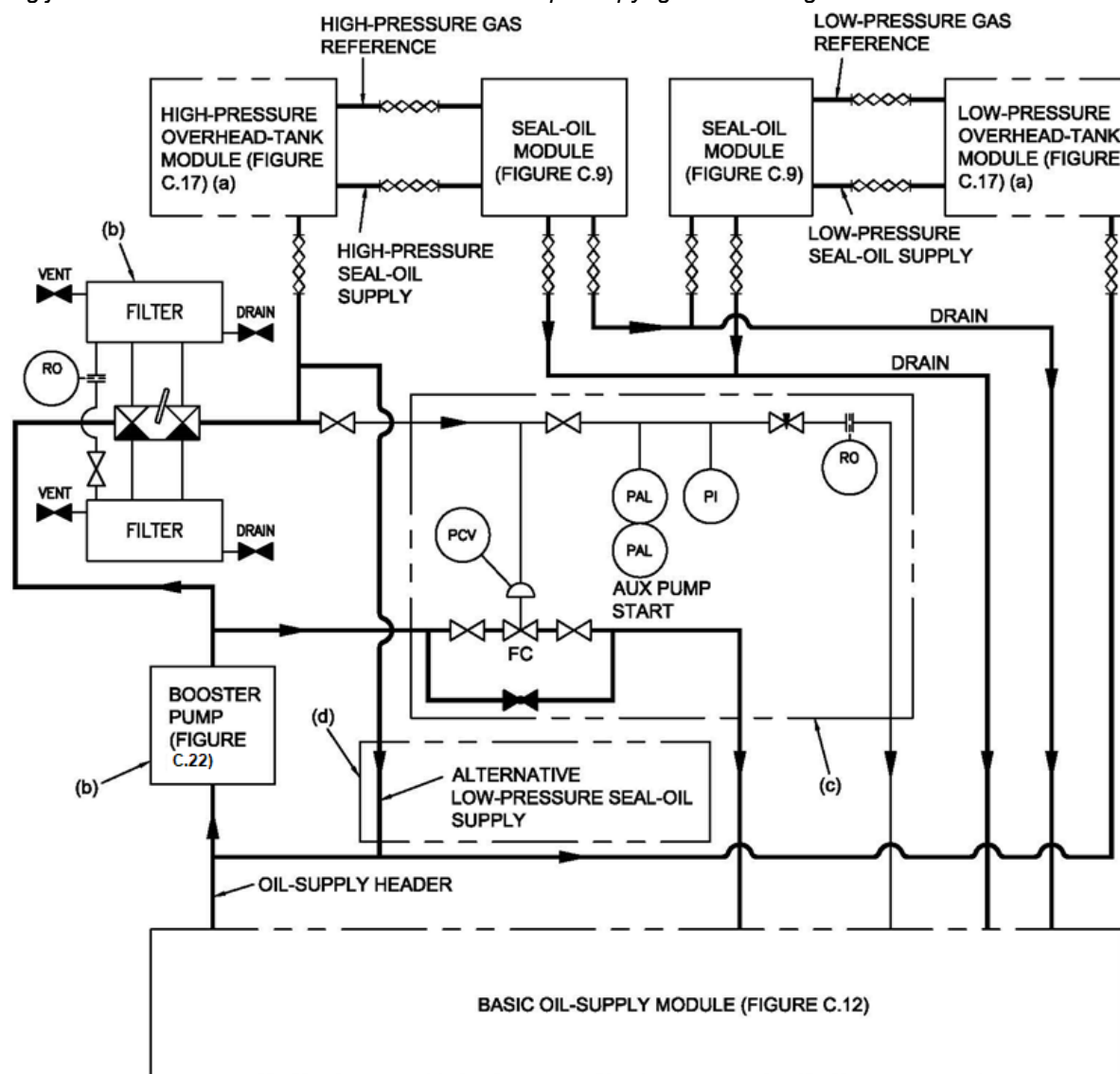


Key

- a The overhead tank module may be either upstream (see Figure C.4) or downstream (see Figure C.5) of the seal-oil module.
- b The booster pump and filter are omitted if the basic oil-supply system is specified to provide the required pressure.
- c The PCV and associated alarms and pressure indicator may be deleted if the equipment seals utilize the total flow of oil from the pumps (e.g. for cooling purposes).

Figure C.2—Seal-oil System Only, with Overhead Tank for Equipment with One Pressure Level

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Key

- a The overhead tank module may be either upstream (see Figure C.4) or downstream (see Figure C.5) of the seal-oil system module.
- b The booster pump and filter are omitted if the basic oil-supply system is specified to provide the required pressure.
- c The PCV and associated alarms and pressure indicator may be deleted when the equipment has seals that take the total flow of oil from the pumps without the need for back-pressure regulation.
- d The source for low-pressure seal oil depends on the required pressure.

Figure C.3—Seal-oil System Only, with Overhead Tanks for Equipment with More Than One Pressure Level

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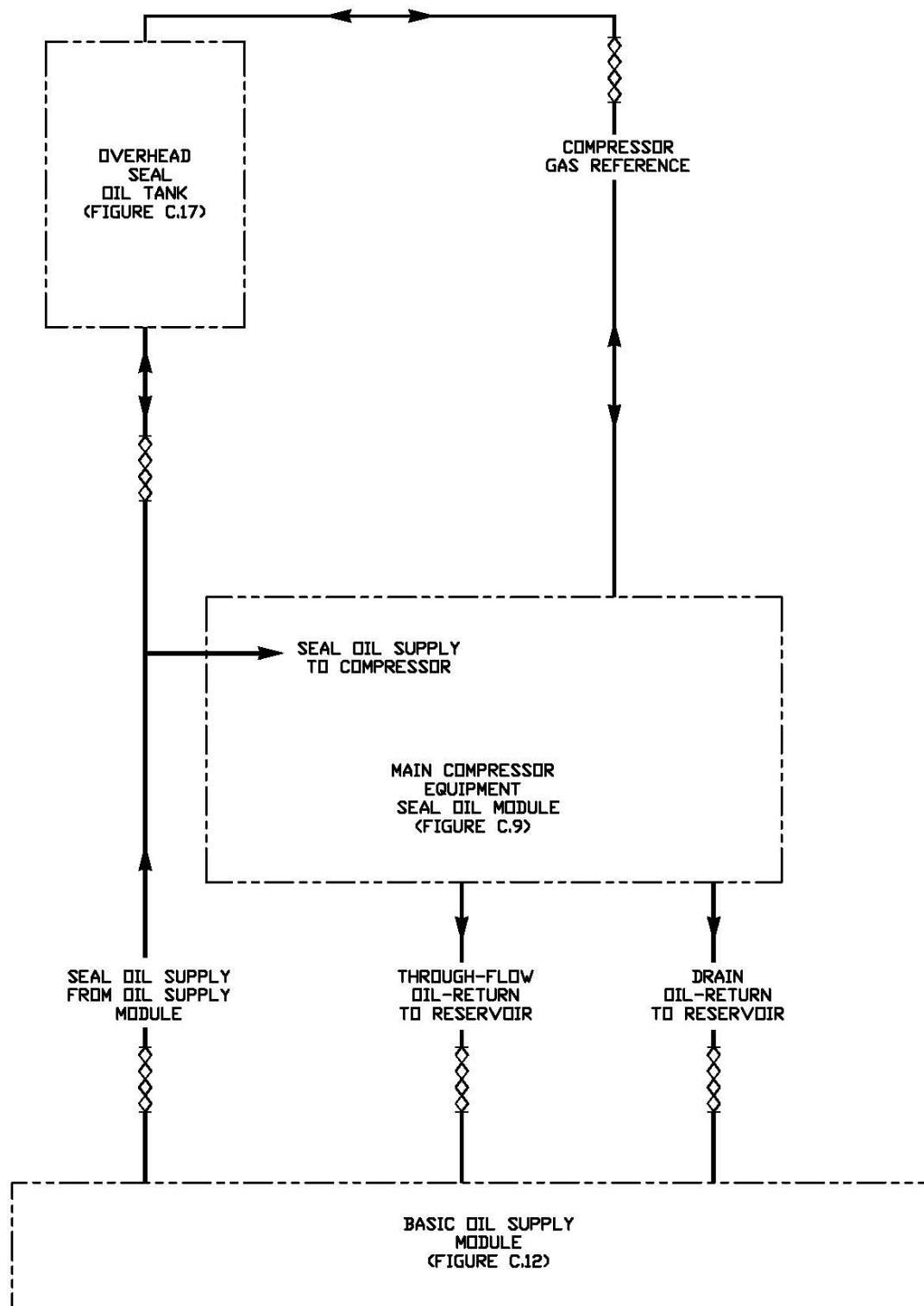
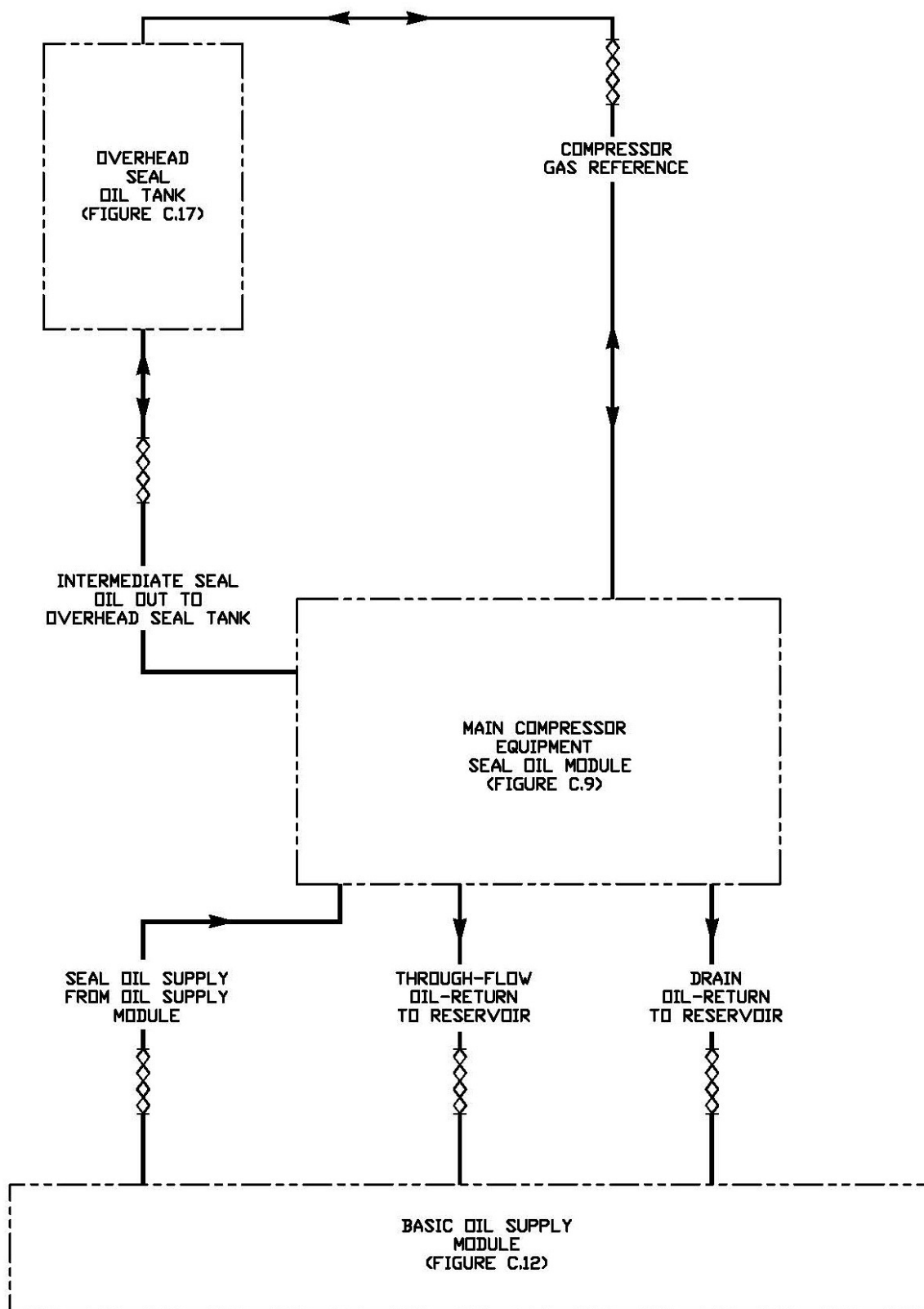


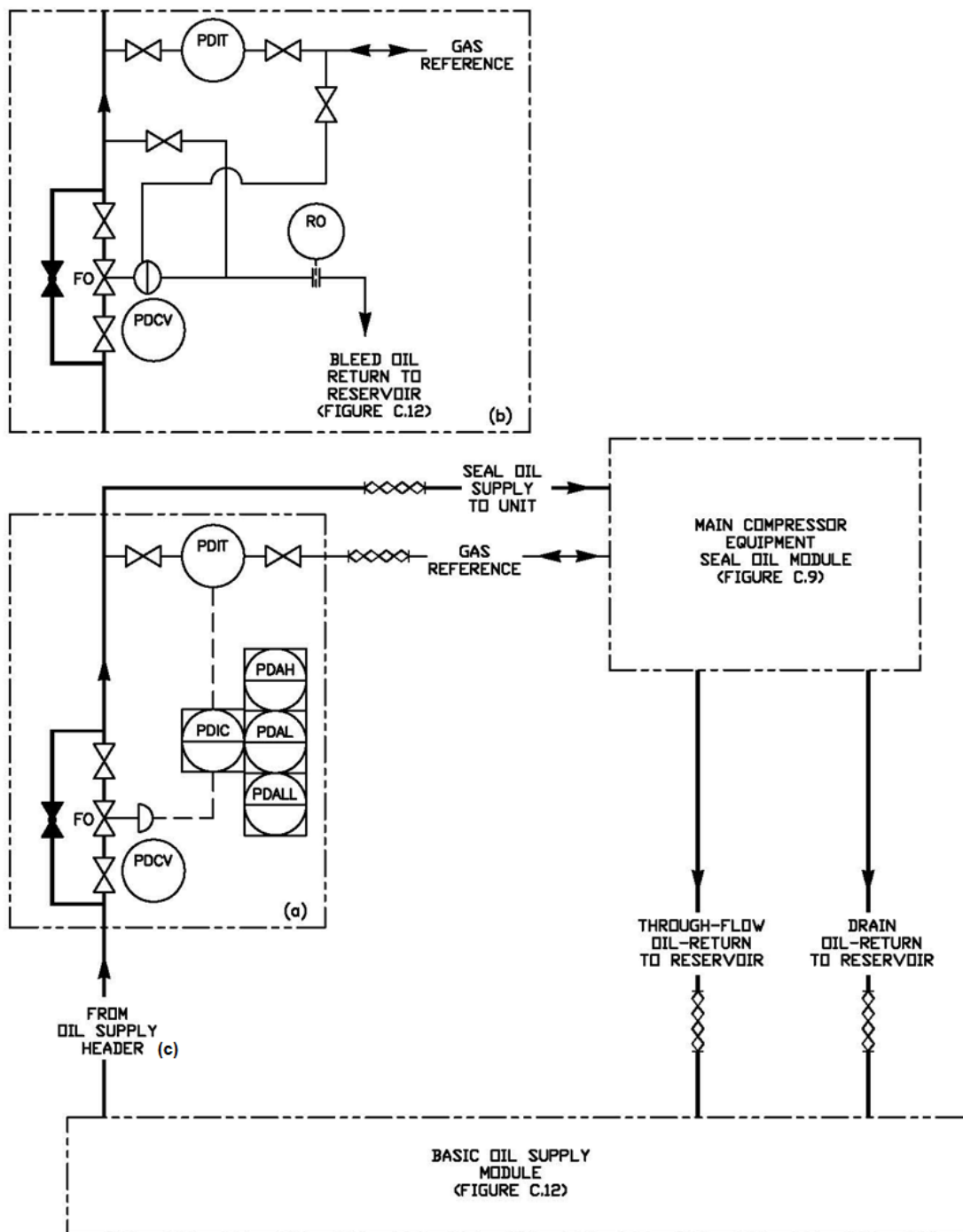
Figure C.4—Seal-oil System Only, for Equipment with Liquid Film-type Seals—Overhead Tank Upstream of Seals

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Figure C.5—Seal-oil System Only, for Equipment with Liquid Film-type Seals—Overhead Tank Downstream of Seals



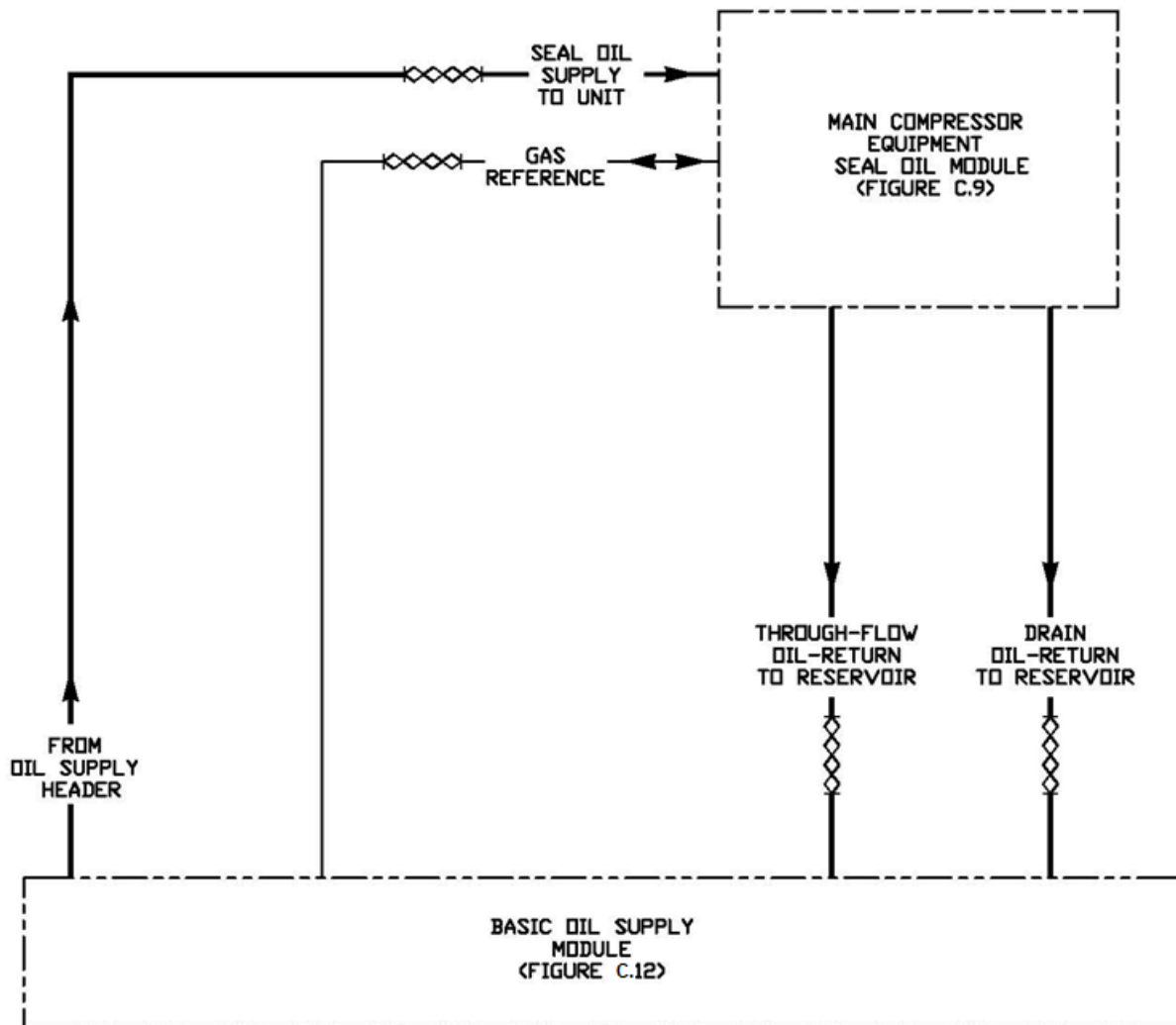
Key

- ^a The seal-oil supply differential pressure control can be accomplished with a differential pressure controller and pneumatic control valve.
- ^b The seal-oil supply differential pressure control can be accomplished with a direct-acting differential PCV.

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- ^c This arrangement is valid only when the pressure of the seal-oil supply, at the compressor, is lower than the cooling water pressure. If the pressure of the cooling water is lower, refer to Figure C.7.

Figure C.6—Seal-oil System with Oil Pressure Lower Than Cooling Water Pressure

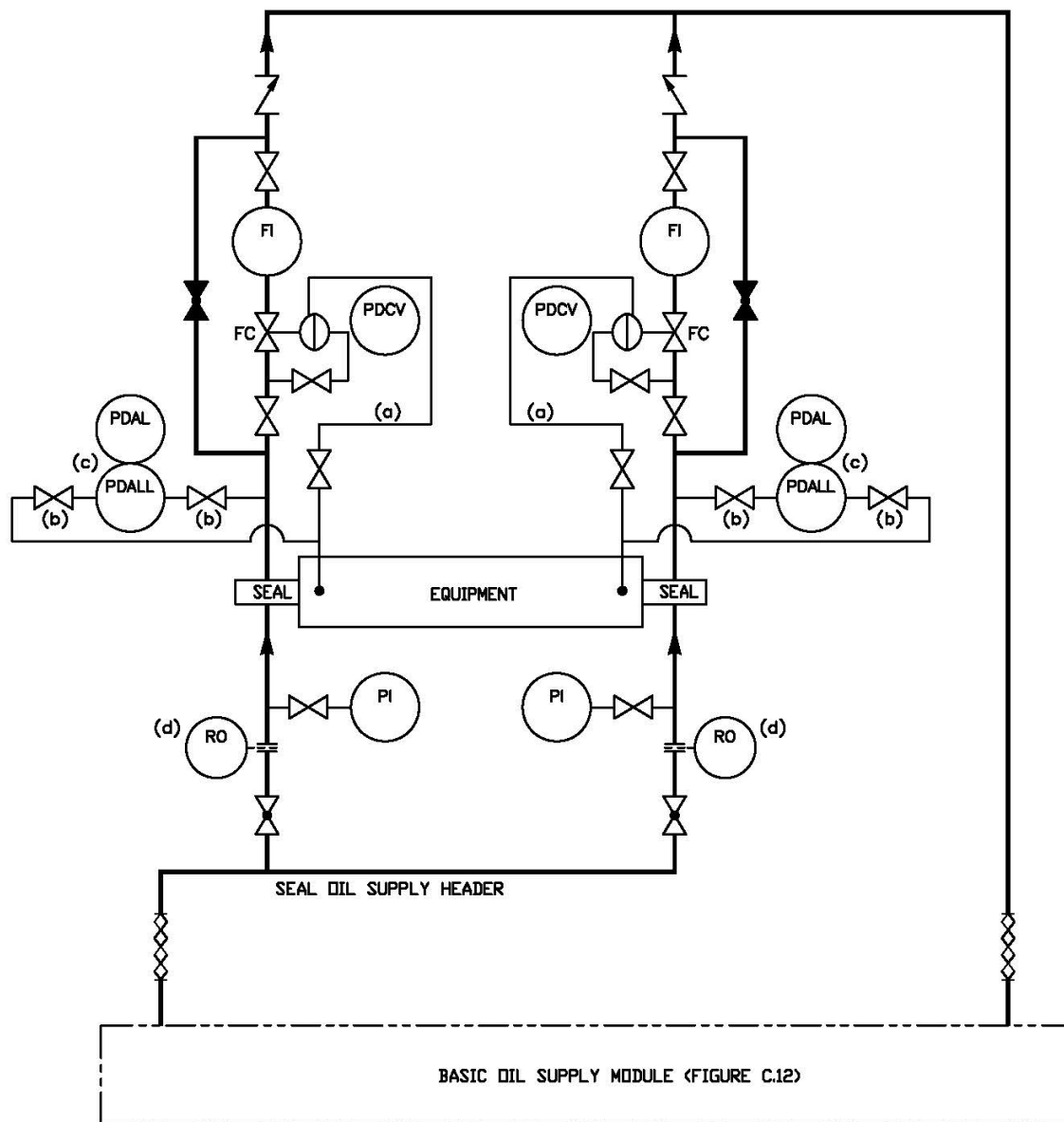


Key

- ^a The seal-oil supply differential pressure control is used according to the alternative arrangement shown in Figure C.12.
- ^b This arrangement is valid only when the pressure of the seal-oil pressure at the compressor is higher than the cooling water pressure. If the pressure of the seal oil at the compressor is lower, refer to Figure C.6.

