

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

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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. This information should be indicated in the data sheets; otherwise, it should be stated in the quotation request or in the purchase order.

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.1 contains a site and utility data sheet.

Annex A.2 contains 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 contains diagrams of typical lubrication, oil-type shaft-sealing, and oil-control systems.

Annex I provides guidance on oil drain line sizing.

Annex J contains an inspector’s checklist.

Annex K contains a guide to system reliability.

Annex L provides guidance on varnish and electrostatic discharge.

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

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. For dry gas seal systems, refer to API 692.

NOTE For 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 amendments) applies, except that new editions may be used on issue and shall become mandatory upon the effective date specified by the publisher or 6 months from the date of the revision (where no effective date is specified).

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 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*

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*

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

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.

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/D1.1M ⁵, *Structural Welding Code—Steel*

EN 1092-1 ⁶, *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*

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

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.

IEEE 841 ⁸, *Premium-Efficiency, Severe-Duty, Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors--Up to and Including 370 kW (500 hp)*

ISA S12.4 ⁹, *Instrument Purging for Reduction of Hazardous Area Classification*

ISA 18.1, *Annunciator Sequences and Specifications*

ISO 7-1 ¹⁰, *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 behaviour*

ISPM Pub. No. 15 ¹¹, *Regulation of wood packaging material in international trade*

NFPA 70 ¹², *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*

TEMA ¹⁴, *Standards of the Tubular Exchanger Manufacturers Association*

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.

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

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 parameter at which an alarm warns of a condition requiring corrective action.

NOTE API 670 provides additional information for monitoring of alarm points.

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.

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 millimetres, 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.

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**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.

3.1.24**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.

3.1.25**normal operating point**

Point at which normal operation is expected and optimum efficiency is desired.

NOTE This point is usually the point at which the vendor certifies that the performance is within the tolerances stated in the relevant standard.

3.1.26**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.

3.1.27**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.

3.1.28**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.

3.1.29**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.

3.1.30**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.

3.1.31**owner**

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

3.1.32**package**

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

3.1.33**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).

3.1.34**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.

3.1.35**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.

3.1.36**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.

3.1.37**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.

3.1.38**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.

3.1.39**remote**

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

3.1.40**rundown**

Oil capacities associated with operational vs. nonoperational states.

NOTE Pertains to oil capacities in reservoirs and overhead tanks.

3.1.41**self-contained regulator**

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

3.1.42**separation gas**

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

3.1.43**settling-out pressure**

Maximum pressure the system can reach under static conditions.

3.1.44**shaft-driven pump**

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

3.1.45**shutdown**

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

3.1.46**shutdown point**

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

NOTE API 670 provides additional information for monitoring of shutdown points.

3.1.47**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.

3.1.48**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.

3.1.49**standby service**

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

3.1.50**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 nonpressurized returns and has an open top or vent holes to equalize to reservoir pressure.

NOTE 2 See Figure C.23.

3.1.51**trip**

Automated shutdown to ensure personnel safety (safety critical).

3.1.52**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.

3.1.53**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.

3.1.54**vent gas**

Gas leakage that is taken away by the vent system.

3.1.55**vent system**

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

3.1.56**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.

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, according to the type of equipment being served, as described in Table 2.