Figure C.7—Seal-oil System with Oil Pressure Higher Than Cooling Water Pressure

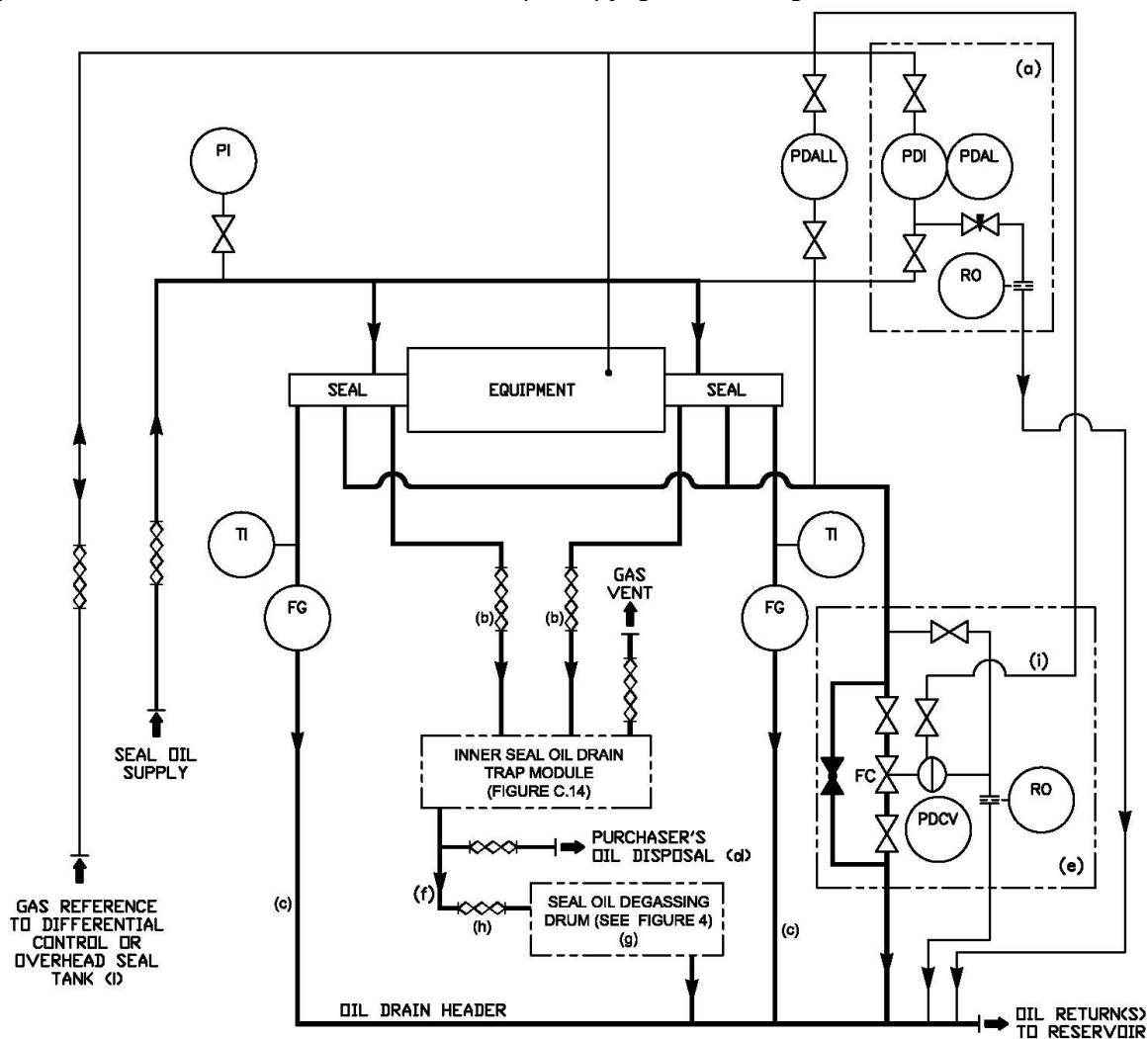
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Key

- a Each direct-acting differential PCV is referenced to sense the working fluid pressure acting at the corresponding mechanical seal.
- b Isolation block valves can be omitted for all instruments in shutdown service with owner's approval.
- c Differential pressure devices for alarm and shutdown are included.
- d Flow restriction orifices are included.

Figure C.8—Seal-oil Circulation System for Equipment with Double Mechanical Seals or Multiple Sealing Pressure Levels

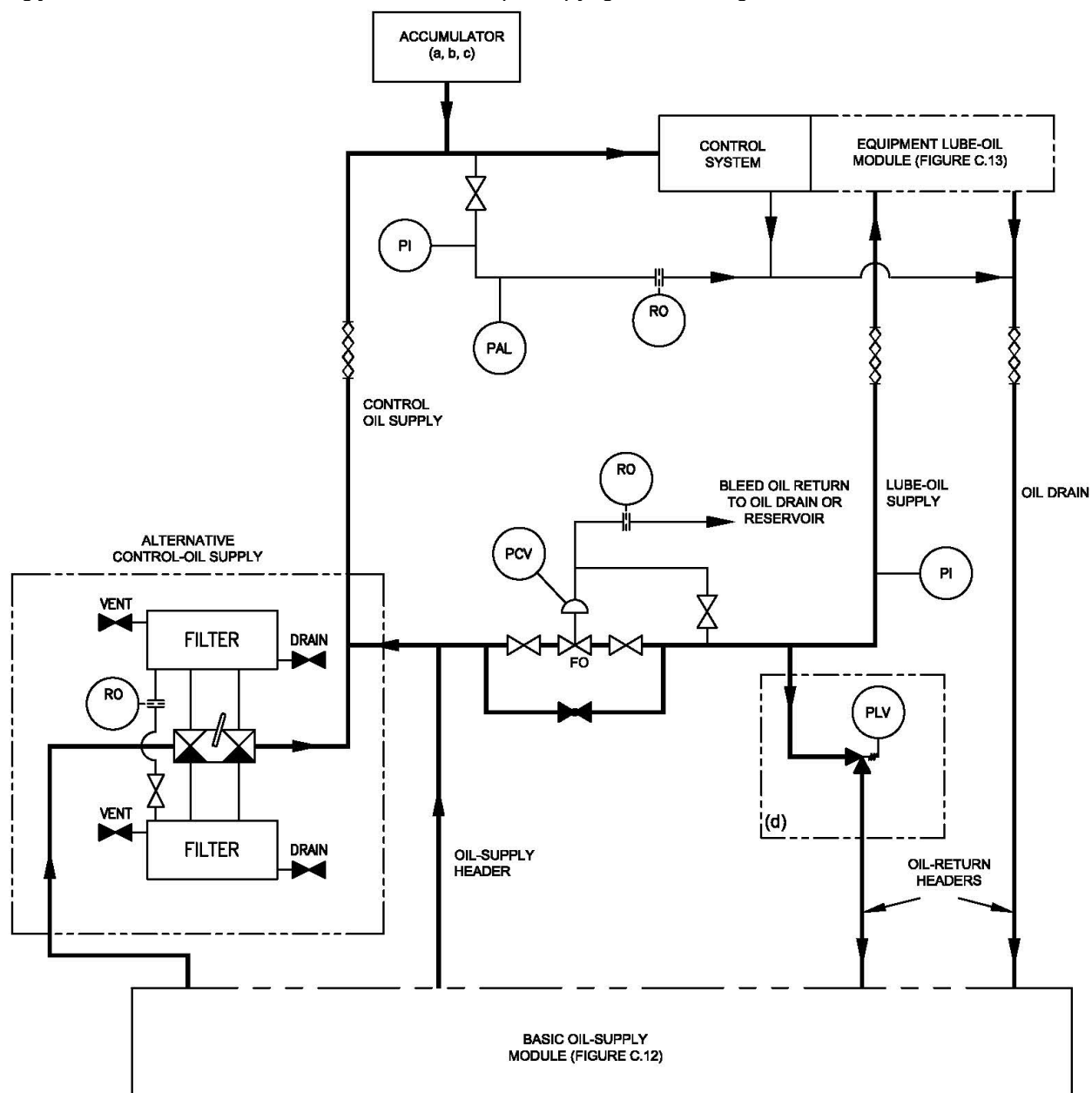


Key

- a The indicated components are omitted if they are furnished separately on the overhead tank.
- b This piping is furnished by the vendor when the drainers are mounted on a compressor baseplate.
- c On combined lube- and seal-oil systems, the outer seal drain may be combined with the lube-oil drain inside the compressor.
- d A drain to the purchaser's waste oil disposal is included.
- e Alternate seal-oil drain arrangement. For this arrangement, sensing instruments (start standby pump, trip main driver) are referenced to a pressure-controlled header, either upstream or downstream of the seals, as agreed.
- f A drain to the degassing drum is included.
- g A degassing drum (see Figure 5) is included.
- h This piping is furnished by the vendor if the degassifier is mounted on a compressor baseplate supplied by the vendor.
- i Each direct-acting differential PCV is referenced to sense the working fluid pressure acting at the corresponding seal.

Figure C.9—Seal-oil Module at Equipment

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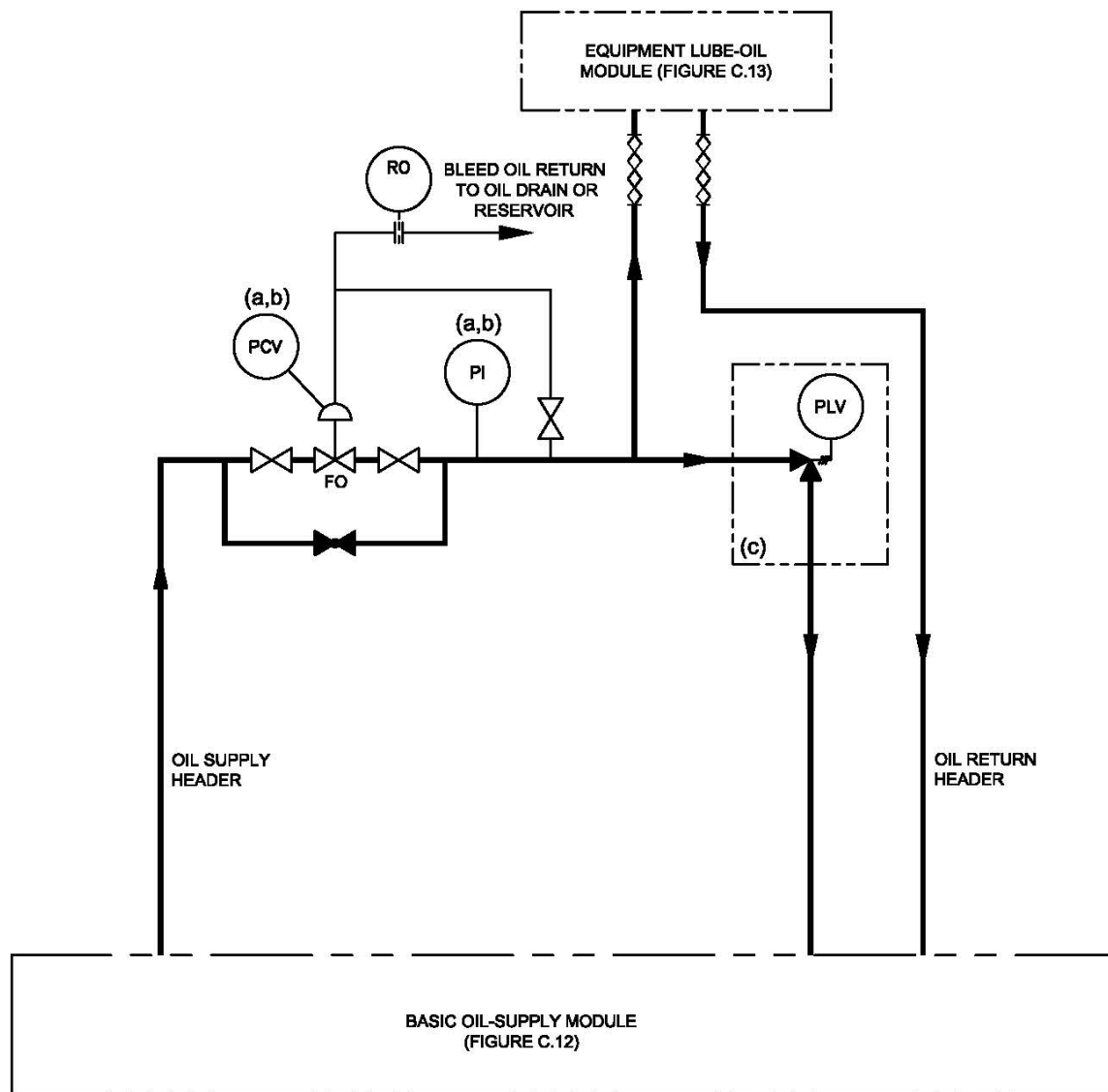


Key

- a A control-oil accumulator is supplied if one is required to maintain the control-oil pressure.
- b The accumulator is mounted as close as possible to the main equipment.
- c Bladder type accumulator is described in Fig. C.18, direct contact type in Fig. C.19.
- d This represents a typical arrangement that includes an additional PLV for any system in which failure of a control valve can jeopardize or damage a low-pressure system.

Figure C.10—Lube-oil and Control-oil Systems Only

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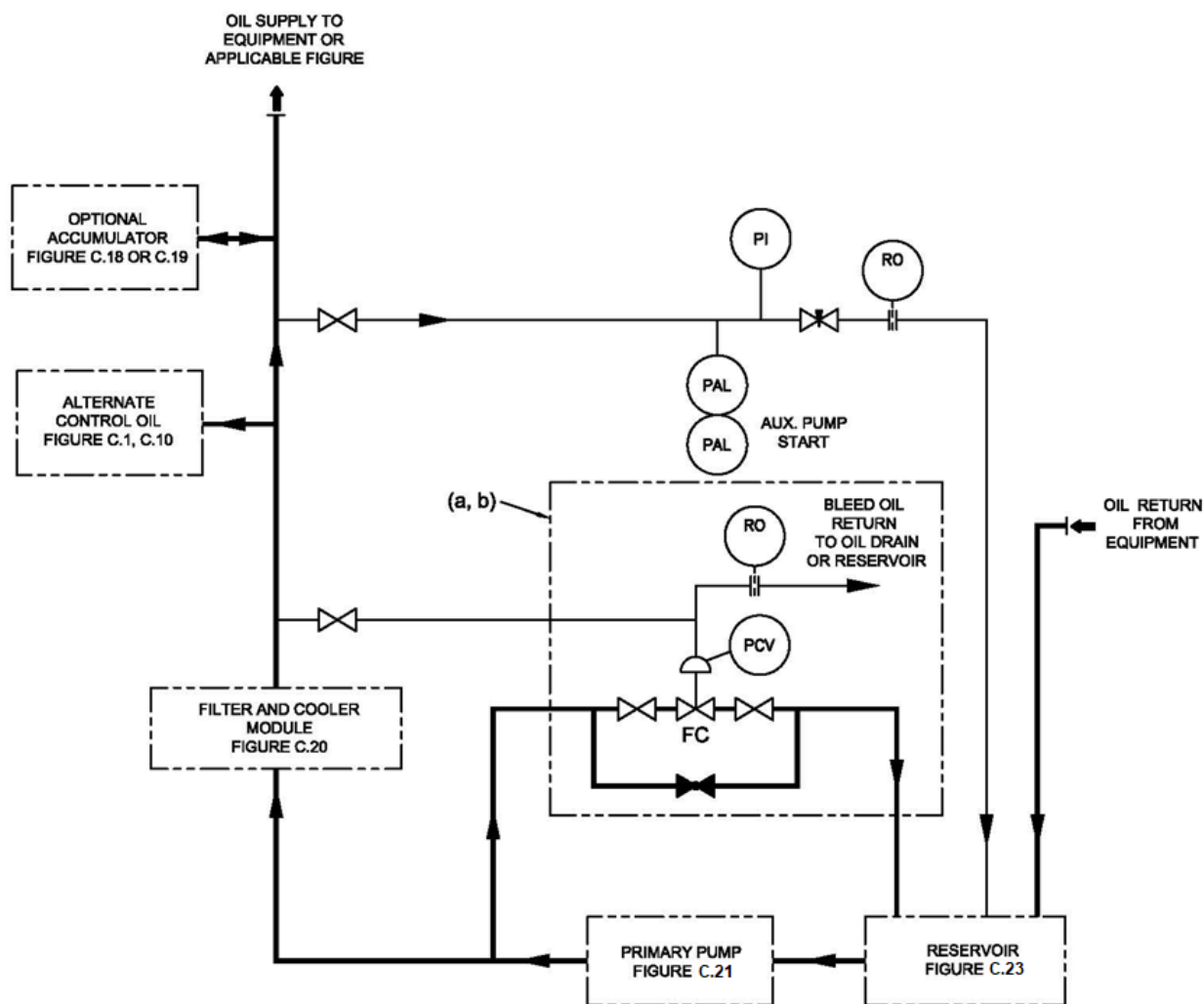


Key

- a The direct-acting PCV and the pressure indicator are omitted when the pressure of the lube-oil supply is higher than the pressure of the cooling water.
- b A direct-acting PCV is required if centrifugal pumps are used.
- c This represents a typical arrangement that includes an additional PLV for any system in which failure of a control valve can jeopardize or damage a low-pressure system.

Figure C.11—Equipment Lube-oil System Only

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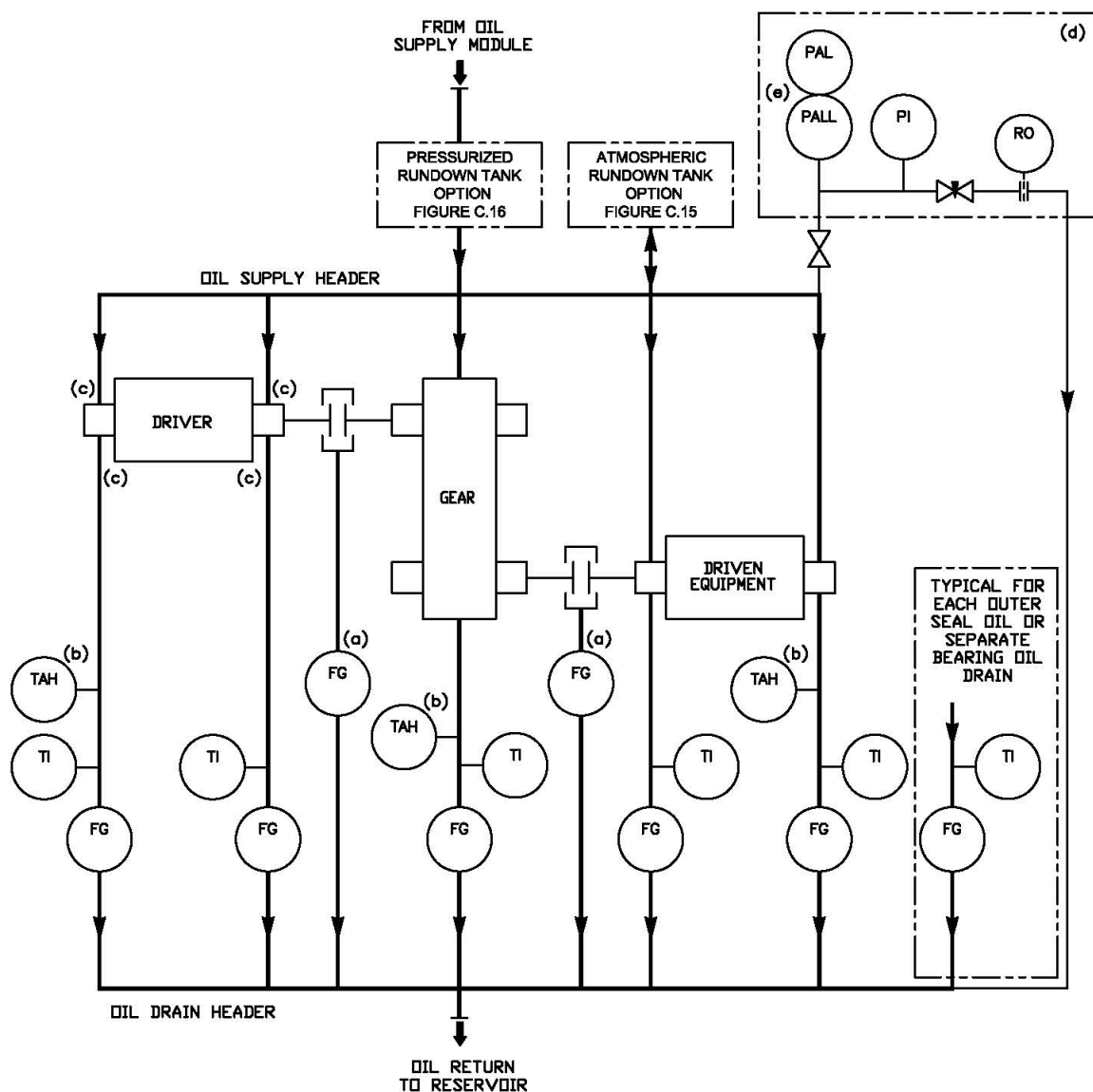


Key

- ^a The heat load can require that the supply to the direct connected PCV be downstream of the coolers.
- ^b The bypass direct connected PCV circuit is omitted when centrifugal pumps are used.

Figure C.12—Basic Oil Supply Module

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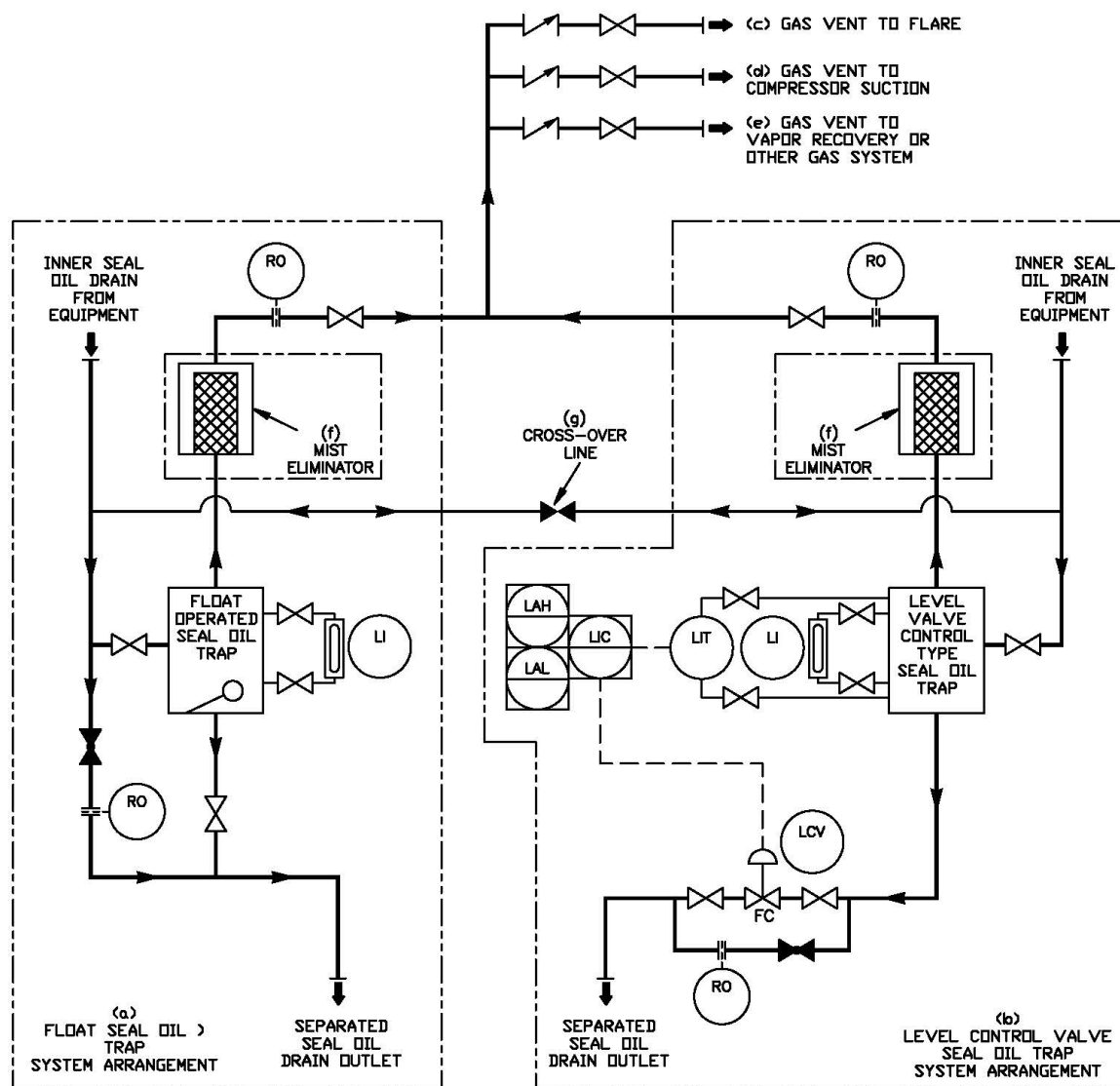


Key

- a The purchaser may specify flow glasses in coupling guard drains.
- b The governing equipment standard can recommend the use of oil drain high-temperature alarms when the serviced equipment is equipped with thrust-bearing metal temperature detector
- c For motor drivers and if required by the motor design, all connections are electrically insulated.
- d These components may be located on the gauge board.
- e The purchaser can specify redundant transmitters for 2 out of 3 voting for low lube-oil shutdown.

Figure C.13—Equipment Lube-oil Supply and Drain Headers

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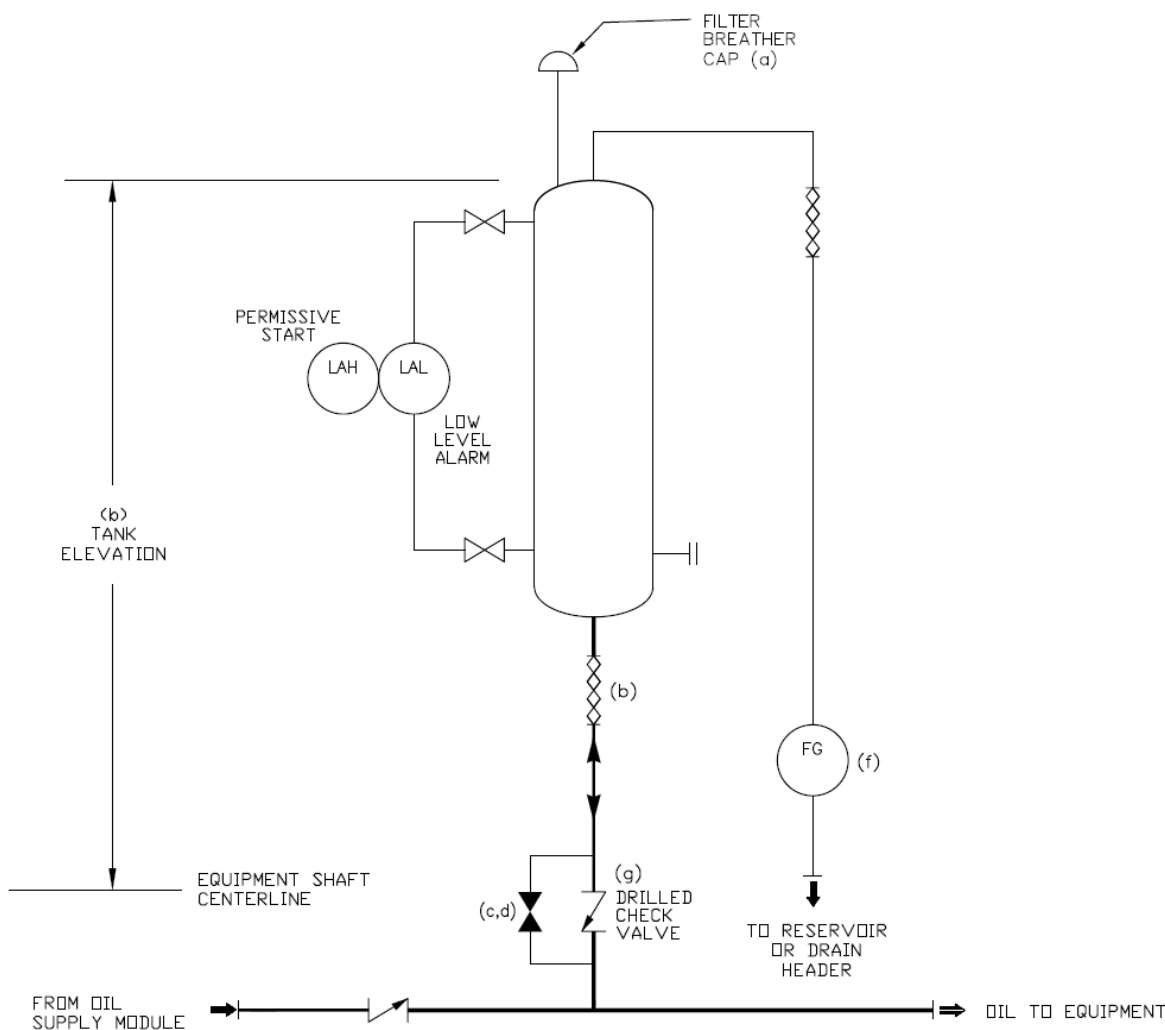


Key

- a The purchaser may specify float-operated drain traps.
- b The purchaser may specify level valve-controlled drain traps.
- c The purchaser may specify a gas vent to flare.
- d The purchaser may specify a gas vent to the suction of a lower compressor suction.
- e The purchaser may specify a gas vent to vapor recovery or another gas system.
- f The purchaser may specify vent gas mist eliminators.
- g The cross-over line is omitted when the seals are not operating at the same pressure.

Figure C.14—Inner Seal-oil Drain Traps

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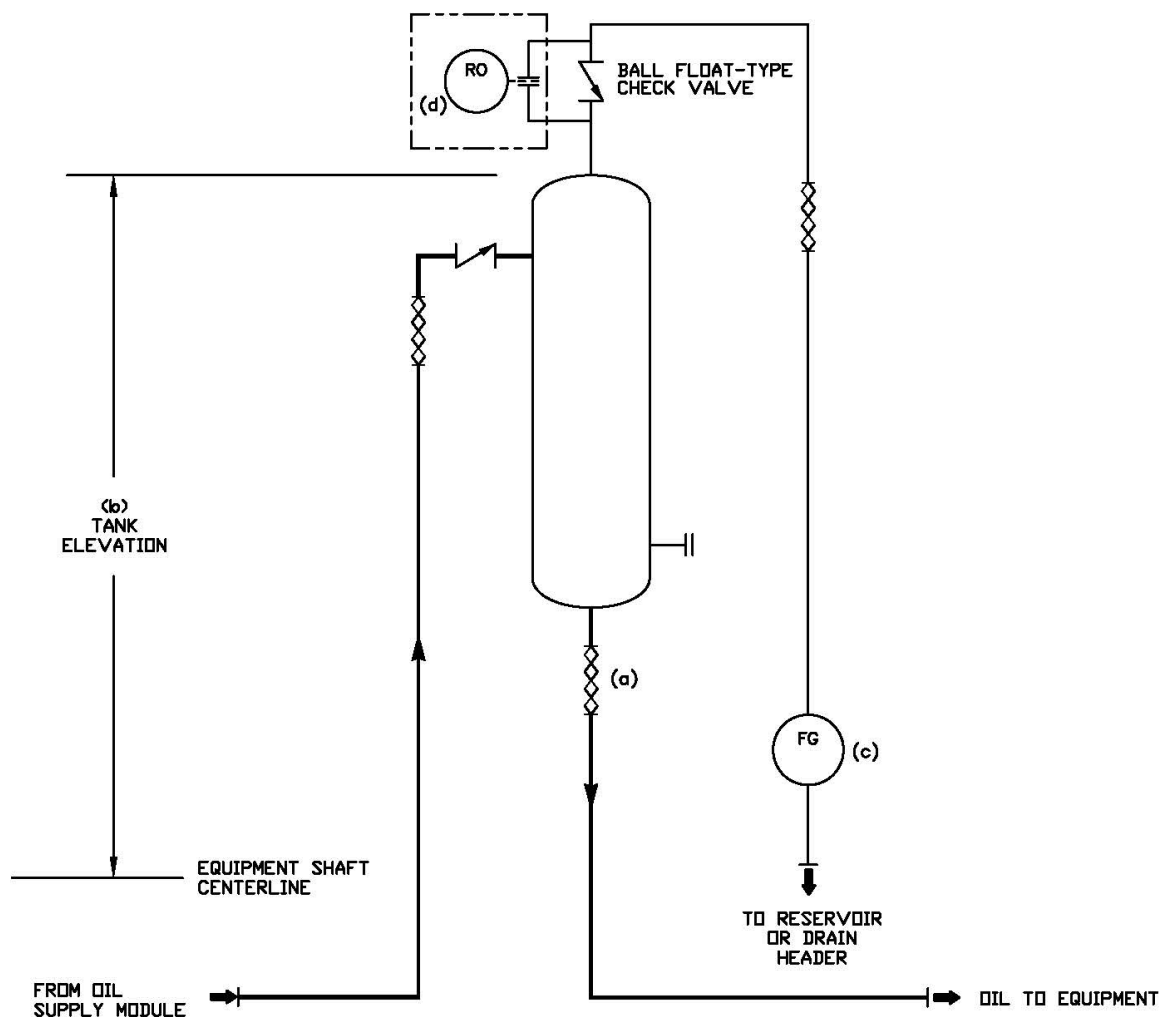


Key

- a The rundown tank vent includes an atmospheric filter breather cap.
- b This tank is located at an elevation such that the static head is less than the equipment lube-oil trip pressure.
- c This valve is normally closed; it is opened only to fill the tank before the equipment is started.
- d This valve may be solenoid controlled to allow an automated start.
- e To reduce pressure-line losses, locate and design interconnecting piping as per system designer's recommendations.
- f Sight glass should be located near the reservoir or oil drain header in a visible location.
- g A bypass orifice around the check valve can be used instead of a drilled check valve.

Figure C.15—Emergency Lube-oil Atmospheric-type Rundown Tank

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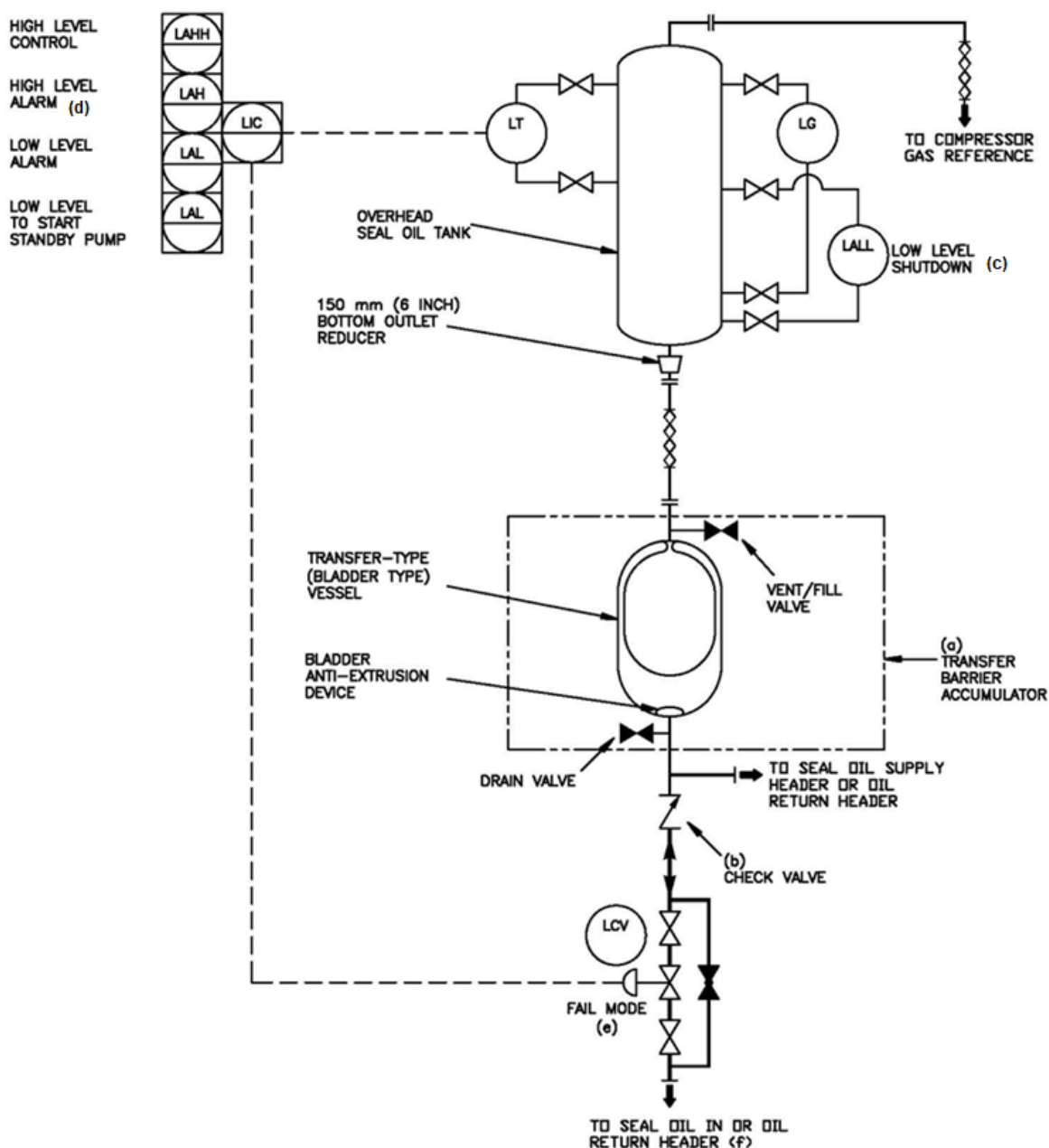


Key

- a To reduce pressure-line losses, locate and design interconnecting piping as per system designer's recommendations.
- b This tank is located at an elevation such that the static head is less than the equipment lube-oil trip pressure.
- c Sight glass should be located near the reservoir or oil drain header in a visible location.
- d The purchaser may specify a bypass orifice around the floating ball check valve.

Figure C.16—Emergency Lube-oil Pressurized-type Rundown Tank

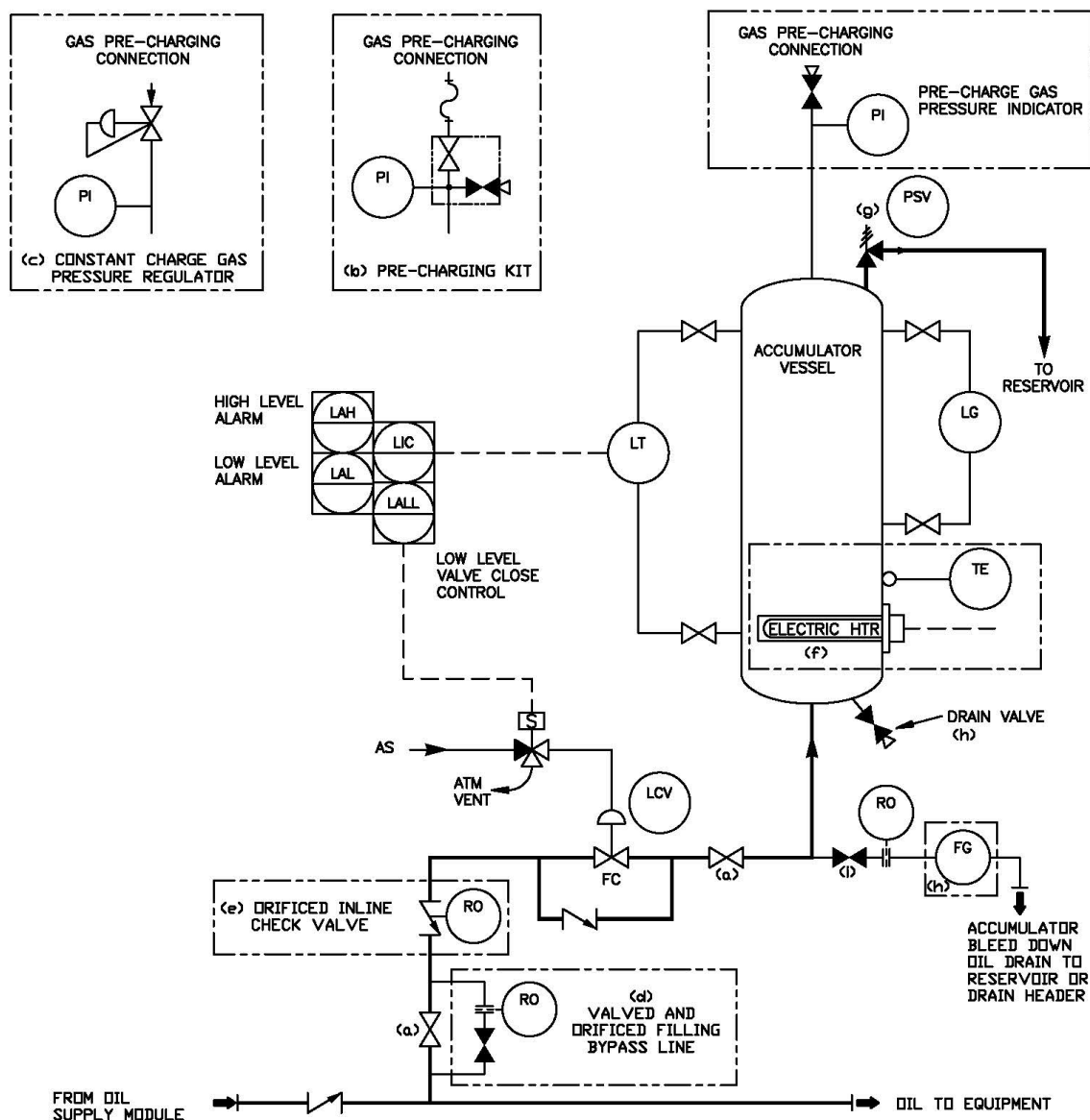
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Key

- a The purchaser may specify a transfer barrier accumulator with an isolation bladder.
- b The check valve is omitted when the overhead tank module is downstream of the seals.
- c Pump stop control for seal-oil only pumps. Does not apply to systems with combined lube- and seal-oil pumps.
- d High-level alarm applies to seal-oil only and to combined lube- and seal-oil systems.
- e Control valve should be in FO or FL position. The following are the failure actions for the loop-actuated control valve: FO in the supply header and FC in the return header.
- f The seal-oil tank connection can be upstream or downstream of the compressor seals; refer to Figures C.4 and C.5.

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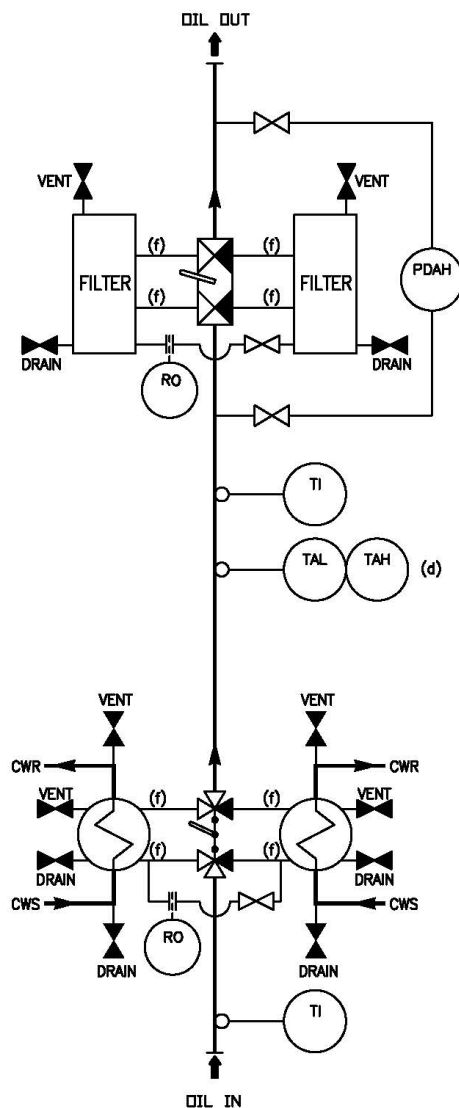


Key

- a The block valves may be car-sealed or locked open.
- b The purchaser may specify a precharging kit with a charging valve, pressure gauge, and hose.
- c The purchaser may specify a constant pressure-regulating system.
- d The valved and orifice bypass arrangement allows placing the accumulator into service with the equipment online.
- e As an alternate to the bypass fill line (d) is utilization of an inline orificed check valve that also allows placing the accumulator into service with the equipment online. However, it should be recognized that this arrangement can reduce attenuation of pressure spikes or pulsations.
- f The purchaser may specify a thermostatically electric heater.
- g A thermal relief valve protects the vessel when blocked in or if the LCV fails in the closed position.
- h The purchaser may specify a sight flow glass in the accumulator bleed return line.
- i Opening the bleed down and/or the drain valve is suitable for thermal overpressure protection when the accumulator is blocked in for maintenance.

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Figure C.19—Accumulator—Direct-contact, Manual-precharge Type

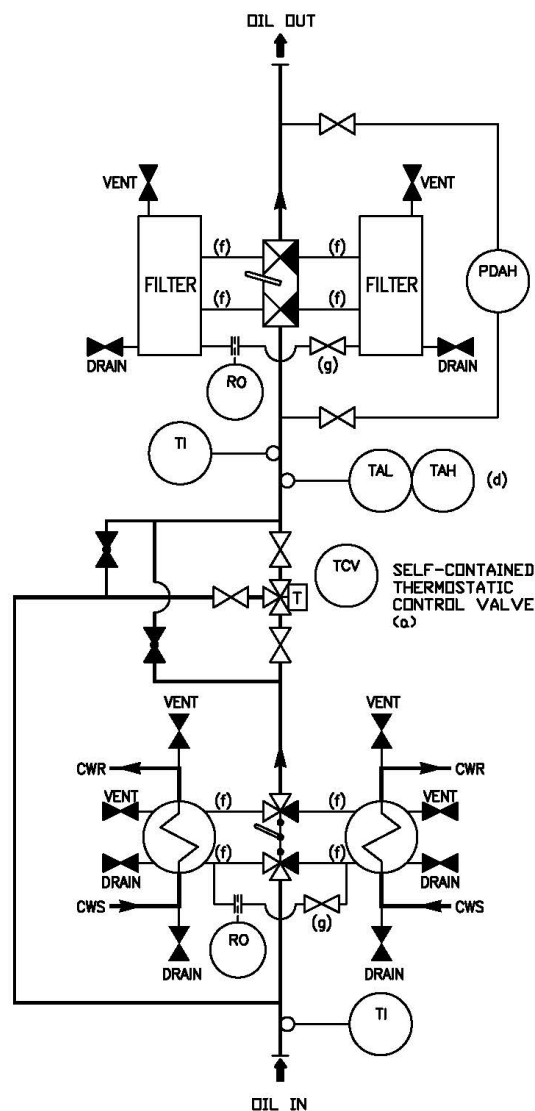


Key (for Figures C.20A through C.20D)

- ^a The purchaser may specify a constant-temperature, self-contained thermostatic valve (see Figure C.20B).
- ^b The purchaser may specify a constant-temperature, three-way control valve (see Figure C.20D).
- ^c The purchaser may specify a bypass oil line and a constant-temperature, two-way control valve (see Figure C.20C).
- ^d The purchaser may specify a high-temperature alarm (TAH) and/or a low-temperature alarm (TAL).
- ^e If the fail-closed (FC) feature of the temperature control valve is not acceptable, the purchaser may specify a valve with an FL feature.
- ^f The purchaser may specify tight shutoff requiring spectacle blinds.
- ^g The equalization/fill line between twin coolers and filters can be piped by the oil system vendor or can be integral with the transfer valve.
- ^h Figure C.20A does not have oil side temperature control. Temperature control is only possible by throttling the cooling medium (not recommended for cooling water due to accelerated water side fouling). For temperature control with heat exchangers using cooling water, option a, b, or c is recommended as shown in Figures C.20B through C.20D.

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Figure C.20A—Twin Oil Heat Exchangers and Duplex Filters with Separate, Continuous-flow Transfer Valves with No Temperature Control Valve



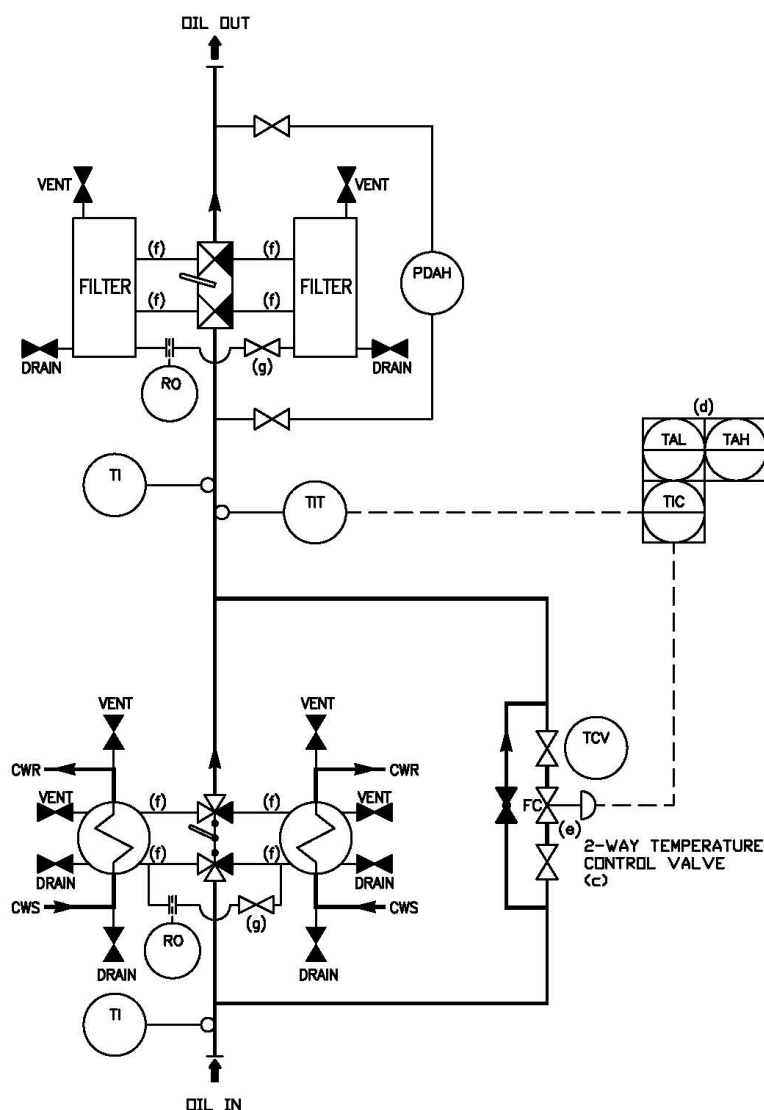
Key (for Figures C.20A through C.20D)

- a The purchaser may specify a constant-temperature, self-contained thermostatic valve (see Figure C.20B).
- b The purchaser may specify a constant-temperature, three-way control valve (see Figure C.20D).
- c The purchaser may specify a bypass oil line and a constant-temperature, two-way control valve (see Figure C.20C).
- d The purchaser may specify a high-temperature alarm (TAH) and/or a low-temperature alarm (TAL).
- e If the fail-closed (FC) feature of the temperature control valve is not acceptable, the purchaser may specify a valve with an FL feature.
- f The purchaser may specify tight shutoff requiring spectacle blinds.
- g The equalization/fill line between twin coolers and filters can be piped by the oil system vendor or can be integral with the transfer valve.
- h Figure C.20A does not have oil side temperature control. Temperature control is only possible by throttling the cooling medium (not recommended for cooling water due to accelerated water side fouling). For temperature

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control with heat exchangers using cooling water, option a, b, or c is recommended as shown in Figures C.20B through C.20D.

Figure C.20B—Twin Oil Heat Exchangers and Duplex Filters with Separate, Continuous-flow Transfer Valves with Three-way Self-contained Thermostatic Control Valve



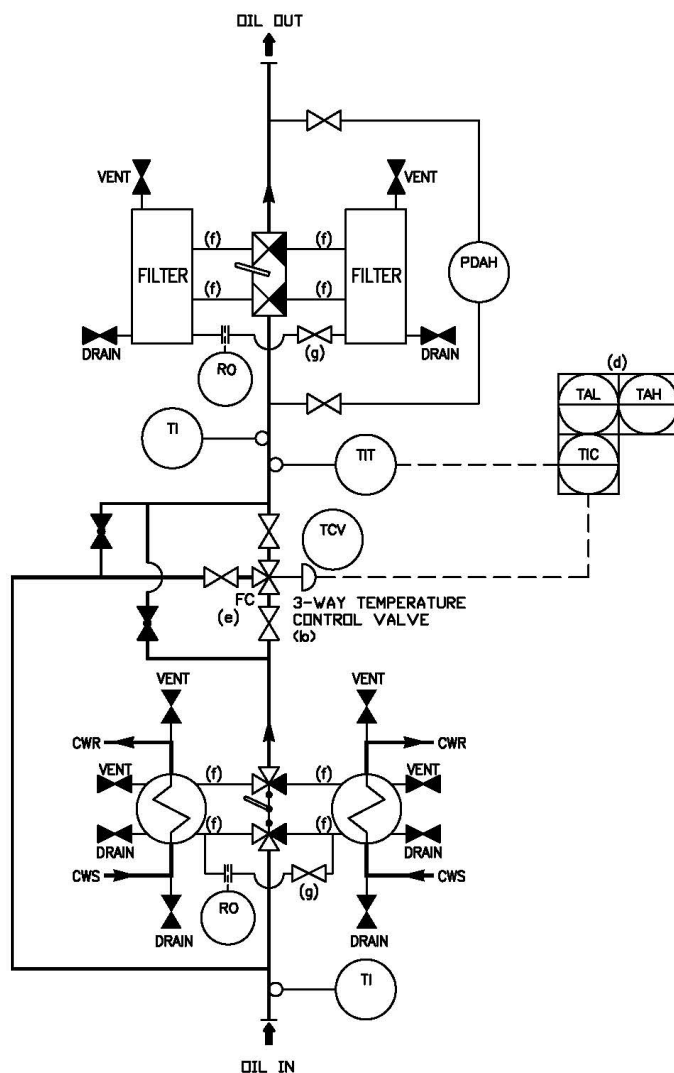
Key (for Figures C.20A through C.20D)

- a The purchaser may specify a constant-temperature, self-contained thermostatic valve (see Figure C.20B).
- b The purchaser may specify a constant-temperature, three-way control valve (see Figure C.20D).
- c The purchaser may specify a bypass oil line and a constant-temperature, two-way control valve (see Figure C.20C).
- d The purchaser may specify a high-temperature alarm (TAH) and/or a low-temperature alarm (TAL).
- e If the fail-closed (FC) feature of the temperature control valve is not acceptable, the purchaser may specify a valve with an FL feature.
- f The purchaser may specify tight shutoff requiring spectacle blinds.
- g The equalization/fill line between twin coolers and filters can be piped by the oil system vendor or can be integral with the transfer valve.

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- ^h Figure C.20A does not have oil side temperature control. Temperature control is only possible by throttling the cooling medium (not recommended for cooling water due to accelerated water side fouling). For temperature control with heat exchangers using cooling water, option a, b, or c is recommended as shown in Figures C.20B through C.20D.

Figure C.20C—Twin Oil Heat Exchangers and Duplex Filters with Separate, Continuous-flow Transfer Valves with Two-way Temperature Control Valve



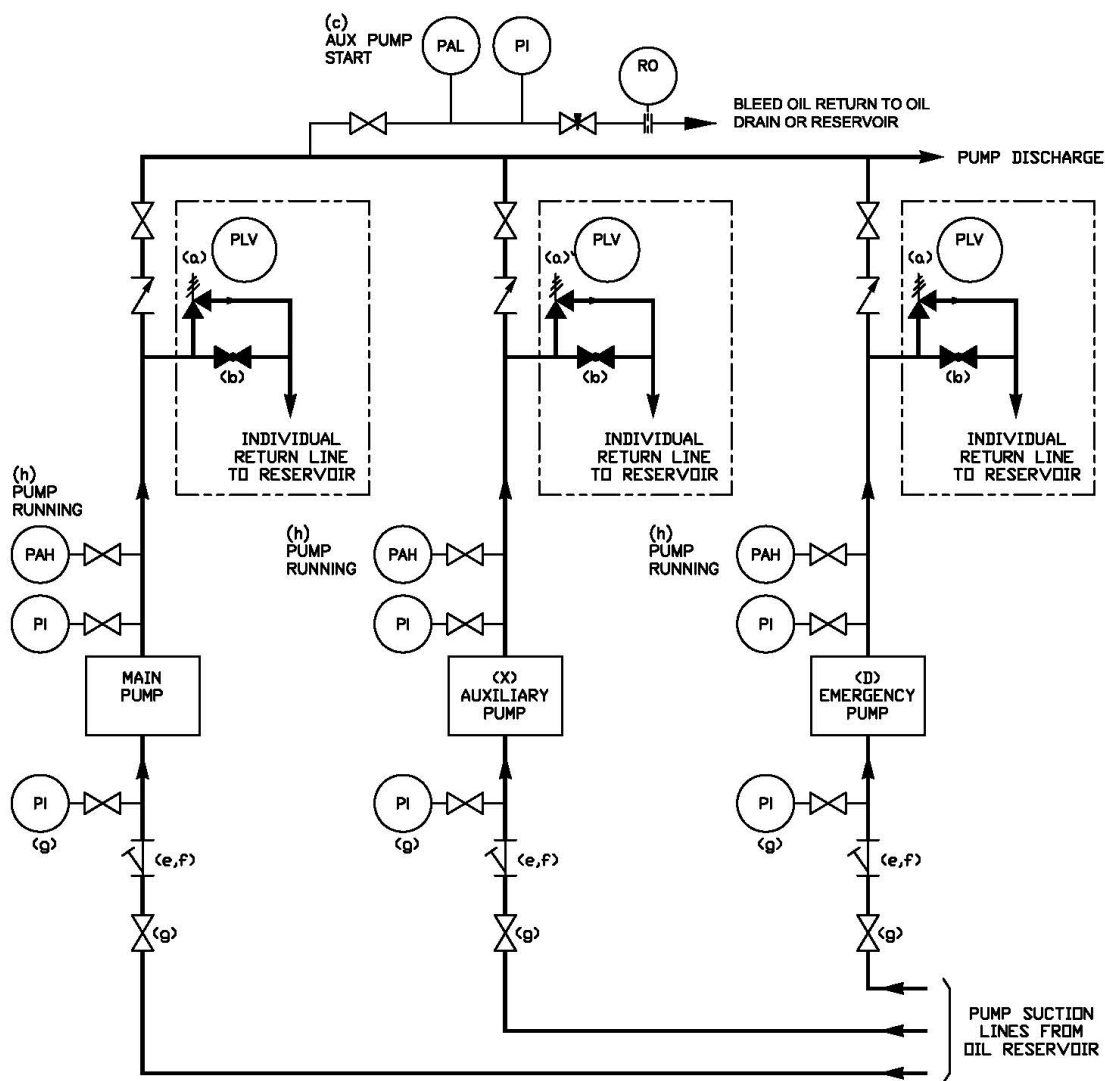
Key (for Figures C.20A through C.20D)

- a The purchaser may specify a constant-temperature, self-contained thermostatic valve (see Figure C.20B).
- b The purchaser may specify a constant-temperature, three-way control valve (see Figure C.20D).
- c The purchaser may specify a bypass oil line and a constant-temperature, two-way control valve (see Figure C.20C).
- d The purchaser may specify a high-temperature alarm (TAH) and/or a low-temperature alarm (TAL).
- e If the fail-closed (FC) feature of the temperature control valve is not acceptable, the purchaser may specify a valve with an FL feature.
- f The purchaser may specify tight shutoff requiring spectacle blinds.
- g The equalization/fill line between twin coolers and filters can be piped by the oil system vendor or can be integral with the transfer valve.

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- ^h Figure C.20A does not have oil side temperature control. Temperature control is only possible by throttling the cooling medium (not recommended for cooling water due to accelerated water side fouling). For temperature control with heat exchangers using cooling water, option a, b, or c is recommended as shown in Figures C.20B through C.20D.

Figure C.20D—Twin Oil Heat Exchangers and Duplex Filters with Separate, Continuous-flow Transfer Valves with Three-way Temperature Control Valve



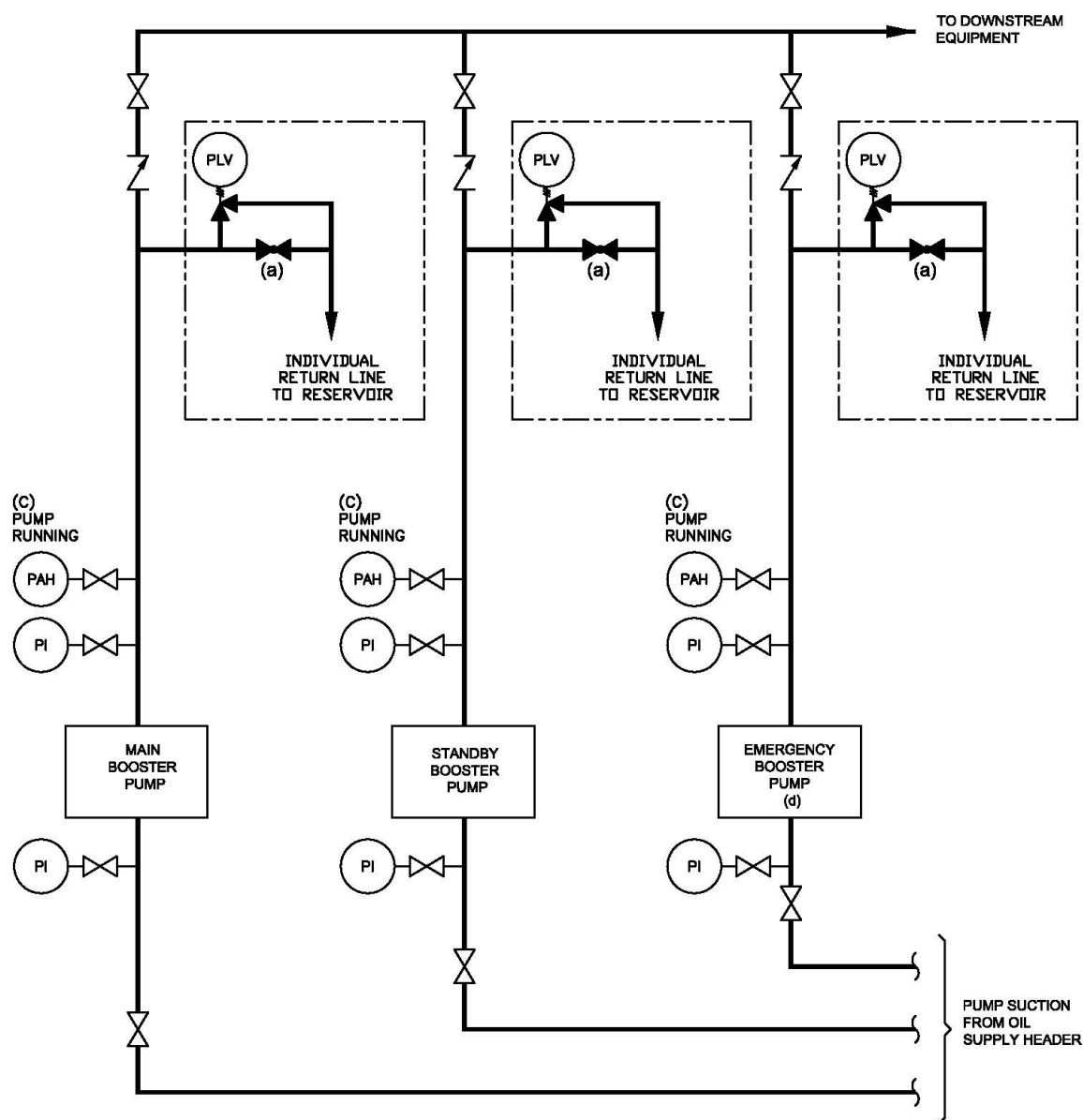
Key

- a PLVs are omitted for centrifugal pumps.
- b The purchaser may specify a bypass valve for pump discharge recirculation.
- c The purchaser may specify an "additional" pressure device to start the standby pump (see Figure C.12).
- d The purchaser may specify an emergency pump.
- e For centrifugal pumps, the line strainers are omitted and temporary screens are provided.

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- ^f A basket-type screen is used instead of a line strainer for the suction of pumps submerged in the reservoir.
- ^g These components are omitted for pumps submerged in the reservoir.
- ^h A pressure device can be used for pump running alarm. The pump running alarm can alternatively be accomplished by an auxiliary contact on the motor starter in the motor control center.
- ⁱ Alternate arrangements such as for shaft-driven pumps are not illustrated.

Figure C.21—Primary (Centrifugal or Rotary) Pump Arrangement



Key

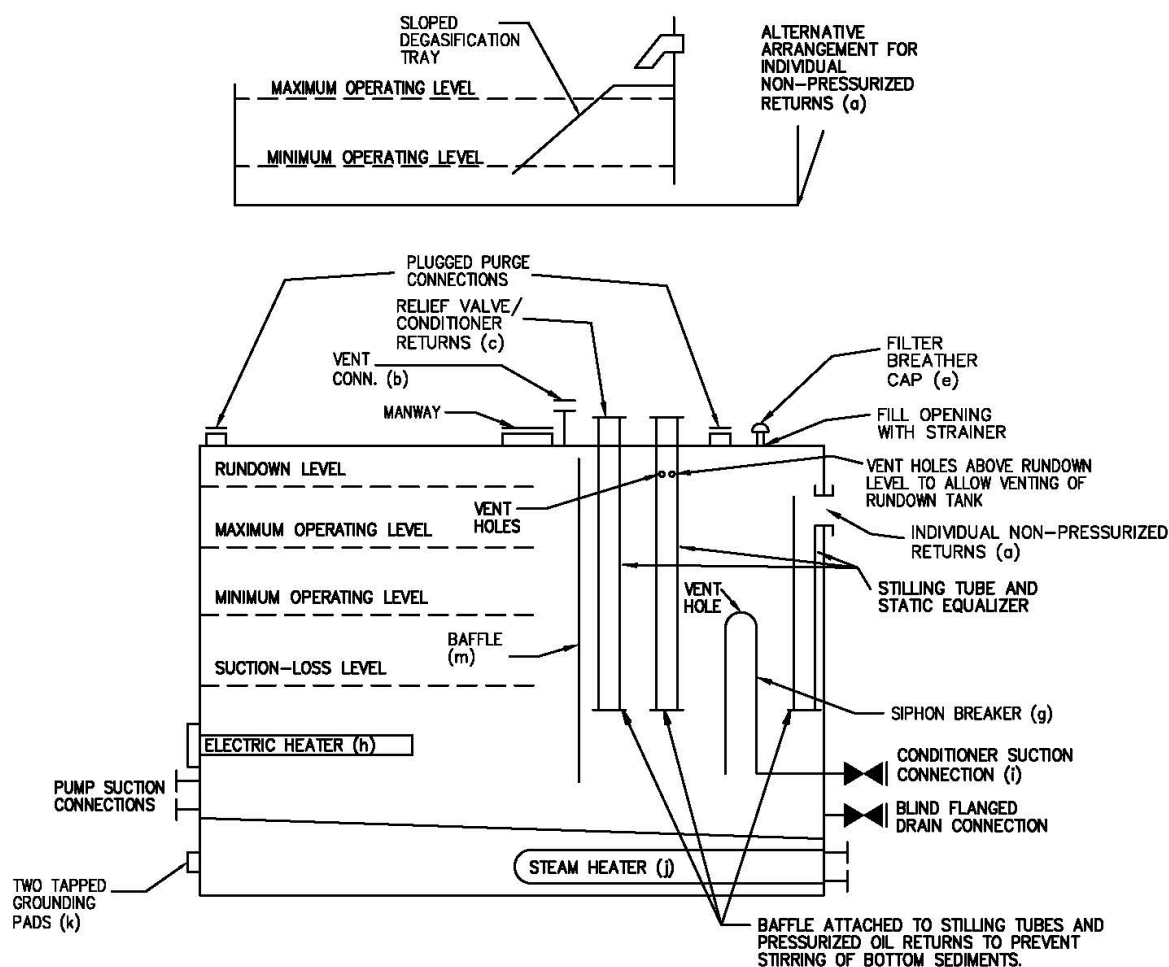
- ^a The purchaser may specify a bypass valve to start.
- ^b The purchaser may specify an alarm and/or a permissive start for the booster pumps or a low-pressure trip.

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^c The pump running alarm can alternatively be accomplished in the motor control center.

^d The purchaser may specify an emergency booster pump.

Figure C.22—Booster (Rotary) Pump Arrangement



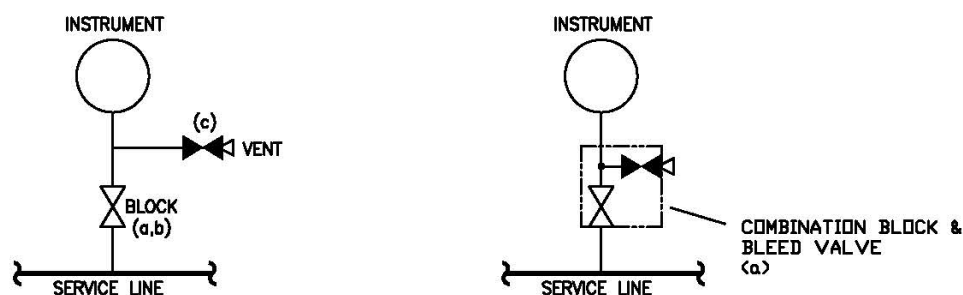
Key

- ^a For nonpressurized gravity oil return lines and fill openings, a stilling tube or sloped degasification tray arranged to prevent splashing and provide free release of foam and gas is required for every return inlet and spare connection.
- ^b A flanged connection is provided for venting the reservoir. For seal-oil reservoirs, this vent is piped to a safe location by the purchaser.
- ^c The purchaser may specify a particular oil conditioner and other pressurized oil returns in addition to the spare top connection.
- ^d Purge and vent connections enter the top of the reservoir. No extension tubes or seals are permitted.
- ^e A filter-breather cap is not permitted on a reservoir containing seal oil.
- ^f

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- g The purchaser may specify a siphon breaker when an oil conditioner suction connection is specified.
- h The purchaser may specify an electric heater.
- i The purchaser may specify an oil conditioner suction connection.
- j The purchaser may specify a steam heater.
- k When specified, two tapped grounding pads positioned diagonally to each other are provided.
- l Individual oil returns are located away from the pump suction and arranged to provide the maximum residence time.
- m Internal baffle to be non-gas tight.

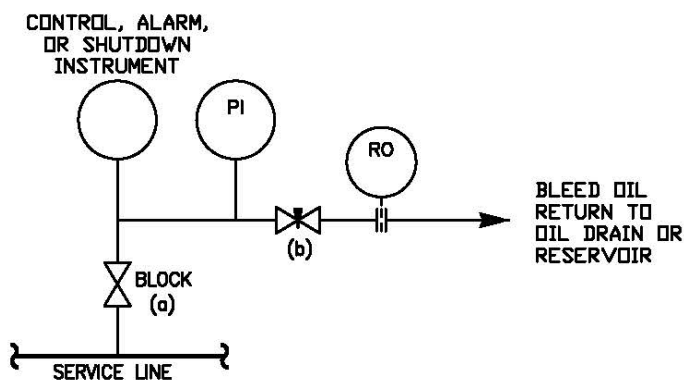
Figure C.23—Oil Reservoir



Key

- a If approved by the purchaser, a combination block and bleed gauge valve may be substituted for individual block and vent/bleed valves, except as specified in footnote b.
- b Block, isolation, and vent-bleed valves can be omitted for all instruments in trip service with owner's approval.
- c For services of less than or equal to 0.3 bar (5 psig), bleed valves may be omitted, except for arrangements shown in Figure C.25 or when footnote b applies.

Figure C.24—Local Instrument Piping Details—Pressure Gauges, Switches, and Transmitters

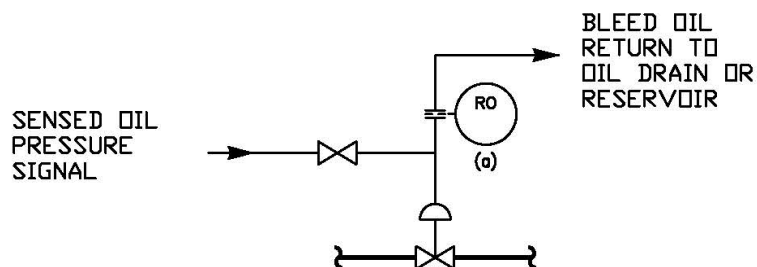


Key

- a The block valve may be locked or car-sealed open.
- b The vent flow-restriction orifice arrangement is for oil service to permit air purging and helps to maintain warm line temperature to minimize cold oil viscosity dampening effects.

Figure C.25—Local Instrument Piping Details—Combined Instrument System for Low-pressure Alarms, Pump-start and Low-pressure Shutdown Devices

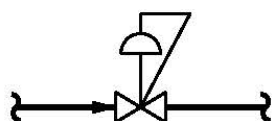
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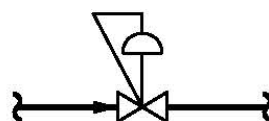
Key

- ^a The vent flow-restriction orifice arrangement is for oil service to permit air purging and helps to maintain warm line temperature to minimize cold oil viscosity dampening effects.

Figure C.26A—Oil Direct Diaphragm Actuators with External Sensing Lines



**PRESSURE REGULATOR
(SELF CONTAINED)**

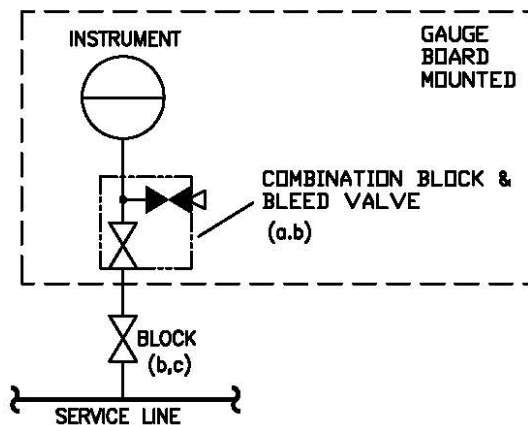
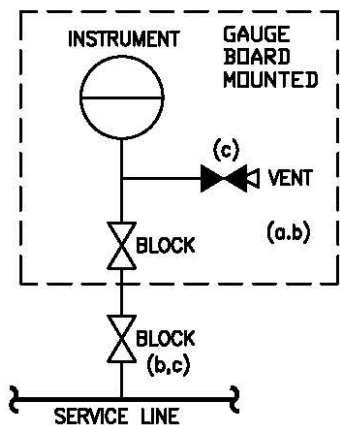


**BACK PRESSURE RELIEF
REGULATOR (SELF CONTAINED)**

Key

- ^a The actuators of self-contained regulators sense pressure via internal valve porting. External pressure-sensing lines are not used for this type of regulating valves.

Figure C.26B—Self-contained Regulators without External Sensing Lines

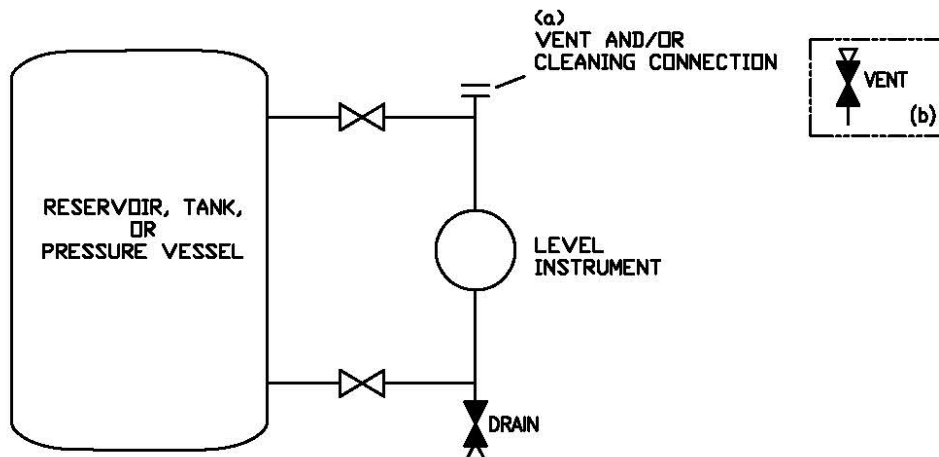


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Key

- ^a Combination isolation/bleed valve may be used.
- ^b Block, isolation, and vent-bleed valves can be omitted for all instruments in trip service with owner's approval.
- ^c For services of less than or equal to 0.3 bar (5 psig), bleed valves may be omitted, except for arrangements shown in Figure C.25 or when footnote b applies.

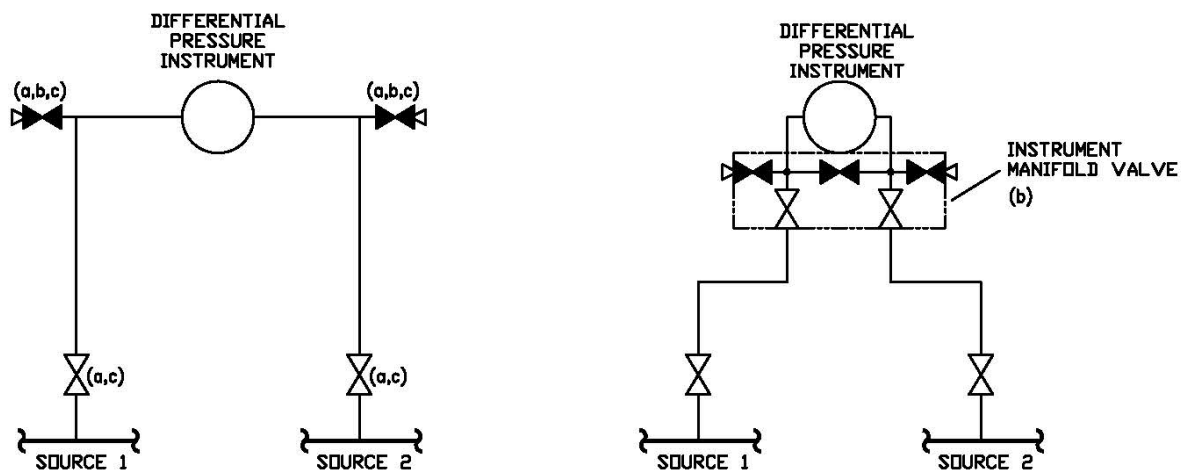
Figure C.27—Remote Instrument Piping Details—Panel- and Board-mounted Gauges, Switches, and Transmitters



Key

- ^a This connection may be added to facilitate venting and cleaning of the level instrument.
- ^b The vent connection is normally valved for pressurized tanks or vessels.

Figure C.28—Instrument Piping Details—Externally Flange Connected Level Instruments

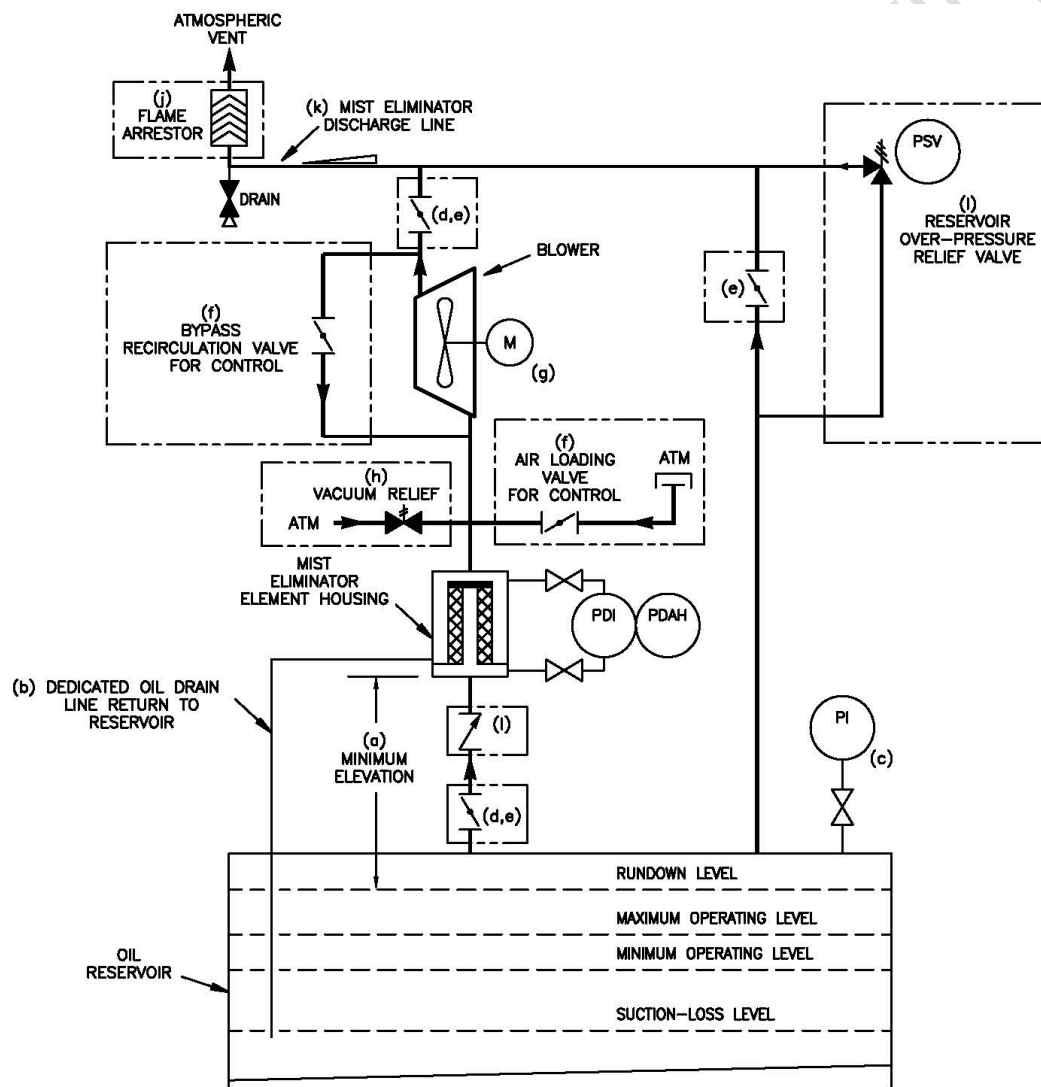


Key

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- ^a Block valves for instruments in trip service to be locked or car-seal open if specified.
- ^b The purchaser may specify instrument manifold valves to facilitate calibration and testing of differential instruments.
- ^c For services of less than or equal to 0.3 bar, effective (5 psig), bleed valves may be omitted, except for arrangements shown in Figure C.25 or when footnote a applies.

Figure C.29—Local Instrument Piping Details—Differential Instruments, Diaphragm Actuators, Indicators, Switches, and Transmitters



Key

- ^a The minimum elevation (geodetic height) above reservoir rundown oil level must be greater than the corresponding head height at the maximum element operating differential pressure.
- ^b The dedicated oil drain line can utilize a nonvented stilling tube that extends below the reservoir suction loss oil level or an inline liquid trap.
- ^c The pressure monitor instrument may be located on the equipment oil drain header instead or in addition to on the reservoir.

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- ^d The purchaser may specify isolation and/or bypass valves for mist eliminator maintenance.
- ^e Isolation valves can also be throttling type valves that can be used for vacuum/capacity control.
- ^f A blower recirculation throttle valve and/or air inlet loading valve can be used for vacuum/capacity control.
- ^g Variable speed drives such as an AFD for a motor-driven blower can be used for vacuum/capacity control.
- ^h The purchaser may specify a mist eliminator vacuum relief device.
- ⁱ The purchaser may specify a reservoir overprotection relief valve.
- ^j The purchaser may specify a vent flame arrestor.
- ^k A sloped mist eliminator discharge line configuration avoids condensate or precipitation run back into the mist eliminator.
- ^l If multiple powered oil mist eliminators are installed, check valves in each mist eliminator inlet prevent backflow through offline or standby demistors.

Figure C.30—Blower Extraction Type Oil Mist Eliminator

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Annex D

(informative)

Contract Documents and Engineering Design Data

D.1 General

D.1.1 When specified by the purchaser in 10.1.2, the contract documents and engineering design data shall be supplied by the vendor.

D.1.2 The following data shall be identified with the following information on transmittal (cover) letters, title pages, and correspondence:

- a) purchaser's/owner's corporate name;
- b) job/project number;
- c) equipment item number and service name;
- d) inquiry or purchase order number;
- e) any other identification specified in the inquiry or purchase order;
- f) vendor's identifying proposal number, shop order number, serial number, or other reference required to completely identify return correspondence.

D.1.3 Each drawing shall have a title block in the lower right-hand corner with the date of certification, identification data specified in D.1.2, revision number, and date and title.

D.1.4 Similar information shall be provided on all other documents including subvendor items.

D.2 Proposals

D.2.1 General

D.2.1.1 The vendor shall forward the original proposal, with the specified number of copies, to the addressee specified in the inquiry documents.

D.2.1.2 The proposal shall include, as a minimum, the data specified in D.2.2 through D.2.5, and a specific statement that the equipment and all its components and auxiliaries are in strict accordance with this standard as stated in 10.3.1.1.1.

D.2.1.3 If the equipment or any of its components or auxiliaries are not in strict accordance, the vendor shall include a list that details and explains each deviation as stated in 10.3.1.1.2.

D.2.1.4 The vendor shall provide sufficient detail to enable the purchaser to evaluate any proposed alternative designs.

D.2.1.5 All correspondence shall be clearly identified in accordance with D.1.3.

D.2.2 Drawings

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D.2.2.1 The drawings indicated on the VDDR form in this annex shall be included in the proposal.

D.2.2.2 As a minimum, the following shall be included:

- a) a general arrangement or outline drawing for each machine train or skid-mounted package, showing overall dimensions, maintenance clearance dimensions, overall weights, erection weights, and the largest maintenance weight for each item; the direction of rotation and the size and location of major purchaser connections shall also be indicated;
- b) cross-sectional drawings showing the details of the proposed equipment;
- c) schematics of all auxiliary systems including fuel, lube-oil, control, and electrical systems;
- d) bills of material;
- e) sketches that show methods of lifting the assembled machine or machines, packages, and major components and auxiliaries. [This information may be included on the drawings specified in item a) above.]

D.2.2.3 If “typical” drawings, schematics, and bills of material are used, they shall be marked up to show the weight and dimension data to reflect the actual equipment and scope proposed.

D.2.3 Technical Data for Proposal

D.2.3.1 All technical data shall be given in units of measurement according to the purchase order. If needed, the technical data in alternate units can be included in parentheses.

D.2.3.2 The following data shall be included in the proposal:

- a) purchaser's data sheets with complete vendor's information entered thereon and literature to fully describe details of the offering;
- b) predicted noise data [10.3.2.3.1 b)];
- c) VDDR form (or equivalent listing) indicating the schedule according to which the vendor agrees to transmit all the data specified;
- d) schedule for shipment of the equipment, in weeks after receipt of an order;
- e) list of major wearing components, showing any interchangeability with the owner's existing machines;
- f) list of spare parts recommended for start-up and normal maintenance purposes;
- g) list of the special tools furnished for maintenance;
- h) description of any special weather protection and winterization required for start-up, operation, and periods of idleness, under the site conditions specified on the data sheets; this description is to indicate the protection to be furnished by the purchaser as well as that included in the vendor's scope of supply;
- i) complete tabulation of utility requirements, e.g. steam, water, electricity, air, gas, lube oil (including the quantity and supply pressure of the oil required, and the heat load to be removed by the oil), and the nameplate power rating and operating power requirements of auxiliary drivers; approximate data is to be clearly indicated as such;
- j) description of any optional or additional tests and inspection procedures for materials as required by 10.3.2.3.4;
- k) description of any special requirements specified in the purchaser's inquiry;
- l) a list of machines, similar to the proposed machine(s), that have been installed and operating under conditions analogous to those specified in the inquiry;
- m) any start-up, shutdown, or operating restrictions required to protect the integrity of the equipment;

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- n) a list of any components that can be construed as being of alternative design, hence requiring purchaser's acceptance (see 6.1.3);
- o) component designed for a finite life (see 6.1.4).

D.2.4 Curves

The vendor shall provide complete oil pump performance curves to encompass the map of operations, with any limitations indicated thereon.

D.2.5 Optional Tests

The vendor shall furnish an outline of the procedures to be used for each of the special or optional tests that have been specified by the purchaser or proposed by the vendor.

D.3 Engineering Design Data

D.3.1 General

D.3.1.1 Engineering data shall be furnished by the vendor in accordance with the agreed VDDR form.

NOTE Typical VDDR form can be modified by the purchaser to match the specific inquiry requirements.

D.3.1.2 The purchaser shall review the vendor's data upon receipt;

D.3.1.2.1 However, this review shall not constitute permission to deviate from any requirements in the order unless specifically agreed in writing.

D.3.1.2.2 After the data have been reviewed and accepted, the vendor shall furnish certified copies in the quantities specified.

D.3.1.3 A complete list of vendor data shall be included with the first issue of major drawings.

D.3.1.4 This list shall contain titles, drawing numbers, and a schedule for transmittal of each item listed.

D.3.1.5 This list shall cross-reference data with respect to the VDDR form.

D.3.2 Drawings and Technical Data

D.3.2.1 The drawings and data furnished by the vendor shall contain sufficient information so that together with the manuals specified in D.3.5, the purchaser can properly install, operate, and maintain the equipment covered by the purchase order.

D.3.2.2 All contract drawings and data shall be clearly legible (8-point minimum font size even if reduced from a larger size drawing),

D.3.2.3 The drawings shall cover the scope of the agreed VDDR form, and shall satisfy the applicable detailed descriptions in this annex.

D.3.3 Progress Reports

The vendor shall submit progress reports to the purchaser at intervals specified that shall, as a minimum, include the following:

- a) overall progress summary;
- b) status of engineering;
- c) status of document submittals;
- d) status of major suborders;

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- e) updated production schedule;
- f) inspection/testing highlights for the month;
- g) any pending issues.

D.3.4 Parts Lists and Recommended Spares

D.3.4.1 The vendor shall submit complete parts lists for all equipment and accessories supplied.

D.3.4.1.1 These lists shall include part names, manufacturers' unique part numbers, and materials of construction (identified by applicable international standards).

D.3.4.1.2 Each part shall be completely identified and shown on appropriate cross-sectional, assembly-type cutaway, or exploded-view isometric drawings.

D.3.4.1.3 Interchangeable parts shall be identified as such.

D.3.4.1.4 Parts that have been modified from standard dimensions or finish to satisfy specific performance requirements shall be uniquely identified by part number.

D.3.4.1.5 Standard purchased items shall be identified by the original manufacturer's name and part number.

D.3.4.2 The vendor shall indicate on each of these complete parts lists all those parts that are recommended as start-up or maintenance spares, and the recommended stocking quantities of each.

D.3.4.3 These shall include spare parts recommendations of subvendors that were not available for inclusion in the vendor's original proposal.

D.3.5 Installation, Operation, Maintenance, and Technical Data Manuals

D.3.5.1 General

The vendor shall provide sufficient written instructions and all necessary drawings to enable the purchaser to install, operate, and maintain all of the equipment covered by the purchase order.

D.3.5.1.2 This information shall be compiled in a manual or manuals with a cover sheet showing the information listed in D.1.2, an index sheet, and a complete list of the enclosed drawings by title and drawing number.

D.3.5.1.3 The manual pages and drawings shall be numbered.

D.3.5.1.4 The manual or manuals shall be prepared specifically for the equipment covered by the purchase order. "Typical" manuals are unacceptable.

D.3.5.1.5 A draft manual(s) shall be issued to purchaser 8 weeks prior to mechanical testing for review and comment.

D.3.5.1.6 Refer to the VDDR form for number of copies. Hard copies as well as electronic copies shall be provided as described on VDDR.

D.3.5.2 Installation Manual

D.3.5.2.1 All information required for the proper installation of the equipment shall be compiled in a manual including, as a minimum, information on:

- alignment;

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- grouting procedures;
- normal and maximum utility requirements;
- centers of mass;
- rigging provisions and procedures;
- all other installation data;

D.3.5.2.2 The manual shall be issued no later than the time of issue of final certified drawings. For this reason, it may be separate from the operating and maintenance instructions.

D.3.5.2.3 All drawings and data specified in D.2.2 and D.2.3 that are pertinent to proper installation shall be included as part of this manual.

D.3.5.2.4 One extra manual, over and above the specified quantity, shall be included with the first equipment shipped.

D.3.5.2.5 All recommended receiving and storage procedures shall be included.

D.3.5.3 Operating and Maintenance Manual

A manual shall be supplied at shipment containing, as a minimum:

- all required operating and maintenance instructions;
- covering operation at all specified process conditions,
- separate sections covering operation under any specified extreme environmental conditions.

D.3.5.4 Technical Data Manual

The vendor shall provide the purchaser with a technical data manual at shipment.

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Table D.1—VDDR for Oil Systems (see text for details of the description)

Vendor Drawing and Data Requirements for Oil-system Applications	Job No.	Item No.
	Purchase order No.	Date
	Requisition No.	Date
	Inquiry No.	Date
	Revision by	Console manufacturer
	For	Unit
	Site	Service ^e

Minimum requirements ^d Proposal ^a — Bidder shall furnish number of paper copies/number of electronic copies of data as indicated. Review — Vendor shall furnish number of paper copies/number of electronic copies of data as indicated. Final — Vendor shall furnish number of paper copies/number of electronic copies of data as indicated.					Distribution Record				
				Description (see following text)	Review due from vendor ^{b, c}	Review received from vendor	Review returned to vendor	Final due from vendor ^c	Final received from vendor
Req'd	/	/	/	a) Certified dimensional outline drawing and list of connection					
	/	/	/	b) Component drawings and bills of materials					
	/	/	/	c) System schematic and bill of materials, including component sizing criteria					
	/	/	/	d) Component data sheets					
Req'd	/	/	/	e) Electrical and instrumentation wiring diagram and bill of materials					
	/	/	/	f) Electrical and instrumentation terminal box layout and list of connections					
	/	/	/	g) Console test procedure					
	/	/	/	h) Weld procedures					
	/	/	/	i) Hydrostatic test logs					
	/	/	/	j) Operational test logs					
	/	/	/	k) As-built data sheets					
Req'd	/	/	/	l) Installation, operating, and maintenance manuals					
	/	/	/	m) Progress reports					
	/	/	/	n) Spare parts recommendation and price list					
	/	/	/	o) Pressure vessel certification data					

^a Proposal drawings and data do not have to be certified. Typical data shall be clearly identified as such.

^b Purchaser may indicate in the column the desired time frame for submission of data.

^c Bidder shall complete these two columns to reflect the actual distribution schedule and include this form with the proposal.

^d "Req'd" signifies minimum drawing and data requirements required by this standard; purchaser may indicate additional requirements.

^e Service may be lube oil (LO), seal oil (SO), or combined lube and seal oil (CLSO).

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Details of each numbered item of the description list given in Table D.1 are as follows:

- a) certified dimensional outline drawing and list of connections for oil system, including the following:
 - size, rating, and location of all customer connections;
 - approximate overall handling mass;
 - overall dimensions, maintenance clearances, and dismantling clearances;
 - dimensions of baseplates from a fixed control point complete with diameter, number, and locations of bolt holes; thickness of the metal through which it is necessary that the bolts pass and recommended clearance; centers of gravity; and details for foundation design;
- b) component drawings and bills of materials for oil system, including the following:
 - filter outline drawings;
 - heat exchanger outline drawings;
 - rundown tank and/or overhead seal tank outline drawings;
 - instrumentation cut sheets with dimensions;
 - oil-pump outline drawings;
 - oil-pump coupling drawings;
- c) system schematic, bill of materials, and instrument list, including component-sizing criteria for oil system, which includes the following:
 - steady-state and transient flows and pressures at each use point;
 - control, alarm, and trip settings (pressures, temperatures, and flows, as applicable);
 - supply temperatures and heat loads at each point at maximum load;
 - utility requirements, including electricity, steam, water, and air;
 - pipe and valve sizes;
 - instrumentation, safety devices, and control schemes;
- d) individual component data sheets, as applicable, on the following:
 - pump data sheets;
 - filter data sheets;
 - heat exchanger data sheets;
- e) electrical and instrumentation wiring diagram and bill of materials;

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- f) electrical and instrumentation arrangement drawings, including terminal box layout and list of connections;
- g) console test procedures, including any special or optional tests to be performed;
- h) welding procedures for fabrication and repair;
- i) certified hydrostatic test logs;
- j) operational test logs;
- k) as-built data sheets;
- l) installation, operating, and maintenance manuals describing the following:
 - start-up;
 - normal shutdown;
 - recommended emergency shutdowns and required trips;
 - operating limits [see item d)];
 - oil recommendations and specifications;
 - routine operational procedures;
 - instructions for maintenance of purchased mechanical components, such as pump, pump seals;
 - performance data, including flows, pressures, temperatures, and heat loads;
 - as-built data, including data sheets [see item k)] and test logs;
- m) progress reports that include, as a minimum, the following:
 - 1) delivery schedule, including vendor buyouts and milestones;
 - 2) engineering, purchasing, manufacturing, and testing schedules for all major components;
 - 3) planned and actual dates and the percentage completed planned for each milestone in the schedule;
- n) spare parts list with stocking level recommendations;
- o) pressure vessel certification data, including pressure vessel calculations, hydro test reports and material mill test reports for filters, heat exchangers, and rundown tanks in the system.

Annex E

(informative)

Oil Filter Performance and Oil-system Cleanliness Testing

E.1 General Considerations

This annex is intended to provide users of API 614 with information relative to oil filter performance and oil-system cleanliness testing.

E.2 Filter Specifications

E.2.1 General Characteristics

The primary requirement of filtration is to reliably remove contaminants of a different phase from a liquid stream. API 614 describes filters necessary to remove from the oil particles that can be detrimental to machine bearings, gears, or oil seals over an extended operating period. API 614 also describes filters that are intended to remove sufficient solid particles from lubricating oil to provide an economical measure of protection for general-purpose equipment bearings and gears.

E.2.2 Filter Element Reliability

The filters shall be reliable, not fail or plug off during normal operation of the system, and be able to retain contaminants during extreme upsets and even pulsating flow. For this reason, it is necessary that filter elements for API 614 systems be able to withstand high differentials without collapse or release of trapped particles.

E.2.3 Water Contamination

filters are to be water resistant up to a water content of 5 % at elevated temperatures to further ensure filter element integrity. Water contamination of the oil can initiate the deterioration of some elements due to the incompatibility of the filter media with water at operating temperatures.

Elements can also absorb water and experience high differential pressures caused by the swelling of the filter medium. nonhygroscopic media filters are designed such that, over an extended exposure period, the pressure drop does not exceed twice the clean, new element pressure drop value. Users of oil systems for which water contamination can be a problem should consider nonhygroscopic filters. The user should keep in mind that water contamination should not persist on a routine basis. If water contamination is experienced, the source of the water should be determined and corrected. If correction is not feasible, a separate water-removal system or a slip stream filter/coalescer or vacuum dehydrator should be considered to keep the water contamination under control. Water contamination can be a problem for an oil system serving a steam turbine. Other systems commonly exposed to water contamination include the following:

- a) oil systems where makeup oil is provided from bulk storage or storage drums that are inadequately protected;
- b) oil systems where the water pressure in the heat exchanger(s) can exceed the oil pressure;
- c) oil systems located at humid sites, especially if the equipment served is in intermittent service and can also experience problems with water contamination.

E.2.4 Beta Ratio

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Of primary importance in the selection of filters for API 614 systems is the filter element micron size rating. In earlier standards, the requirement was 10 μm *nominal* rating. In a clarification note (see the third edition of API 614), *nominal* was implied to be 90 % efficient for 10 μm spherical particles and *absolute* was presumed for 15 μm particles for a 10 μm *nominal* rated element. The words “nominal” and “absolute” are not applied uniformly by vendors and there can be significant performance differences from one filter to another with 10 μm *nominal* filters.

It is more precise to rate filter elements by the beta ratio of the element for a given size particle and larger. The beta ratio expressed as $\beta_x \geq y$, where x is the filter element rating, expressed in micrometers (μm), and y is the ratio of particles x μm equal to or larger entering a filter; divided by the number of particles x μm equal to or larger exiting a filter.

EXAMPLE 1 Display a beta ratio of equal to or greater than 10 for a 10 μm rated filter: $x = 10$ μm ; $y \geq 10$.

$$\beta_{10} \geq 10$$

EXAMPLE 2 Display a beta ratio of equal to or greater than 200 for a 25 μm rated filter: $x = 25$ μm ; $y \geq 200$.

$$\beta_{25} \geq 200$$

In order to determine the particle-removal efficiency, E_{PR} , expressed in percent, for a filter with a known beta ratio, use Equation (E.1):

$$E_{PR} = [1 - (1/y)] \times 100 \quad (\text{E.1})$$

For EXAMPLE 1, where $\beta_{10} \geq 10$ and $y \geq 10$ for particles 10 μm and larger, the minimum E_{PR} is calculated as:

$$E_{PR}(10 \mu\text{m}) = [1 - (1/10)] \times 100$$

$$E_{PR}(10 \mu\text{m}) = 90 \%$$

For EXAMPLE 2, where $\beta_{25} \geq 200$ and $y \geq 200$ for particles 25 μm and larger, the minimum E_{PR} is calculated as:

$$E_{PR}(25 \mu\text{m}) = [1 - (1/200)] \times 100$$

$$E_{PR}(25 \mu\text{m}) = 99.5 \%$$

For every type of filter element, a curve of the beta ratio plotted against the micron size can usually be provided by the filter supplier. The position and shape of this curve is significantly affected by the features of the filter media. Some filter media can have a very wide band of performance and others can have a narrow band. An example of a filter made with media, A, with a wide performance band can have a series of ratios $\beta_2 \geq 2$; $\beta_{10} \geq 10$; $\beta_{15} \geq 200$; and $\beta_{25} \geq 1000$. Another filter element made with media, B, with a narrower band can have a series of ratios $\beta_5 \geq 2$; $\beta_{10} \geq 10$; and $\beta_{15} \geq 1000$.

In both examples A and B, the filter element is acceptable. The main issue is that the manufacturer of both A and B may give a different nominal rating. It is not until the beta ratio for a given micron size is greater than or equal to the specified beta ratio that the filter is acceptable.

There are many factors in determining the performance of a filter on a range of particles. Factors such as flow, differential pressure, particle size distribution, particle shape, fluid viscosity, degree and rate of loading can result in different beta ratios for the same type of filter element. There is a widely used standard hydraulic filter test that is relatively similar to the conditions encountered in API 614 lube and seal systems. For the purpose of API 614, ISO 16889 or equal, multi-pass-method type testing is required for assessing the filter rating. A more detailed description of ISO 16889 testing is outlined in E.3.2. Filter vendors who supply type-tested elements have and can make available the test data for the elements being considered by API 614.

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E.2.5 Relative Size of Particles

In order to provide protection for equipment, it is necessary that the filter be able to remove particles that are in the range of the operating clearance of the component. For some insight into film thickness and particle sizes, see Tables E.1 and E.2. For the majority of systems covered by API 614, the filter ratings provide sufficient removal of the particles of concern as well as a reasonable installed life.

Based on the data presented in Tables E.1 and E.2, it can be tempting to use a finer filtration specification, but this can be inappropriate in many cases. Overspecification of the filter requirements can result in costly filter systems and frequent and expensive element changes.

Users of API 614 filter specifications should be aware that filters also remove particles smaller than the rated size. The filtration efficiency, E_{PR} , or beta ratio, for 1 μm particles for a 10 μm rated filter will be lower, which means that fewer number of these particles are captured by the filter element. It only takes many passes through the filter before the levels reach an equilibrium state where the filter removes the same number as ingress into the system. How small a particle below the rated size that be captured effectively is a function of the filter media construction. There are some exceptions where fine filtration can be necessary. These include, but are not limited to, control-oil systems with electrical-hydraulic pilot valves that have very close internal clearances and the oil-supply systems for high-speed gear-type couplings. In these applications, it can be appropriate to install separate duplex filter(s) in the branch stream(s) just ahead of the sensitive component(s). The E_{PR} for these filters should be mutually agreed based on the requirements of the component.

Table E.1—Relative Size Comparison of Particles of Some Common Materials

Particle Size μm (mils)	Comparison
159 (6.26)	100-mesh screen opening
100 (3.94)	Table salt
74 (2.91)	200-mesh screen opening
60 (2.36)	Pollen
40 (1.58)	Lower limit of human vision
2 (0.08)	Bacteria

Table E.2—Typical Dynamic Film Thickness for Equipment

Component	Thickness μm (mils)
Roller bearings	0.4 to 1.0 (0.016 to 0.039)
Ball bearings	0.1 to 0.7 (0.004 to 0.028)
Journal bearings	0.5 to 25 (0.020 to 1.0)
Gears	0.1 to 1.0 (0.004 to 0.039)
Seals	0.05 to 0.5 (0.002 to 0.020)
Servo valves: — orifice	130 to 450 (5.1 to 17.7)
— flapper to wall	18 to 63 (0.71 to 2.48)
— spool to sleeve	1 to 4 (0.039 to 0.158)
Hydraulic actuators	25 to 250 (1.0 to 9.9)

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E.2.6 Filter Dirt-holding Capacity

In most systems covered by API 614, the ingress of contamination is not significant after the system is initially flushed. In general, filters that have sufficient flow capability to meet the requirements of 6.9.1.1 have an acceptable service life. The service life of filter elements in a system after flushing should be more than 6 months unless there is some problem external to the filters that is causing a significant degree of contamination.

E.3 Standards

E.3.1 General

A brief description of applicable filtration standards is outlined in E.3.2 to E.3.3 to provide the users of this part of API 614 with some background on the basis for use of these standards. For more information, the actual standard should be reviewed.

E.3.2 ISO 16889

ISO 16889 specifies a rigorous method of type testing of filter elements in a recirculating loop with the injection of a standard test dust into the upstream side of the loop. Reporting of the results of the tests is in a standard format and the beta ratio for each of several micron sizes is averaged over the range from clean to maximum element differential pressure. This averaging is done over ten equal time increments. Typically, test data are taken for minimum of five particle-size ranges. The test standard recommends particle counting in sizes ranging from 4 to 30 $\mu\text{m(c)}$ and at flow rates in the test loop from 4 l/min to 600 l/min (1 gal/min to 160 gal/min). In addition to the filter-element average beta rating for five or more particle sizes, a contaminant loading capability for a filter element is established.

The following items are controlled during the test of a filter to ensure consistent results.

- a) The type of oil that meets a given specification. The temperature of the test fluid is controlled within a specific range.
- b) The test contaminant is restricted to a known particle size distribution and is standardized (ISO medium test dust).
- c) An automatic particle counter is used and calibrated to a standard.
- d) The automatic particle counter is used online and is validated to be correct in the system by means of a validation procedure.
- e) A system volume-to-flow ratio is established.
- f) Testing condition variations are limited to flow, upstream contamination level on a mass basis, viscosity, temperature, and system volume.
- g) Instrument accuracy is established for the test circuit.
- h) The injection system is validated to ensure constant rates of contaminant injection.

The ISO 16889 test procedure provides a reproducible method for evaluating the performance of filter elements for use in lube-oil, control-oil, and seal-oil systems. Filters used in API 614 should be type-tested in accordance with the ISO 16889 or equivalent procedure. The ISO 16889 test terminal differential pressure should also be within the range of the expected operational differential pressure, since the removal efficiency performance of the filter is differential pressure dependent.

ISO 4406 provides a means of defining the quantity of solid particle contaminants in lube and hydraulic fluids. The "Cleanliness Code" is comprised of three scale numbers separated by slash, "/", which are based on the number of particles greater than or equal to 4 $\mu\text{m(c)}$, 6 $\mu\text{m(c)}$, and 14 $\mu\text{m(c)}$ per milliliter of fluid. The number for the smallest size range ($\geq 4 \mu\text{m}$) is presented first, followed by the next larger size ($\geq 6 \mu\text{m}$) and then the next larger size ($\geq 14 \mu\text{m}$). Table E.3 shows the range of the particle counts and the corresponding scale numbers. The suffix "c" next to the micron size indicates that automatic particle counter used to

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generate the particle counts was calibrated in accordance with ISO 11171. If microscope is used for the counting, only the $\geq 5 \mu\text{m}$ and $\geq 15 \mu\text{m}$ size particle counts are reported as 2 number code and the first number is replaced by a dash "-" to signify that there was no requirement for these data (see EXAMPLE 2 below).

EXAMPLE 1 For a 1 ml sample at the indicated size, the cleanliness code is as follows:

- a) 58,000 particles $\geq 4 \mu\text{m}$ (c): 23;
- b) 4100 particles $\geq 6 \mu\text{m}$ (c): 19;
- c) 210 particles $\geq 14 \mu\text{m}$ (c): 15.

The cleanliness code for the sample is ISO 23/19/15.

EXAMPLE 2 For a 10 ml sample with the following particle counts using a microscope:

- a) 4100 particles $\geq 5 \mu\text{m}$;
- b) 210 particles $\geq 15 \mu\text{m}$.

The numbers are determined as:

- a) $4100/10 = 410$ particles/ml = scale number of 16;
- b) $210/10 = 21$ particles/ml = scale number of 12.

Thus, the cleanliness code for the sample is ISO code -/16/12.

Table E.3—Allocation of Scale Numbers per ISO 4406

Number of Particles per milliliter <i>n</i>	Scale Number
$80,000 < n \leq 160,000$	24
$40,000 < n \leq 80,000$	23
$20,000 < n \leq 40,000$	22
$10,000 < n \leq 20,000$	21
$5000 < n \leq 10,000$	20
$2500 < n \leq 5000$	19
$1300 < n \leq 2500$	18
$640 < n \leq 1300$	17
$320 < n \leq 640$	16
$160 < n \leq 320$	15
$80 < n \leq 160$	14
$40 < n \leq 80$	13
$20 < n \leq 40$	12
$10 < n \leq 20$	11
$5 < n \leq 10$	10
$2.5 < n \leq 5$	9
$1.3 < n \leq 2.5$	8
$0.64 < n \leq 1.3$	7
$0.32 < n \leq 0.64$	6
$0.16 < n \leq 0.32$	5
$0.08 < n \leq 0.16$	4
$0.04 < n \leq 0.08$	3
$0.02 < n \leq 0.04$	2
$0.01 < n \leq 0.02$	1

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E.3.3 SAE AS4059E

SAE AS4059E (which replaces NAS 1638) is another frequently used standard for assigning fluid cleanliness levels. SAE AS4059E Revision E defines cleanliness in terms of:

- a) 14 classes based on differential particle counts per 100 mL (per in AS4059), in each of the following five size ranges: 5 μm to 15 μm , 15 μm to 25 μm , 25 μm to 50 μm , 50 μm to 100 μm , and > 100 μm . These size ranges are based on optical microscope measurement of the longest dimension of the particle or automatic particle counters calibrated per ISO 4402-1991. These classes are the same as in the NAS 1638 standard. The standard also provides the option of cleanliness class determination based on the counts generated with automatic particle counter calibrated per the more recent ISO 11171 method. Table E.4 shows the cleanliness classes based on the differential counts for both particle size measurement methods. The cleanliness is defined by a single class (as in NAS 1638), which is the highest class in any given particle size range.
- b) 15 classes based on cumulative particle counts per 100 ml (per Table 2 in AS4059) in each of the following six sizes: > 1 μm , > 5 μm , > 15 μm , > 25 μm , > 50, and > 100 μm . These size ranges are based on optical microscope measurement of the longest dimension of the particle or automatic particle counters calibrated per ISO 4402-1991. The standard also provides the option of cleanliness class determination based on the counts generated with automatic particle counter calibrated per the more recent ISO 11171 method. Table E.5 shows cleanliness classes based on the cumulative counts for both particle size measurement methods. The cleanliness is defined by the relevant class at the size of interest.

Of the SAE AS4059E and ISO 4406 standards, ISO 4406 is more frequently used, especially for hydraulic systems. Reference photomicrographs of the membrane filters ("patches") prepared in accordance with ISO 4407 and representing AS4059 classes or ISO 4406 Cleanliness Codes are available and can be used for a quick estimate of the cleanliness level of a fluid sample in the field by comparing the "patch" prepared using the sample against the reference photomicrograph.

Table E.4—SAE AS4059E Cleanliness Classes for Differential Particle Counts (Particles/100 ml)

Cleanliness Class	Number of Particles/100 ml for Selected Particle-size Ranges				
	(1) 5 to 15 μm	15 to 25 μm	25 to 50 μm	50 to 100 μm	> 100 μm
	(2) 6 to 14 $\mu\text{m(c)}$	14 to 21 $\mu\text{m(c)}$	21 to 38 $\mu\text{m(c)}$	38 to 70 $\mu\text{m(c)}$	> 70 $\mu\text{m(c)}$
00	125	22	4	1	0
0	250	44	8	2	0
1	500	89	16	3	1
2	1000	178	32	6	1
3	2000	356	63	11	2
4	4000	712	126	22	4
5	8000	1425	253	45	8
6	16,000	2850	506	90	16
7	32,000	5700	1012	180	32
8	64,000	11,400	2025	360	64
9	128,000	22,800	4050	720	128
10	256,000	45,600	8100	1440	256
11	512,000	91,200	16,200	2880	512
12	1,024,000	182,400	32,400	5760	1024

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- (1) Size range, using optical microscope, based on longest dimension as measured per SAE ARP598 or using automatic particle counter (APC) calibrated per ISO 4402-1991.
- (2) Size range, using APC calibrated per ISO 11171 or using electron microscope, based on projected area equivalent diameter.

Table E.5—SAE AS4059E Cleanliness Classes for Cumulative Particle Counts (Particles/100 ml)

Cleanliness Class	Number of Particles/100 ml for Selected Particle-size Ranges					
	(1) > 1 µm	> 5 µm	> 15 µm	> 25 µm	> 50 µm	> 100 µm
	(2) > 4 µm(c)	> 6 µm(c)	> 14 µm(c)	> 21 µm(c)	> 38 µm(c)	> 70 µm(c)
	Size A Code	B	C	D	E	F
000	195	76	14	3	1	0
00	390	152	27	5	1	0
0	780	304	54	10	2	0
1	1560	609	109	20	4	1
2	3120	1217	217	39	7	1
3	6250	2432	432	76	13	2
4	12,500	4864	864	152	26	4
5	25,000	9731	1731	306	53	8
6	50,000	19,462	3462	612	106	16
7	100,000	38,924	6924	1224	212	32
8	200,000	77,849	13,849	2449	424	64
9	400,000	155,698	27,698	4898	848	128
10	800,000	311,396	55,396	9796	1696	256
11	1,600,000	622,792	110,792	19,592	3392	512
12	3,200,000	1,245,584	221,584	39,184	6784	1024
(1) Size range, using optical microscope, based on longest dimension as measured per SAE ARP598 or using automatic particle counter (APC) calibrated per ISO 4402-1991.						
(2) Size range, using APC calibrated per ISO 11171 or using electron microscope particle counts based on projected area equivalent diameter.						

Table E.6 provides the ISO 4406 Cleanliness Code for each SAE Cleanliness Class based on the cumulative particle count criteria of SAE AS4059E.

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Table E.6—SAE AS4059E Class to ISO Cleanliness Code Conversion

SAE AS4059E Class	Number of Particles/100 ml for Selected Particle-size Ranges			ISO 4406 Cleanliness Code
	(1) > 1 µm	> 5 µm	> 15 µm	
	(2) > 4 µm(c)	> 6 µm(c)	> 14 µm(c)	
	Size A Code	B	C	
000	195	76	14	8/7/4
00	390	152	27	9/8/5
0	780	304	54	10/9/6
1	1560	609	109	11/10/7
2	3120	1217	217	12/11/8
3	6250	2432	432	13/12/9
4	12,500	4864	864	14/13/10
5	25,000	9731	1731	15/14/11
6	50,000	19,462	3462	16/15/12
7	100,000	38,924	6924	17/16/13
8	200,000	77,849	13,849	18/17/14
9	400,000	155,698	27,698	19/18/15
10	800,000	311,396	55,396	20/19/16
11	1,600,000	622,792	110,792	21/20/17
12	3,200,000	1,245,584	221,584	22/21/18
(1) Size range, optical microscope, based on longest dimension as measured per SAE ARP598 or automatic particle counter (APC) calibrated per ISO 4402-1991. (2) Size range, APC calibrated per ISO 11171 or electron microscope particle counts based on projected area equivalent diameter.				

E.4 System Cleanliness Testing

The intent of the 100-mesh screen test for lube and seal system consoles is to confirm that, when shipped, there is no debris remaining in the console or vendor-supplied piping or components that can contaminate the remainder of the system and extend system flushing time at the site. If applied by other standards to vendor testing of equipment or by users at machinery installation, it is intended to confirm that there is no debris remaining in the system downstream of the filters that can be immediately detrimental to the machinery components served by the system(s).

The method for determining if a oil or seal-oil system is clean enough to deliver or if a vendor oil system is clean enough for factory-run testing of machinery is covered by 9.3.3.11. This requirement may also be extended to a site evaluation of installed oil and seal-oil systems.

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The use of test screens has been a reliable indicator of when an oil system with an adequate filter system can support start-up and/or testing of special-purpose machinery. The advantage of this testing is that a large representative volume of fluid is circulated through the test screens and the harmful debris that is introduced during fabrication and assembly of a special-purpose system is removed. When this test is done to an appropriate procedure and the test screens are located where there is downward flow through the screens in supply lines, the system will be free of damaging debris downstream of the screens.

There is some concern that 100-mesh screens do not pick up the small particles that can have undesirable long-term effects on the equipment serviced by the lube- and seal-oil system. The test specified in API 614 is not intended to define how well a system performs in the long term. Long-term reliability of components served by a special-purpose system is more a function of the system design including the permanent filters than the test screen specification. Other factors, such as control of the ingress of damaging size particles and the type of particle contamination, are important factors contributing to long-term reliability of machinery.

Some users of API 614 have started to add a criterion from ISO 4406 or SAE AS4059E to make sure the system is clean enough for long-term operation. The ISO 4406 grade specification often used is 20/15/12, (-/15/12 if only 5 μm and larger particles are counted). The approximate equivalent SAE requirement is Class 6. For some very critical or sensitive special-purpose machines, the ISO criterion may be as stringent as 18/14/11 (-/14/11 if particles smaller than 5 μm are not counted) downstream of the filters. This is approximately equivalent to SAE Class 5. (See Table E.6.)

In the context of factory testing large consoles with a large residence capacity, the use of a low particle count requirement, such as ISO grade 14/11, can result in extensive circulation through the filters before a sufficient number of passes through the filters have been completed to remove enough particles in the 5 μm to 10 μm range. This testing can be valid only after the screens have shown that the system is free of damaging debris at the equipment-supply connections. It is highly likely that the act of inspection of a console for debris of the console in accordance with API 614 introduces enough debris to exceed the particle-count criteria. If not, the particle-count criteria will almost certainly be exceeded, due to even minor contamination that is inevitable in the course of special-purpose console and system preservation, shipping, storage, and construction.

Caution should be used if only a particle-count criterion is specified for special-purpose systems/consoles in any context (console vendor, machinery test floor, at site operation). Because small volumes are sampled, the use of only particle-count criteria can easily miss damaging debris that can be released intermittently from piping and components.

Particle-count criteria can be useful in the course of flushing an entire system at the installation site if used in conjunction with testing the supply lines with 100-mesh screens. An ISO scale -/15/12 criteria (SAE Class 6) is acceptable for the start-up of most special-purpose equipment, and even an ISO scale -/16/13 criterion should not be a problem for start-up so long as particle counts are trending downward. In general, unless there is an equipment malfunction or a deficiency in the system filters, the system should be able to reach an ISO cleanliness -/14/11 (SAE Class 5) level or better within a week or 2 of continuous service.

In general, users of special-purpose lube-oil and seal-oil systems who have tracked their systems by means of qualitative testing (e.g. using ISO 4406 or SAE AS4059E) from installation through operation have noted at least one grade or class improvement from start-up of the system until a steady state particle level is reached.

API 614 requires 100-mesh screen testing of oil consoles.

The alternate test specifies an ISO 4406 scale -/17/14 or SAE Class 8 be obtained as a means to verify whether the oil console is clean enough. It is necessary to select a circulation time to ensure that there is mixing to suspend any sediments. Prior to taking a sample, it is suggested that the minimum circulation time be five times the reservoir capacity divided by the pump normal flow.

Some larger debris in the oil console can be missed by checking only the particle count. If the oil is clean enough to pass ISO 4406 -/17/14 grade, then the quantity of debris left in the system should not require additional flushing effort at the site. At the site, prior to placing the system in service, it is still recommended that the entire system be flushed. A 100-mesh screen evaluation based on Table E.6 at the equipment oil-supply header should be done prior to commissioning the equipment.

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Annex F (informative)

International Materials Specifications

Table F.1—Materials Standards

Material Class	Applications	International	USA		Europe			Japan
		ISO	ASTM	UNS ^a	EN ^b	Grade	Material No.	JIS
Cast iron	Pressure castings	185/Gr. 250	A278/A278M Class 30	F12401	EN 1561	EN-GJL-250	JL 1040	G 5501, FC 250
	General castings	185/Gr. 300	A48/A48M Class 25/30/40	F11701/ F12101	EN 1561	EN-GJL-250 EN-GJL-300	JL 1040 JL 1050	G 5501, FC 250/300
Carbon steel	Pressure castings	4991 C23-45 AH	A216/A216M Gr WCB	J03002	EN 10213	GP 240 GH	1.0619	G 5151, CI SCPH 2
	Wrought/ forgings	683-18-C25	A266 Class 4	K03506	EN 10222-2	P 280 GH	1.0426	G 3202, CI SFVC 2A
	Bar stock: pressure	683-18-C25	A696 Gr B40	G10200	EN 10273	P 295 GH	1.0481	G 4051, CI S25C
	Bar stock: general	683-18-C45e	A576 Gr 1045	G10450	EN 10083-2	C 45	1.0503	G 4051, CI S45C
	Bolts and studs	2604-2-F31	A193/A193M Gr B7	G41400	EN 10269	42 Cr Mo 4	1.7225	G 4107, Class 2, SNB7
	Nuts	683-1-C45	A194/A194M Gr 2H	K04002	EN 10269	C 35 E	1.1181	G 4051, CI S45C
	Plate	9328-4, P 355 TN/ PL 355 TN	A516/A516M Gr 65/70	K02403/ K02700	EN 10028-3	P 355 N P 355 NL1	1.0562 1.0566	G 3106, Gr SM400B
	Pipe	9329-2 PH26	A106/A106M Gr B	K03006	EN 10208-1	L 245 GA	1.0459	G 3456, Gr. STPT 370/410
	Fittings	—	A105/A105M	K03504	—	—	—	G 4051, CI S25C G 3202, CI SFVC 2A, SFVC2B
4140 Alloy steel	Bar stock	—	A434 Class BB A434 Class BC	G41400 ^c	EN 10083-1	42 Cr Mo 4	1.7225	G 4105, CI SCM 440
	Bolts and studs	2604-2-F31	A193/A193M Gr B7	G41400	EN 10269	42 Cr Mo 4	1.7225	G 4107, Class 2, SNB7
	Nuts	683-1C45	A194/A194M Gr 2H	K04002	EN 10269	C 45 E	1.1191	G 4051, CI S45C

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Table F.1—Materials Standards (continued)

Material Class	Applications	International	USA		Europe			Japan
		ISO	ASTM	UNS ^a	EN ^b	Grade	Material No.	JIS
12 % Chrome steel	Pressure castings	—	A487/A487M Gr CA6NM	J91540	EN 10213	GX 4 Cr Ni 13-4	1.4317	G 5121, C1 SCS 6, SCS 6X
	General castings	—	A743/A743M Gr CA 15	J91150	EN 10283	GX 12 Cr 12	1.4011	G5121, CI SCS 1, SCS 1X1
		—	A743/A743M Gr CA6NM	J91540	EN 10283	GX 4 Cr Ni 13-4	1.4317	G5121, CI SCS 6, SCS 1X1
	Wrought/ forgings: pressure	683-13-3	A182/A182M Gr F6a CI 1 A 182/A182M Gr F 6 NM	S41000	EN 10250-4	X12 Cr13	1.4006	G 3214, Gr. SUS 410-A G 3214, CI SUS F6 NM
				S41500	EN 10222-5	X 3 Cr Ni Mo 13-4-1	1.4313	
	Wrought/ forgings: general	683-13-2	A473 Type 410	S41000	EN 10088-3	X 12 Cr 13	1.4006	G 3214, Gr. SUS 410-A
	Bar stock: pressure	683-13-3	A479/A479M Type 410	S41000	EN 10272	X12 Cr 13	1.4006	G 4303, Gr. SUS 410 or 403
	Bar stock: general	683-13-3	A276 Type 410	S41400	EN 10088-3	X 12 Cr 13	1.4006	G 4303, Gr. SUS 410 or 403
	Bar stock: forgings ^c	683-13-4	A276 Type 420 A473 Type 416 A582/A582M Type 416	S42000 S41600 S41600	EN 10088-3	X 20 Cr 13 X 20 Cr S 13 X 20 Cr S 13	1.4021 1.4005 1.4005	G 4303, Gr. SUS 420J1 or 420J2
	Bolts and studs ^d	3506-1, C4-70	A193/A193M Gr B6	S41000	EN 10269	X22CrMoV 12-1	1.4923	G 4303, Gr. SUS 410 or 403
	Nuts ^d	3506-2, C4-70	A194/A194M Gr 6	S41000	EN 10269	X22CrMoV 12-1	1.4923	G 4303, Gr. SUS 410 or 403
	Plate	683-13-3	A240/A240M Type 410	S41000	EN 10088-2	X 12 Cr 13	1.4006	G 4304/4305 Gr. SUS 403 or 410

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Table F.1—Materials Standards (continued)

Material Class	Applications	International	USA		Europe			Japan
		ISO	ASTM	UNS ^a	EN ^b	Grade	Material No.	JIS
Austenitic stainless steel	Pressure castings	683-13-10	A351/A351M Gr CF3	J92500	EN 10213-4	GX2 Cr Ni 19-11	1.4309	G 5121, CI SCS 19A
		683-13-19	A351/A351M Gr CF3M	J92800	EN 10213-4	GX2 Cr Ni Mo 19-11-2	1.4409	G 5121, CI SCS 16A, SCS 16AX
	General castings	—	A743/A743M Gr CF3	J92500	EN 10283	GX2 Cr Ni 19-11	1.4309	G 5121, CI SCS 19A
		—	A743/A743M Gr CF3M	J92800	EN 10283	GX2 Cr Ni Mo 19-11-2	1.4409	G 5121, CI SCS 16A, SCS 16AX
	Wrought/ forgings	9327-5, XCrNi18-10	A182/A182M Gr F 304L	S30403	EN 10222-5	X2 Cr Ni 19-11	1.4306	G 3214, Gr. SUS F 304 L
		9327-5, XCrNiMo17-12	A182/A182M Gr F 316L	S31603	EN 10222-5 EN 10250-4	X2 Cr Ni Mo 17-12-2	1.4404	G 4304/4305, Gr. SUS 304L/316L
	Bar stock ^e	9327-5 X2CrNi18-10	A479A/479M Type 304L A479A/479M Type 316L A276, grade 316L	S30403 S31603	EN 10088-3 EN 10088-3	X2 Cr Ni 19-11 X2 Cr Ni Mo 17-12-2	1.4306 1.4404	G 4303, Gr. SUS 304 L G 4303, Gr. SUS 316 L
		683-13-19	A276, grade 316 Ti	S 31635	EN 10088-3	X2 Cr Ni Mo Ti 17-12-2	1.4571	G 4303, Gr. SUS 316 Ti
		9327-5 X2CrNi-Mo17-12	A479A/479M Type XM19	S20910	—	—	—	—
	Plate	9328-5 X2CrNi-Mo17-12-2	A240/A240M Gr 304L/ 316L	S30403 S31603	EN 10028-7 EN 10028-7	X2 Cr Ni 19-11 X2 Cr Ni Mo 17-12-2	1.4306 1.4404	G 4304/4305, Gr. SUS 304 L/ 316 L
	Pipe	683-13-10 683-13-19	A312/A312M Type 304L 316L	S30403 S31603	—	—	—	G 3459, Gr. SUS 304 LTP/316 LTP
	Fittings	9327-5, X2CrNi18-10 9327-5, X2CrNiMo17-12	A182/A182M Gr F304L, Gr 316L	S30403 S31603	EN 10222-5	X2 Cr Ni 19-11 X2 Cr Ni Mo 17-12-2	1.4306 1.4404	G 3214, Gr. SUS F304L/F316L
	Bolts and studs	3506-1, A4-70	A193/A193M Gr B 8 M	S31600	EN 10250-4	X5 Cr Ni Mo 17-12-2	1.4401	G 4303, Gr. SUS 316
	Nuts	3506-2, A4-70	A194/A194M Gr B 8 M	S31600	EN 10250-4	X5 Cr Ni Mo 17-12-2	1.4401	G 4303, Gr. SUS 316

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Table F.1—Materials Standards (continued)

Material Class	Applications	International	USA		Europe			Japan
		ISO	ASTM	UNS ^a	EN ^b	Grade	Material No.	JIS
Duplex stainless steel	Pressure castings	—	A890/A890M Gr 1 B A995/A995M Gr 1 B	J93372	EN 10213-4	GX2 CrNiMoCuN- 25-6-3-3	1.4517	—
		—	A890/A890M Gr 3 A A995/A995M Gr 3 A	J93371 J93371	—	—	—	G 5121, Gr. SCS 11
		—	A890/A890M Gr 4 A A995/A995M Gr 4 A	J92205 J92205	EN 10213-4	GX2 CrNiMoCuN- 25-6-3-3	1.4517	G 5121, Gr. SCS 10
	Wrought/ forgings	9327-5, X2CrNiMoN 22-5-3	A182/A182M Gr F 51	S31803	EN 10250-4 EN 10222-5	X2CrNiMoN- 22-5-3	1.4462	—
		—	A479/A479M	S32550	EN 10088-3	X2CrNiMoCuN- 25-6-3	1.4507	—
	Bar stock	9327-5, X2CrNiMo N22-5-3	A276-S31803	S31803	EN 10088-3	X2CrNiMoN- 22-5-3	1.4462	B 2312/B 2316 Gr. SUS 329 J3L
	Plate	—	A240/A240M- S31803	S31803	EN 10028-7	X2CrNiMoN- 22-5-3	1.4462	G 4304/G 4305, Gr. SUS 329 J3L
	Pipe	—	A790/A790M- S31803	S31803	—	—	—	G 3459, Gr. SUS 329 J3LTP
	Fittings	9327-5, X2CrNiMo N22-5-3	A182/A182M Gr F 51	S31803	EN 10250-4 EN 10222-5	X2CrNiMoN- 22-5-3	1.4462	B 2312/B 2316 Gr. SUS 329 J3L
	Bolts and studs	—	A276-S31803	S31803	EN 10088-3	X2CrNiMoN- 22-5-3	1.4462	G 4303, Gr. SUS 329J3L
	Nuts	—	A276-S31803	S31803	EN 10088-3	X2CrNiMoN- 22-5-3	1.4462	G 4303, Gr. SUS 329 J3L

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Table F.1—Materials Standards (continued)

Material Class	Applications	International	USA		Europe			Japan
		ISO	ASTM	UNS ^a	EN ^b	Grade	Material No.	JIS
Super duplex stainless steel ^f	Pressure castings	—						
		—	A890/A890M Gr 5A	J93404	EN 10213-4	GX2CrNiMo N26-7-4	1.4469	—
		—	A890/A890M Gr 6A	J93380	—	—	—	—
	Wrought/forgings	—	A182/A182M Gr 55	S32750 S32760	EN 10250-4 EN 10088-3	X2CrNiMoCu-WN 25-7-4	1.4501	G 4303, Gr. SUS 329 J4L
	Bar stock	—	A276-S32760 A479/A479M-S32760	S32750 S32760	EN 10088-3	X2CrNiMoCu-WN 25-7-4	1.4501	G 4304/G 4305, Gr. SUS 329 J4L
	Plate	—	A240/A240M-S32760	S32750 S32760	EN 10028-7	X2CrNiMoCu-WN 25-7-4	1.4501	—
	Pipe	—	A790/A790M-S32760	S32750 S32760	—	—	—	G 3459, Gr. SUS 329 J4LTP
	Fittings	—	A182/A182M Gr F55	S32750 S32760	EN 10250-4 EN 10088-3	X2CrNiMoCu-WN 25-7-4	1.4501	B 2312/B 2316 Gr. SUS 329 J4L
	Bolts and studs	—	A276-S32760	S32750 S32760	EN 10088-3	X2CrNiMoCu-WN 25-7-4	1.4501	G 4303, Gr. SUS 329 J4L
	Nuts	—	A276-S32760	S32750 S32760	EN 10088-3	X2CrNiMoCu-WN 25-7-4	1.4501	G 4303, Gr. SUS 329 J4L

^a UNS (unified numbering system) designation for chemistry only.

^b Where EN standards do not yet exist, European national standards are available, e.g. AFNOR, BS, DIN.

^c Do not use for shafts in the hardened condition (over 302 HB).

^d Special, normally use AISI 4140.

^e For shafts, standard grades of austenitic stainless steel may be substituted in place of low carbon (L) grades.

^f Super duplex stainless steel classified with pitting resistance equivalent (PRE) number greater than or equal to 40;

PRE = $w_{Cr} + 3.3(w_{Mo} + (0.5w_{W})) + 16w_{N}$, where w is the percentage mass fraction of the element indicated by the subscript.

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Table F.2—Miscellaneous Materials Specifications

Bronze	UNS C87200 (silicon bronze), C90700 or C92200 (tin bronze), C95200 (aluminium bronze) or C95800 (nickel aluminium bronze)
Inhibited admiralty	ASTM B111, UNS: 44300, EN 12451—Grade: CW706R—Material No. 2.0470 (heat exchanger tubes)
Low-carbon nickel-molybdenum-chromium alloy (Alloy C276)	ASTM B564, UNS N10276 (forgings) ASTM B574, UNS N10276 (bar and rod) ASTM B575, UNS N10276 (plate, sheet and strip) ASTM A494, Grade CW-2M (weldable cast)
Naval brass	Chemical symbol CuZn38SnAl: ASTM B171, UNS: 36500, EN 1653—Grade: CW715R—Material No. 2.0525 Chemical symbol CuZn38Sn1: ASTM B171, UNS: 46400, Material No. 2.0530
Nickel copper alloy (Alloy 400)	ASTM B564, UNS N04400 (forgings) ASTM B164, Class A, UNS N04400 (bar and rod) ASTM B127, UNS N04400 (plate, sheet, and strip) ASTM A494, Grade M30C (weldable cast)
Ni-resist	ASTM A436, Type 1, 2, or 3, UNS F41000, F41002, and F41004, respectively (austenitic cast iron), ASTM A439, Type D2, UNS F43000 (austenitic ductile iron)
Precipitation-hardening nickel alloy (Alloy 718)	ASTM B637, UNS N07718 (forgings and bar) ASTM B670, UNS N07718 (plate, sheet, and strip)
Alloy 20	ASTM A744 Grade CN7M, UNS N08007 (casting) ASTM B473, UNS N08020 (bar)
Alloy 42	ASTM F30, UNS K94100 (bar)
Precipitation-hardening stainless steel	ASTM A564, Grade 630, UNS S 17400 or Grade 631, UNS 17700 (wrought) ASTM A747, Grade CB7Cu-1, UNS J92180 (cast)

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Annex G

(informative)

Explanation of Reservoir Levels

G.1 The rundown level is the highest level that oil in the reservoir can reach when the entire system is shut down.

G.2 The maximum operating level is the highest level that oil can reach during normal operation of the equipment.

G.3 The minimum operating level is the lowest level that oil can reach during normal operation of the equipment.

G.4 The suction-loss level is the level above the pump suction level at which the pump begins to lose prime. The pump suction-loss level is defined by the pump suction vortex and net positive suction head requirements.

G.5 The charge capacity is the total volume below the rundown level.

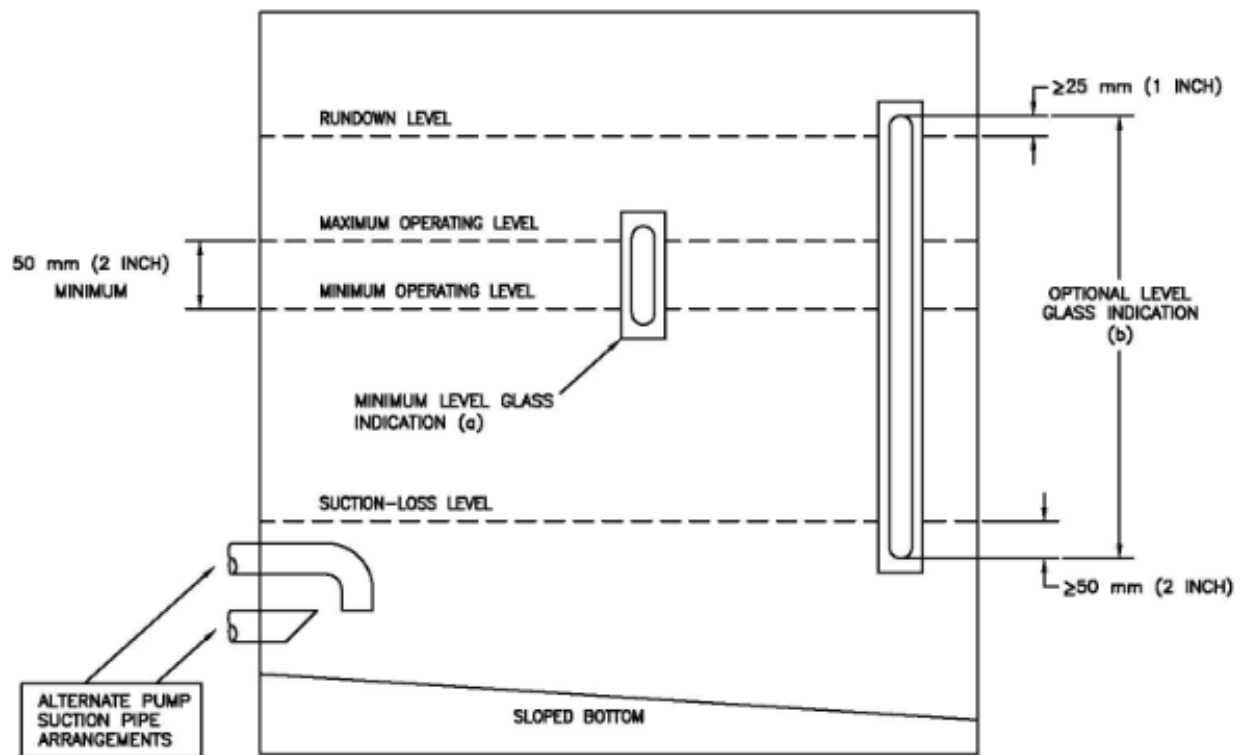
G.6 The normal operating range is any level between the maximum and minimum operating levels.

G.7 The retention capacity is the total volume below the minimum operating level.

G.8 Retention time is the time allowed for disengagement of entrained air or gas.

G.9 The rundown capacity is the volume between the rundown level and the maximum operating level.

G.10 The working capacity is the volume between the minimum operating level and the suction-loss level.



Key

- ^a The minimum level gauge glass configuration spans the minimum to maximum operating levels.
- ^b The purchaser may specify a level gauge glass with bottom of the gauge no less than 50 mm (2 in.) below the minimum operating level and 25 mm (1 in.) above the rundown level; additional excess length being above the rundown level.

Figure G.1—Reservoir Levels and Oil Level Glass Details

Annex H

(informative)

Oil Drain Line Sizing

H.1 General Considerations

This annex is intended to provide information and considerations associated with atmospheric oil drain return line sizing. Normal criteria for atmospheric oil drain return lines are to size and install them in a manner to ensure they run no more than half full. A brief discussion of various sizing methods for atmospheric oil drain return lines is reviewed. Further, one suggested computational sizing method is presented for consideration.

Maintaining atmospheric oil drain return lines at one-half full (or less) by proper sizing and adequate slope ensures free gravity flow permitting bearing, seal, gearbox, and coupling guard housings to breath adequately promoting good oil drainage.

Arbitrary oversizing of these drain lines can result in flowing oil levels being significantly less than one-half full creating a situation where the flowing oil level can be hard to observe in sight flow indicators as a result of the levels being below the sight windows in the flow glasses. This situation can also result in drain return line temperature instruments not being adequately submersed into the oil flow.

H.2 Common Sizing Methods

H.2.1 Different methods have been and are used for partially full oil drain return line sizing. Common sizing methods include:

- a) low velocity sizing (one foot per second or less) basis full flowing lines where it is understood the installed lines will flow much faster and less than full;
- b) open weir or trough flow calculation methods;
- c) partially full pipe and conduit calculation methods;
- d) utilization of empirical test results for determination of oil drain line size capacities.

H.2.2 Use and consideration of these common sizing methods are as follows:

H.2.2.1 The low velocity sizing approach in many cases provides adequate line sizes but does not accurately predict how full the installed return lines will actually flow. In some cases, the fluid levels in the return lines may be significantly less than one-half full creating situations previously mentioned where sight flow indicator level observation and temperature probe immersion may be problematic.

H.2.2.2 Open weir and trough flow methods can be utilized but have restrictions and limited accuracy when applying and translating to circular conduit or pipe flow. The majority of these methods have been developed for open water weir and trough flows and are impacted by the geometry of the weir or trough as well as the surface roughness values of such flow paths.

H.2.2.3 Partially full pipe and conduit calculation methods are generally accurate for sizing atmospheric drain return lines. One of these popular methods is the Manning formula method, which is often used for partially full pipe flow calculations and does provide good results. However, the Manning formula method is considered more suited to water flow drain line configurations since it does not take into account the

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viscosities associated with lubrication, seal, and hydraulic control oil fluids. Fluid viscosity effects reduce drain line flow capacities.

H.2.2.4 Another method for partially full pipe calculation, accounting for the influence of fluid viscosity, is the Darcy–Weisbach calculation method as given in Crane Technical Paper No. 410. This Darcy formula is a phenomenological equation, which relates the fluid's head (pressure) loss due to flowing friction through a given size and length of pipe to the average velocity of the fluid flow and accounts for the influence of viscosity. The Darcy–Weisbach method is outlined in H.3 below.

H.2.2.5 Finally, utilization of empirical test results for determination of atmospheric oil drain return line size capacities can provide very accurate results. However, this approach is valid only if the conditions of the drain return line application are consistent with the conditions for which the empirical testing was conducted. The significant variation is generally viscosity.

H.3 Darcy–Weisbach Calculation Method

This example of this calculation method is provided in USC units of measure only.

The basic Darcy Formula is as follows:

$$h_L = f \left(\frac{L}{D} \right) \frac{v^2}{2g} \quad (\text{H.1})$$

Assigning coefficient K :

$$K = f \left(\frac{L}{D} \right) \quad (\text{H.2})$$

$$\therefore h_L = K \left(\frac{v^2}{2g} \right) \quad (\text{H.3})$$

Written in terms of gallons per minute (Q):

$$h_L = \frac{0.00259KQ^2}{d^4} \quad (\text{H.4})$$

Solving for Q :

$$Q = \frac{h_L d^4}{0.00259K} \quad (\text{H.5})$$

$$Q = 19.65d^2 \sqrt{\frac{h_L}{K}} \quad (\text{H.6})$$

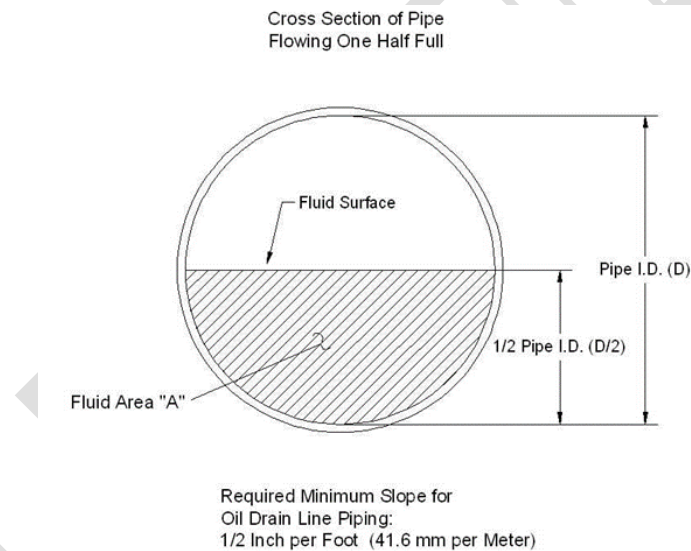
Therefore:

$$Q = 19.65d^2 \sqrt{\frac{h_L D}{fL}} \quad (\text{H.7})$$

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where

- h_L is head loss due to friction (ft/ft);
- L is length of the pipe (ft);
- d is pipe ID (inches); D = pipe ID (ft);
- v is average flow velocity, experimentally measured as the volumetric flow rate per unit cross-sectional wetted area (ft/s);
- g is the local acceleration due to gravity (ft/s²);
- Q is liquid flow in gallons per minute (US GPM);
- f is dimensionless coefficient called the Darcy friction factor; it can be found from a Moody diagram or more precisely by solving the Colebrook equation;
- K is resistance coefficient representing the head loss through a valve or fitting in terms of velocity head or through an equivalent length of pipe for a given diameter.



Since the pipe has circular geometry and is flowing less than full, the equivalent fluid pipe diameter D is determined from the hydraulic radius which is used in the sizing calculation where:

$$D = 4R_H; R_H = \frac{\text{Flow Area "A" Cross Section (ft}^2\text{)}}{\text{Wetted Perimeter (ft)}} \quad (\text{H.8})$$

NOTE The wetted perimeter does not include the free liquid surface.

d^2 in this case is:

$$d^2 = \frac{4A}{\pi} \quad (\text{H.9})$$

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where A is the flow area.

Therefore:

$$Q = 19.65d^2 \sqrt{\frac{h_L D}{fL}} \quad (\text{H.10})$$

can be rewritten as:

$$Q = 39.3d^2 \sqrt{\frac{h_L R_H}{fL}} \quad (\text{H.11})$$

NOTE For oil drain lines, the minimum required slope of $1/2$ inch per foot (41.6 mm per meter) defines the minimum head loss h_L expressed as foot loss per foot.

$$\frac{\Delta h_L}{\Delta L} = \left(\frac{\frac{1}{2} \text{ inch}}{12 \text{ inches}} \right) \frac{\text{ft}}{\text{ft}} = 0.04167 \frac{\text{ft}}{\text{ft}} \quad (\text{H.12})$$

In order to determine the friction factor (f), the relative roughness of the pipe interior surface needs to be known. The relative roughness is determined from e/D , where e is the absolute roughness of the pipe interior wall surface profile or height of the irregularities in unit of feet and D is the pipe inside diameter in feet. For commercial grade steel pipes, $e = 0.00015$ ft. Therefore, e/D ranges from 0.00218 to 0.00015 for pipe sizes 3/4 in. Sch 80 through 12 in. Sch 10, respectively.

Using the range of relative roughness (e/D), the friction factor (f) can be initially estimated from the Moody Diagram or by computing via the Colebrook equation.

Moody diagrams are readily available in the public domain and various technical publications including the referenced Crane Technical Paper No. 410. The Colebrook equation has a number of variations and expanded forms.

The basic Colebrook equation is also known as the Colebrook–White equation and is based on a circular conduit (pipe) flowing completely full with the Reynolds number greater than 4000 for transition zone flows. This equation takes the form:

Colebrook–White equation for full flowing pipes with $Re > 4000$:

$$\frac{1}{\sqrt{f}} = -2 \log_{10} \left(\frac{\varepsilon}{3.7D_h} + \frac{2.51}{Re \sqrt{f}} \right) \quad (\text{H.13})$$

or

$$\frac{1}{\sqrt{f}} = -2 \log_{10} \left(\frac{\varepsilon}{14.8R_h} + \frac{2.51}{Re \sqrt{f}} \right) \quad (\text{H.14})$$

A variation of this Colebrook–White equation exists for flowing liquids having a free surface such as is the case in partially full flowing pipes. In this situation, the Colebrook–White equation is slightly modified and is expressed as:

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$$\frac{1}{\sqrt{f}} = -2\log_{10}\left(\frac{\varepsilon}{12R_h} + \frac{2.51}{R_e\sqrt{f}}\right) \quad (\text{H.15})$$

There are also a number of other variations of the Colebrook equation that have been derived via different methods and are used for specific applications such as fully turbulent flows, or rough conduit wall flow conditions.

For Reynolds numbers less than 2000, the fluid flow is considered laminar. For laminar flow characteristic friction factor (f) is determined as:

$$f = 64/R_e \quad (\text{H.16})$$

For Reynolds number greater than 2000, the flow will be in the transition zone and the friction factor can be determined from the Moody diagram or from the Colebrook relationship.

In most cases, the flow characteristic for oil drain lines will fall into laminar (R_e less than 2000) or the transition zone area. Flow capacities can then be calculated from determining an initial friction factor (f) and then computing flow.

Once the flow is computed, the initial friction factor (f) can be verified by computing the Reynolds number (R_e) and checking the resultant friction factor (f) for agreement with the initial value. If the initial friction factor value does not agree with the friction factor value determined from the actual computed Reynolds number, the friction factor is adjusted, flow and Reynolds number (R_e) recalculated until agreement in the pre and post flow calculation friction factors (f) is reached. This is an iterative process and can take a number of iterations to reach agreement.

Reynolds number (R_e) is determined as:

$$R_e = \frac{1.054Q\rho}{R_H\mu} \quad (\text{H.17})$$

where

Q is flow in US GPM;

ρ is density in lb/ft³;

R_H is hydraulic radius (ft);

μ is dynamic viscosity centipoise (C_P).

The example provides computations for determining drain line flow capacities for ISO VG 32 Light Turbine lubricating oil at a conservative temperature of 120 °F.

NOTE The oil temperature 120 °F is used since it represents the default oil supply temperature to the equipment. Elevated temperatures due to frictional heat rejection from the bearings, seals, and gears will result in reduced fluid viscosities.

The example also provides various intermediate calculated and fixed values.

A safety factor of 1.2 is applied to the calculated flow capacity numbers to account for installed variations of drain line slope and tolerances and uncertainties of oil flows.

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The method can be applied to other oils of heavier viscosities, which will reduce the computed flow rates.

NOTE 1 All units of measure are given in USC units of measure.

NOTE 2 Table H.1 provides typical examples of oil drain lines flowing $\frac{1}{2}$ full.

Table H.1—Example: Capacities of Atmospheric Oil Drain Lines Flowing $\frac{1}{2}$ Full with $\frac{1}{2}$ in. per Foot Slope [for Light Turbine Oil (ISO VG 32) Flowing at 120 °F]

Pipe Size (NPS)	Schedule	d Pipe ID (Inches)	D Pipe ID (Ft)	1/2 Full Flow Area (Sq Ft)	Wetted Perimeter (Ft)	RH (Ft)	(d) ² Equiv Diameter (Sq In)	Relative Roughness ~ e/D	Iterated Friction Factor ⁽¹⁾ f	Computed 1/2 Full ⁽²⁾ Flow Rate Q (US GPM)	Reynolds Number Re	Flow Characteristic (for Laminar f=64/Re)	Friction Factor Eval f	Q Fluid Velocity (Ft/Sec)	1/2 Full ⁽³⁾ Flow Rate with S.F. Q' (US GPM)
3/4"	40	0.824	0.0687	0.0019	0.1079	0.0172	0.3395	0.00218	0.8780	0.4	7.289E+01	Laminar	0.8780	0.46	0.3
	80	0.742	0.0618	0.0015	0.0971	0.0155	0.2753	0.00243	1.2025	0.3	5.322E+01	Laminar	1.2025	0.37	0.2
1"	40	1.049	0.0874	0.0030	0.1373	0.0219	0.5502	0.00172	0.4255	1.0	1.504E+02	Laminar	0.4255	0.74	0.8
	80	0.957	0.0798	0.0025	0.1253	0.0199	0.4579	0.00188	0.5603	0.7	1.142E+02	Laminar	0.5604	0.62	0.6
1-1/2"	40	1.610	0.1342	0.0071	0.2107	0.0335	1.2961	0.00112	0.1177	5.6	5.437E+02	Laminar	0.1177	1.75	4.6
	80	1.500	0.1250	0.0061	0.1963	0.0313	1.1250	0.00120	0.1455	4.2	4.398E+02	Laminar	0.1455	1.52	3.5
2"	40	2.067	0.1723	0.0117	0.2706	0.0431	2.1362	0.00087	0.0556	15.1	1.151E+03	Laminar	0.0556	2.88	12.6
	80	1.939	0.1616	0.0103	0.2538	0.0404	1.8799	0.00093	0.0674	11.7	9.497E+02	Laminar	0.0674	2.54	9.7
3"	10	3.068	0.2557	0.0257	0.4016	0.0639	4.7063	0.00059	0.0510	42.3	2.173E+03	Transition	Iterated	3.67	35.2
	40	2.900	0.2417	0.0229	0.3796	0.0604	4.2050	0.00062	0.0500	37.1	2.017E+03	Transition	Iterated	3.60	30.9
4"	10	4.260	0.3550	0.0495	0.5576	0.0888	9.0738	0.00042	0.0460	101.1	3.744E+03	Transition	Iterated	4.55	84.3
	40	4.026	0.3355	0.0442	0.5270	0.0839	8.1043	0.00045	0.0480	85.9	3.367E+03	Transition	Iterated	4.33	71.6
6"	10	6.357	0.5298	0.1102	0.8321	0.1324	20.2057	0.00028	0.0331	324.2	8.045E+03	Transition	Iterated	6.55	270.2
	40	6.065	0.5054	0.1003	0.7939	0.1264	18.3921	0.00030	0.0338	285.3	7.419E+03	Transition	Iterated	6.34	237.7
8"	10	8.329	0.6941	0.1892	1.0903	0.1735	34.6861	0.00022	0.0293	677.1	1.282E+04	Transition	Iterated	7.97	564.3
	40	7.981	0.6651	0.1737	1.0447	0.1663	31.8482	0.00023	0.0299	602.5	1.191E+04	Transition	Iterated	7.73	502.1
10"	10	10.420	0.8683	0.2961	1.3640	0.2171	54.2882	0.00017	0.0266	1244.1	1.883E+04	Transition	Iterated	9.36	1036.8
	40	10.020	0.8350	0.2738	1.3116	0.2088	50.2002	0.00018	0.0271	1117.7	1.759E+04	Transition	Iterated	9.10	931.4
12"	10	12.390	1.0325	0.4186	1.6218	0.2581	76.7561	0.00015	0.0248	1986.5	2.529E+04	Transition	Iterated	10.57	1655.4
	40	11.938	0.9948	0.3887	1.5627	0.2487	71.2579	0.00015	0.0252	1795.8	2.373E+04	Transition	Iterated	10.29	1496.6

epsilon (e) for Commercial Stainless Steel Pipe	0.00015	Ft/Ft
Fluid Viscosity μ at Flowing Temperature (Centipoise)	17.0	Cp
Fluid Density (Rho) in Lbs / Cubic Foot	53.0	Lb/Ft ³
Head Loss in Inches per Foot (Due to Line Slope)	0.5	Inch/Ft
=====► 0.04167 Ft/Ft		

(1) Friction Factor f from Moody Diagram or Colebrook equation for partially full pipes. Used Re Number Value Between Laminar Zone and Transition Zone for Initial Assumption and then iterated to agree. Laminar flow yields a friction factor $f = 64/Re$.

(2) Flow Rates Based Upon Following Equation: $Q = (39.3 \times d^2) Sg R_h [(h_L \times R_h) / (f \times 1 \text{ Ft})]$
Does not include Safety Factors.

(3) Q' Flow Value Includes a Suggested De-rating Safety Factor (S.F.) of 1.2 of computed 1/2 Full Flow Rate Q.

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Annex I (informative)

Inspector's Checklist

Table I.1—Inspector's Checklist

Item	Date Inspected	Inspected by	Status
1) Sound pressure level requirements met (6.1.12.1)			
2) Oil characteristics:			
a) In accordance with specification (6.2.8)			
b) Hydro test compatible (9.3.2.1)			
c) Run-test compatible (9.3.3.7)			
3) Compatible rust preventatives used (9.4.6, 9.4.7)			
4) Lube-oil/seal-oil selection demonstrated, if applicable (6.2.7)			
5) System arrangement (6.2.11):			
a) In accordance with drawings			
b) Providing adequate clearances			
c) Providing safe access			
d) Adequate for maintenance (6.2.12, 6.2.16)			
6) ASME code stamp, if applicable (6.3.3):			
a) Heat exchangers			
b) Filters			
c) Accumulators			
d) Lube-oil rundown tanks			
e) Drain traps			
f) Other pressure vessels			
g) Overhead seal-oil tanks			
h) Degassing drum			
7) Welding operators and procedures qualified:			
a) Welding of pressure vessels (6.4.1)			
i. Heat exchangers			
ii. Filters			
iii. Accumulators			
iv. Lube-oil rundown tanks			
v. Seal-oil tanks			
vi. Degassing drum			
vii. Other pressure vessels			
viii. Oil conditioner			

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Table I.1—Inspector's Checklist (continued)

Item	Date Inspected	Inspected by	Status
b) Welding of piping (6.4.1)			
c) Welding of oil reservoir, if specified (6.6.12.1)			
d) Dissimilar-metal welding and weld repairs (6.4.1)			
e) Verification of welds (9.2.2.1.1)			
8) Welding procedures (other than above) (6.4.3):			
a) Baseplates			
b) Panels			
c) Nonpressure ducting			
d) Other			
9) Baseplates:			
a) Major components mounted directly on structural steel (6.5.1)			
b) Adequate drain gutter (6.5.3.2)			
c) Adequate lifting lug (distortion, damage) (6.5.6.2)			
d) Metal decking (6.5.4)			
e) Pre-coat for epoxy grout (6.5.8)			
f) Flatness and elevation check of oil pump & driver sub-base, when supplied (6.7.45.1.X)			
10) Reservoir top sealed and sloped properly (6.6.1.6, 6.6.1.11)			
11) Manway openings adequate (6.6.3.4.1, 6.6.3.4.2)			
12) Reservoir heaters adequate for the application (6.6.8.1)			
13) Clips provided:			
a) Insulation clips (6.6.9.1)			
b) Grounding clips (6.6.15.1)			
14) Pumps:			
a) Piping vented or arranged to avoid air pockets (6.7.26.2)			
b) Strainers installed and tabbed (6.7.27.1)			
c) Alignment checked (6.7.42)			
d) Mounting surfaces flat and parallel (6.7.45.1.2)			
e) Shims installed (6.7.45.2.1)			
f) Bolting and unbolting of piping demonstrated (9.3.3.14)			
g) Jackscrews adequate (6.7.45.5)			
15) Oil filters			
Drainability demonstrated [6.9.7 g)]			
16) Oil conditioner siphon breaker installed and demonstrated (6.6.11.2, 6.6.11.3)			
17) Piping:			
a) Examined and inspected in accordance with (6.4)			
b) Fabricated in accordance with specification (6.3.4)			

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18) Oil drains shown to run not more than half full [7.2.1 a)]			
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Table I.1—Inspector's Checklist (continued)

Item	Date Inspected	Inspected by	Status
19) Electrical systems/panels			
a) Wiring suitable (8.4.3)			
b) Spare terminal points adequate (8.4.8)			
c) Clearances adequate for maintenance (8.4.9)			
d) Fungus/corrosion protection provided (8.4.11)			
e) Wiring clearly labelled and isolated (8.4.7, 8.4.13)			
20) Material inspected as specified (list each component) (9.2.2)			
21) Verification of compliance for buy-out items:			
a) Equipment			
b) Instrumentation			
c) Piping, tubing, flanges, and fittings			
d) Electrical components			
22) Components inspected for cleanliness (list each) (9.2.3.1)			
23) Hydrostatic tests:			
a) Hydro tests certified (list each component) (9.3.2.1)			
b) Assembled oil system hydrostatic test performed (9.3.2.2)			
c) Chlorides in hydro test liquid addressed adequately (9.3.2.4)			
d) Test pressures verified (9.3.2.1, 9.3.2.6)			
24) Operational tests:			
a) System cleanliness demonstrated before test, if specified (9.3.3.12)			
b) All leaks corrected before starting [9.3.3.10 a)]			
c) Limiting pressures verified [9.3.3.10 b)]			
d) Filter-heat exchanger changeover performed [9.3.3.10 c)]			
e) Control valve response and stability demonstrated [9.3.3.10 d), 9.3.3.10 f)]			
f) Pressure drop on pump trip checked/demonstrated [9.3.3.10 e)]			
g) Acceptable transfer valve leakage demonstrated [9.3.3.10 i)]			
h) System cleanliness after test demonstrated (9.3.3.11)			
25) Painting (9.4.4)			
26) Preparation for shipment:			
a) Equipment cleaned and prepared properly (9.4.4–9.4.29)			
b) Items properly tagged (9.4.14)			
c) Storage/handling/installation instructions received (9.4.2, 9.5.9)			
d) Piping and components adequately protected (9.4.15, 9.4.16)			
e) Connections properly tagged (9.4.24)			
f) Shipping documents included (9.5.7)			

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Annex J

(informative)

Guidance to System Reliability

This guide is specifically for oil systems. Please refer to API 691 for additional information on failure modes and effects analysis (FMEA) and reliability.

Prior to the first edition of API 614, the standard was directed at systems where only the most critical reliability demands were required. With the introduction of coverage for general-purpose systems in later editions of API 614, a broad new class of systems was introduced for which it is necessary to better balance the initial cost and system reliability to maximize the effectiveness in meeting business requirements.

System design for less-than-critical systems is a trade-off between initial cost associated with taking too much risk vs. taking too little risk of meeting the reliability goal. This relates to the concept of underinvesting vs. overinvesting (i.e. the trade-off between system reliability and initial cost). The real issues to determine are: What is the impact of unreliability and how much availability (or unavailability) can one afford?

Methods exist utilizing sophisticated software to aid in the determination of the probability that a particular system can meet the required mission time specified by the business. These methods require reliability data on individual components for input into the system analysis and require a level of sophistication and analysis that is not usually conducted on noncritical systems due to the level of complexity involved in the analysis.

While some sophisticated users take this approach to optimize design for a general-purpose system, the more commonly used approach taken is to provide guidance based on the past experiences of the user to aid in considering the deviations that can be taken from the base systems. (These deviations can either increase or decrease the system reliability and, inversely, the system cost depending upon the mission time and the business need.) These types of deviation decisions have historically been made based on experience, but require an individual or individuals with sufficient operating experience to recognize the potential risks involved in order to make an informed judgment.

One approach to help determine what additional options should be considered (or base requirements deleted) on a given system is to consider possible failure modes of the components and the actions that can be taken to mitigate the risk associated with a particular failure mode. FMEA has been included in this annex to assist the user in this regard. The probability of a particular failure occurring within the mission time has not been provided due to a lack of industry data and effects of site variations on failure rate; however, the example given explains how a user can utilize the FMEA table to make design decisions based on his perception of the probability of a particular failure mode within the mission time considered.

The FMEA included as Table J.1 is a first attempt to document failure modes on type of equipment covered by API 614. The system used in the example has the following characteristics:

- a) equipment description: lubrication system;
- b) classification: general-purpose;
- c) design life of equipment: 20 years;
- d) mission of equipment: 24 months (provided as an example).

NOTE This should be determined by the user (see 6.1.2).

Although efforts have been made to make it as complete as possible, the user may wish to add failure modes and risk-reduction activities based on their own experiences.

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EXAMPLE A user has an application for a lubrication system for an API 610 pump. The business has defined a required mission time of 21 months. In this particular plant, the cooling-water quality is poor and tube fouling has historically been a problem. The user feels that this failure mode reduces the probability of the system reaching the 21-month mission time required for a single heat exchanger. The API 610 base standard system has a single heat exchanger; however, from the FMEA, under failure modes for a heat exchanger, tube fouling is listed along with some possible risk-reduction activities that can be considered. These include purchasing dual heat exchangers with a transfer valve for online switching, keeping the water velocity high and purchasing heat exchangers that have tubes that can be easily rodded out. In this case, due to the poor cooling-water properties, the user specifies that all of the options be taken into consideration in their specification. The use of dual heat exchangers in this instance allows a run-to-failure for this failure mode without affecting the system availability by allowing the standby heat exchanger to be used while the other heat exchanger is repaired.

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Table J.1—Failure Modes and Effects Analysis

Component	Subcomponent	Failure Mode of Subcomponent	Failure Cause	Example Risk Reduction Activity	Reference
Reservoir module		Inadequate heat for start-up	Low ambient, no heater provided	Provide an electric or steam heater.	6.6.8.1
		Corrosion	Material susceptibility	This requires consideration of SS or coatings if equipment casing is utilized as a reservoir.	6.6.14
		Water contamination due to a steam turbine-driven vertical pump	Poor design	Consider electric motor-driven vertical pumps or a horizontal steam turbine-driven pump not located on the reservoir. Use an oil conditioner on the supplied connections.	— 6.6.11, Figure C.23; see conditioner connections
		Moisture due to condensation	High humidity	Use a nitrogen purge with the supplied connections. Use an oil conditioner on the supplied connections.	6.6.10 6.6.11, Figure C.23; see conditioner connections
		Oil foaming	Inadequate retention time	Consider a longer retention time if a gear or other equipment that tends to entrain air in the oil is involved.	6.6.7.3, 6.6.7.5
		Presence of explosive atmosphere in vapor space	Compressor or pump seal failure, hazardous installation environment	Use nitrogen purge or verify nitrogen seal separation gas flow is sufficient to displace oxygen in vapor space. Add extraction mist eliminator.	— 6.6.5
		Ignition of explosive atmosphere in vapor space	ESD in low conductivity oils	Use antistatic filter media to reduce and dissipate charging of low conductivity oil. Use of grounding brushes for steam turbine drivers	L.5 and 6.2.10 NOTE 3 API 612
	Heater—electric	Burnt-out element	Excessive heat at element, time	Test element continuity prior to start-up when it is needed in cold weather. Specify a heater that is removable during operation.	— 6.6.8.7
		Loss of power	Electrical feed failure	—	—
		Inadequate heat into the system for start-up	Low ambient, excessive system heat loss	Consider the design of the entire system.	6.6.8.1, NOTE 2
	Heater—steam	Thermostat failure—contacts fail open or closed	Defective thermostat	Specify a heater that is removable during operation.	6.6.8.7
		Steam leak	Coil corrosion	Use a steam heater design with coils external to the reservoir.	—
		Inadequate heat into the system for start-up	Low ambient, excessive system heat loss	Consider the design of the entire system.	6.6.8.1, NOTE 2
	Level gauge	Clouded window	Time, material	Clean the sight glass; provide separate transmitter or magnetic flag type level indicator.	—
		Broken glass	Impact	Provide armored sight glasses; consider location.	—
	Level transmitter	Loss of signal	Transmitter failure	Use a self-diagnosing transmitter; replace transmitter online.	—

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Level switch

Failure to operate

Switch failure

Provide external cage-type housing that
can be tested online.

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Table J.1—Failure Modes and Effects Analysis (continued)

Component	Subcomponent	Failure Mode of Subcomponent	Failure Cause	Example Risk Reduction Activity	Reference			
Pump module	Shaft-driven pump	Pump failure	Pump-drive failure (coupling or shaft), pump failure	Provide an auxiliary pump.	6.7.1.3			
				Provide two motor-driven pumps for online replacement.	—			
	Motor-driven pump	Pump failure	Coupling failure, pump failure, motor failure	Provide an auxiliary pump.	6.7.1.3			
		Loss of power	Electrical feed	Separate electrical feeds on dual motor-driven pumps.	6.7.7.1, NOTE 2			
				Provide an HOA or HA switch for auxiliary pump testing.	8.2.1.4			
		Life of pump component	Time	Specify a larger, lower-speed pump.	—			
Submerged motor-driven pump	Pump failure	Pump component failure	Avoid submerged pumps if local regulations do not allow access while the unit is running.	—				
Heat exchanger module	Shell-and-tube or multi-plate	Tube or plate leak	Corrosion, erosion, manufacturing defect	Consider dual heat exchangers for online swapping and online repair.	—			
				A header pressure-control module can keep water out of the oil in the event of failure.	6.8.1.23			
				Choose alternate materials to withstand corrosion.	6.8.2.6.2			
				Mis-operation, such as live steam injection for heating	Sparge steam through the water; operate heat exchangers only under the conditions designed.	6.8.1.17		
				Water side fouling	Poor cooling water quality, time, corrosion	Consider dual heat exchangers for online swapping and online repair.	6.8.1.2	
						Maintain recommended water velocity.	6.8.1.9	
						Choose heat exchangers with straight tubes that can be easily rodded out, or with easily replaceable standard designs.	—	
						Choose alternate materials to better withstand corrosion.	6.8.2.6.2	
						Use a temperature control bypass. Do not throttle cooling water.	6.8.1.15.5	
						Use a shell-in-tube rather than multi-plate, which is less susceptible to fouling.	—	
				Loss of utility water	Utility system failure	Add cooling tower or utility water pump redundancy.	—	
						Car seal open any valves used in the system.	—	
				Multi-plate	Leak	Gasket failure	Use a fully welded unit (throwaway).	—
				Fin-fan	Fan failure	Motor, v-belt, bearings, fan blades	Use multiple fans.	6.8.4.4.1
	Consider direct drive rather than v-belts.	—						

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Oil too cold	Low ambient	Provide a temperature-controlled bypass valve; consider variable louvers.	6.8.4.4.10
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Table J.1—Failure Modes and Effects Analysis (*continued*)

Component	Subcomponent	Failure Mode of Subcomponent	Failure Cause	Example Risk Reduction Activity	Reference
Filter module		Collapse filter	High Δp due to cold oil	Make sure that the standby heat exchanger is adequately warmed using a bleed valve prior to switching.	—
			High Δp due to fouling	Consider use of a Δp transmitter to trend differential if in a service where fouling can be at a high level.	—
		Incorrect filter element	Incorrect element used	Standardize filter element, maintenance procedures.	—
		Static charge generation	Increased oil velocity through the filter element, higher-viscosity oil, certain oil additives	Ensure that reservoir grounding lug is connected; consider additional grounding of oil filters.	6.2.10, 6.6.15
Header pressure-control module	Regulator	Regulator fails closed	Regulator failure	Specify blocks and bypasses to repair online.	Schematic
Supply pressure-reducing module	Regulator	Regulator fails open	Regulator failure	Specify blocks and bypasses to repair online.	Schematic
Rundown tank module	—	Inadequate capacity for specific driver and driven equipment needs	Not feasible to make large enough	Provide lube-oil pump backup via alternate source (air, nitrogen, batteries, etc.).	—
	Atmospheric type	Fails to flow due to cold oil	Low ambient	Insulate, heat, or use pressurized-type rundown tank.	—
	Level transmitter	Loss of signal	Transmitter failure	Use a self-diagnosing transmitter; replace transmitter online.	—
		No permissive start signal	Empty tank	Failure to manually open fill bypass or failure in automated fill bypass system.	—
Piping		Connection leak	Excessively long-term vibration	Provide gusseting, proper support.	—
			Improper installation	Use API 686 installation guidelines.	—
Tubing		Connection leak	External loading	Revise support design; use pipe as alternative.	—
Instrumentation	Pressure gauge	Leak due to failed bourdon tube	Fatigue, corrosion	Keep block valves closed unless actually reading pressure.	8.3.8
				Allow replacing of blocks and bleeds online.	—
		Difficult to read due to vibration	Vibration, location	—	8.3.8.2
	Pressure switch	Switch fails to act when needed	Various	Use transmitters that have online fault-detection, assuming proper response time of system can be attained.	8.3.3
				Periodically test switches and use multiple switches.	—
	Pressure transmitter	Fails to operate	Internal failure	Use multiple transmitters and voting for trip signals.	—

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Annex K

(informative)

Varnish and Electrostatic Discharge

K.1 General

This annex is intended to provide users of API 614 with information relative to oil filter performance and oil-system cleanliness testing.

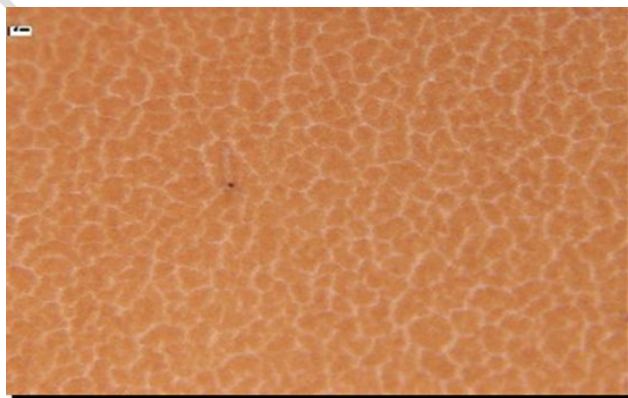
K.2 What Is Varnish

Varnish is the thin, insoluble film deposit that forms on fluid wetted surfaces inside hydraulic power and lubrication systems, including bearings, heat exchangers, and valves. Figure K.1 shows such deposit on the spool of a servo valve.



Figure K.1—Varnish Deposits on Lubrication System Servo Valve

The material is comprised of a wide range of oil additive and high molecular weight thermo-oxidative fluid breakdown compounds that have limited solvency in the base fluid. These compounds are polar in nature and, over time, begin to migrate from the base fluid to the wetted surfaces, based on the system and fluid conditions and their polar affinities. Initially, the surfaces start to show a gold/tan color building to darker gum-like layers that eventually develop into a hard lacquer-like material. The chemical compositions of these insoluble materials vary depending on the system operating conditions and the fluid base-stock and additive type. Figure K.2 shows a photomicrograph of the varnish material on an analysis membrane (0.45 μm porosity) at 100x magnification. The same material is shown at 1000x magnification in Figure K.3, using scanning electron microscope.



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Figure K.2—Varnish Material at 100x Magnification

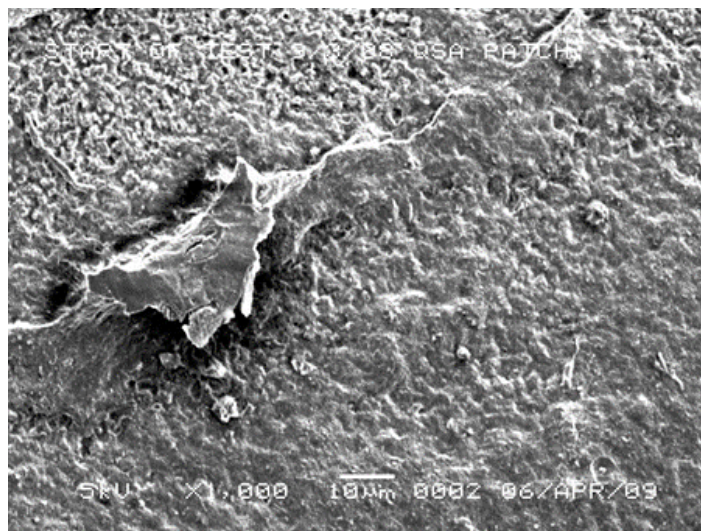


Figure K.3—SEM Photomicrograph of the Varnish Material at 1000x Magnification

There are a number of tests to quantify the amount of the varnish forming material in a fluid sample. These include ultracentrifuge, FTIR (nitration procedure), gravimetric analysis (for toluene soluble material), submicron particle count, and membrane patch colorimetric (MPC) analysis. The MPC method is by far the most commonly used method and was recently approved by ASTM (see ASTM D7843-12).

K.3 How Is Varnish Formed

Mineral oil-based fluids generate insoluble materials even under normal operating conditions. The rate of generation can be accelerated under severe and/or unusual operating conditions. Factors such as fluid oxidation, hot spots, chemical contamination, filter-related electrostatic discharge, micro-dieseling, and adiabatic compression are widely believed to be among the sources of varnish generation. Typical hydrocarbon-based fluids undergo oxidative degradation/polymerization to produce oil-insoluble sludge/varnish. Based on GPC analysis, this material has a molecular weight between 500 and 10,000 depending on the degree of polymerization (see Reference [K.1]). The chemical species responsible for varnish formation are not always related to the base-stock; the additive package and its interaction with the base-stock sometime plays a significant role in varnish formation. A number of oxygenated chemical compounds can be generated during the course of thermal oxidation including acids, alcohols, esters, or ketones. However, studies have shown that varnish precursors have species that contain predominantly two oxygen atoms per molecule, pointing to the role of hydroxyl-acids as active intermediates in varnish formation (see Reference [K.2]).

Oxidation inhibitor additives are added to the fluid to control the oxidation process. Two common categories of additives are hindered phenols and aromatic amines. Hindered phenols act as radical scavengers, more suited for lower temperatures, whereas amines perform better at higher temperatures. The mixed phenol/amine additive package has proven to be more robust since the phenols, in addition, also rejuvenate the depleted amines. A type of amine antioxidant, PANA, is known to form deposits of its own when it depletes, hence contributing to the deposits. Once the additives are depleted, the oxidation process greatly accelerates. Experts recommend close monitoring of the depletion of phenol and amine antioxidants. When the phenolic antioxidants approach the depletion level (20 % to 30 % of the original level), one may expect amine levels to begin falling, and the varnish potential to rise (see Reference [K.3]).

Elevated temperatures play an important role in the oxidation process—the general rule of thumb is that for every 10 °C (18 °F) increase in the operating temperature, the rate of oxidation doubles (Arrhenius Rate

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Rule). Water, wear metal particles such as iron and copper, and aeration act as catalysts to speed up this process. The material formed as a result of oxidation has characteristic infrared (IR) absorbance peaks in the 1740 cm^{-1} region as shown in Figure K.4. Besides oxidation, the other major pathway for fluid degradation in a turbine is thermal degradation. Three common sources of thermal degradation of the fluid and resulting varnish formation are a) adiabatic compression of the oil entrained air bubbles, b) hot spots in the system, and c) filter-induced electrostatic discharge. These items are discussed in more detail below, especially filter-induced electrostatic discharge since it is fairly common.

The source of the air bubbles, entrained in the fluid, can be the suction line leaks, pump seal leaks, and tank agitation caused by the fluid returning to the reservoir. These air bubbles when exposed to fast compression, such as at the inlet of a high-pressure pump or high load region of a bearing, can undergo rapid adiabatic compression with a resultant rapid increase in fluid temperatures. This is said to occur as the heat generated due to compression does not have enough time to dissipate. Typically, temperatures in excess of $1000\text{ }^{\circ}\text{F}$ may be reached during this adiabatic compression of the air bubbles. The high temperature spike initiates thermal degradation of the fluid, resulting in formation of resinous, varnish-forming materials. The materials formed as a result of thermal degradation often have characteristic IR absorbance peaks in the 1600 to 1640 cm^{-1} region—also known as nitration peaks due to the nitrogenous by-products, as shown in Figure K.4 (see Reference [K.4]).

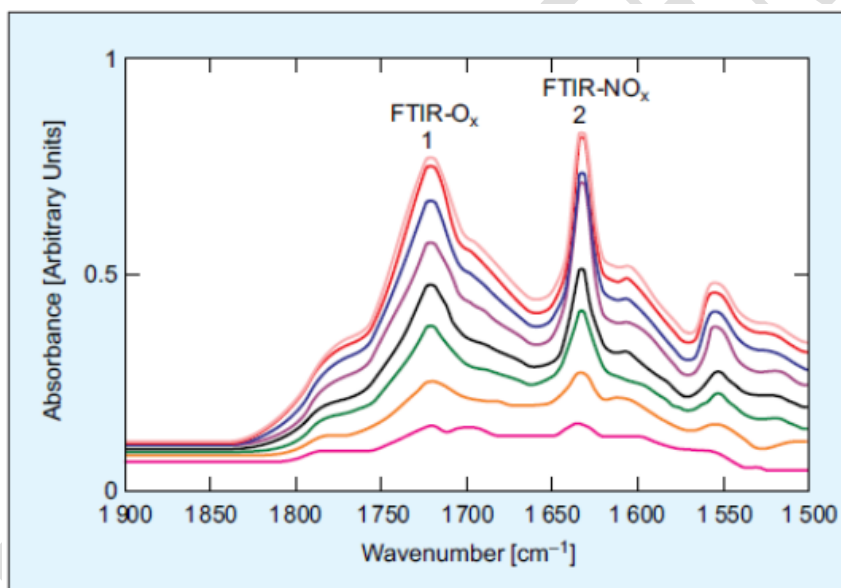


Figure K.4—FTIR Spectra of the Oxidation and Thermal Degradation Produced Varnish Material
(Adapted from Reference [K.4])

K.4 Varnish Mitigation

The technologies commonly in use for the removal of the existing varnish forming material from fluid systems can be divided into three categories—electrostatic purification, chemical cleaning/flushing, and adsorption by a disposable media (see Reference [K.5]) and fine filtration.

The electrostatic method, operating in kidney-loop mode off the main tank, subjects the fluid to an electrical field causing the varnish precursors to charge and agglomerate into larger particles, which are then captured by filter mat/pleats or force the particles that are polar to adhere to a charged, disposable surface. There are several designs based on variants of the electrostatic charging principle to accomplish the goal. The electrostatic-type devices are reported to remove varnish precursors from the fluid phase, and as the fluid cleans up, soft varnish deposits from surfaces are re-entrained in the fluid, and removed, thus resulting

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in the cleaning up the deposits accumulated over a period of time. Since the removal of varnish from system components is a relatively slow process, these devices are recommended to be operated over a long period of time or to be installed permanently. The electrostatic-type devices are reported to be sensitive to elevated moisture levels in the fluid and also to the presence of high levels of metal wear particles.

Chemical cleaning/flushing method for removing soft varnish utilizes cleaning chemicals that are typically circulated through the system to dislodge varnish from components. These chemicals soften and dissolve the insoluble materials and the flushing action suspends the hard deposits in the fluid, which are then removed with the fluid when the fluid is drained from the system. This process is usually performed for several hours to several days, depending on the size of the system and the extent of the varnish build-up on components. Hard lacquer-like varnish deposits are difficult to remove with just chemical flushing and require physical agitation (manual scrubbing) to remove. Once the flush and chemical treatment is complete, the system is flushed again with an appropriate flush fluid to remove all residual chemicals and to ensure no contamination finds its way into the new lubricating oil. Although this process is more intensive, it does allow for quicker removal of varnish deposits versus the other methods, especially in a large system. This method requires close monitoring and entails lost production as the system being treated is out of operation.

The adsorption method utilizes adsorbent medium with a large surface area and high void volume, relatively low fluid flux, and in some cases, electro-chemical affinity for the varnish precursors. Many materials can be used as adsorbents, including compressed cellulose, cotton linters, macroporous media such as resin beads, fuller's earth, or activated carbon. Adsorption is of two types: physisorption or chemisorption. Physisorption, also called physical adsorption, is a process in which the adsorbent material and the adsorbate (varnish precursors in the present case) molecules do not form chemical bonds. They are bonded by weak electrostatic forces, arising from induced dipole moments, such as van der Waals forces; therefore, the electronic structure of the adsorbate does not change upon adsorption. Because of its chemical structure, varnish molecules are believed to be attracted to the adsorbent through weak molecular forces such as van der Waals and hydrogen bonding. There are several vendors offering physisorption-based technologies for the removal of the varnish forming material from operating systems.

Use of fine filtration can be debated as a first line of defence against varnish. Some specially formulated media with extremely high filtration efficiencies and large surface area have shown to reduce varnish. Varnish material being semi-soft, finely dispersed particles and/or dissolved in oil, especially at higher temperature, is difficult to capture by the standard glass fiber filter. However, if the oil is cooled down and the dissolved particles come out of solution, they can form larger particulates that can be captured with the filter media to help with mitigating the varnish levels in the oil.

K.5 What Is Electrostatic Discharge?

Electrostatic charge generation occurs in hydraulic and lubrication systems as a result of the interaction between the fluid and the system components, referred to as triboelectric charge generation. Glass fiber media filters commonly used have high surface area in contact with moving fluid, thus have potential to generate copious amounts of charge. Electrostatic charge manifests itself in several ways, the most obvious, noticeable effect being an audible noise (clicking sound) as the accumulated charge discharges, causing sparking internally within the system. The charged fluid carries the electrical charge downstream of the filter, causing damage to system components and the filter itself when the charge dissipates by discharging to a lower electrical potential or grounded surface.

The high energy in the electrostatic discharge cracks the oil molecules producing hydrogen and low molecular weight hydrocarbon gases. These gases and other flammable gases introduced by the process (e.g. natural gas compressor) are a potential source of explosion in the presence of oxygen from air and the arcing due to electrostatic charge inside a fluid reservoir. Oil mist, commonly present in the headspace of a reservoir, is another potential source of explosion by the arcing due to electrostatic discharge (see Reference [K.6]).

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Numerous studies have been conducted on the effects of static discharge in hydraulic and lubrication systems. Recently, attention has been directed to fluid electrification and static discharge by filters as a prominent contributor to sludge and varnish formation in turbine lubrication systems (see Reference [K.7]).

The amount of charge generated by the flow of a hydrocarbon liquid through a filter is related to several fluid and filter properties. Charge generation/accumulation generally increases with increasing flow rate (velocity through the filter element), reduced fluid conductivity, with certain additive packages, and with lower temperature (higher viscosity). In the filter housing, the charge on the filter element is of opposite polarity than that of the fluid. The charge is carried downstream by the fluid, and when enough charge is accumulated, the fluid dielectric constant is exceeded and discharge occurs to a conductive part of the filtration or fluid system that is at a potential lower in magnitude, resulting in potential damage to that part of the system. The extent of damage will depend upon the material involved and the magnitude of the generated charge.

Currently, there is no standard test procedure, ratified by a standardization body such as ISO or ASTM, for the measurement of electrostatic charge generated in a fluid system. Several filter companies have come up with proprietary field and laboratory test methods to measure the charge generated by the filters. The two biggest factors contributing to electrostatic charge generation are oil conductivity (measured in pS/m) and the hydraulic load (flow rate per unit area); these values should be reviewed with the filter manufacturer when selecting a filter.

Various methods have been tried to alleviate the potential of static charge accumulation in fluid systems. Among them are antistatic additives, which may not be suitable for turbine oils; the use of conductive mesh downstream of the filter material, which have limited effectiveness in preventing charge accumulation in the fluid; increasing the time for the charge to decay, which requires system design change. Filtering the fluid at a lower flow density (i.e. increasing the filter size) does rectify the problem, but this is not a viable option for every system (see Reference [K.8]). Several filter manufacturers have introduced filters made with filtration media that do not generate charge to the same extent as the "standard" glass fiber-based media that is currently the most commonly used filter media in the industry. Therefore, the filters reduce accumulation of the charge to levels that can prevent arcing and discharges and the resulting damage to the fluid and the system components.

NOTE 1 Due to potential static electricity, there is a possibility to ignite an explosive mixture if present in the reservoir.

NOTE 2 Measures available to mitigate static electricity build-up include separate grounding of oil filters; minimize any recirculation of oil downstream of the filters and use of antistatic filter media.

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