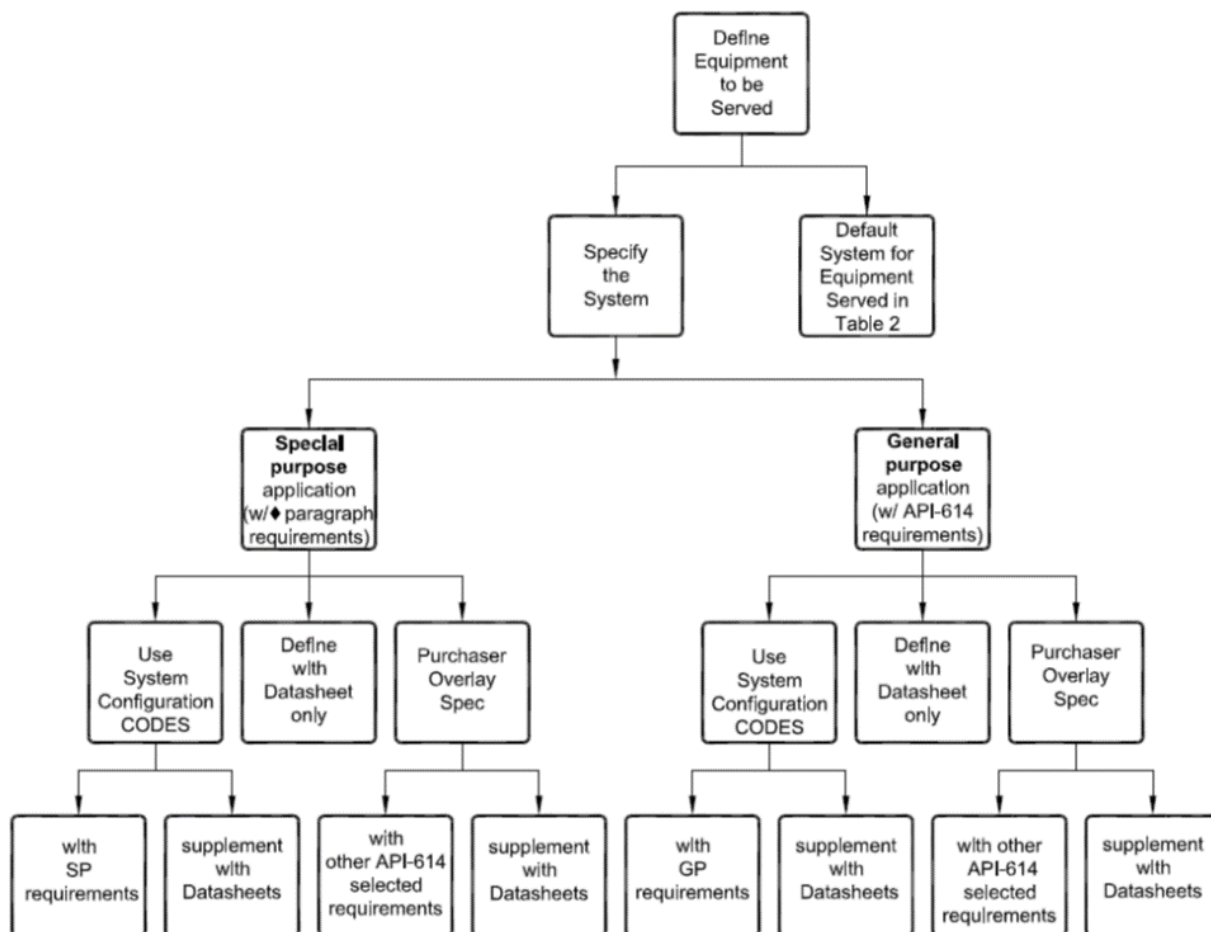
NOTE The system configuration codes are intended for use when no other purchaser requirements are given.

- **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 in Table 2.

- a) Specify the configuration option codes from Table 1.
- b) 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.

- c) Specify system features and options individually on the oil system data sheet (typical data sheets are included in Annex A.2).
- d) Purchaser specification.



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 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.

- **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 Default minimum system configuration by equipment class is shown in Table 2.

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 Various API standards have supplied minimum recommended systems as indicated in Table 2 for their equipment. Refer to figures in Annex H for further clarification.

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
Pump and driver configuration: — Steam turbine-driven main pump — AC motor-driven auxiliary pump	Rotary pumps		PRTA0
	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	R0
External reservoir			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	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
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	w/o block-and-bypass	If air-cooled heat exchangers are used, or oil pressure is not above water cooling pressure.	PV1
	w block-and-bypass		PV1B
Additional lube-oil PCV downstream of filter	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
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.2.

Table 2—Requirements for Oil System Code by Equipment Type

Equipment Type ^a	Figure	System Code
API 541 Squirrel cage induction motors ≥ 375 kW	H.1	LO-PRAA0-R1-HE-BP2-CS1-F2-A0-PV0-TV1-OT0
API 546 Synchronous motors and generators	H.1	LO-PRAA0-R1-HE-BP2-CS1-F2-A0-PV0-TV1-OT0
API 547 General-purpose form-wound squirrel cage induction motors—185 kW (250 hp) through 2240 kW (3000 hp)	H.2	LO-PRAA0-R1-H0-BP1-CS1-F2-A0-PV0-TV1-OT0
API 610 Centrifugal pumps	H.3	LO-PRAA0-R1-H0-BP0-CS1-F2-A0-PV1-TV1-OT0 Or LO-PRAA0-R1-H0-BP1-CS1-F2-A0-PV1-TV1-OT0
API 611 General-purpose steam turbines	H.4	LO-PRAA0-R1-HE-BP1-CS1-F2-A0-PV1-TV0-OT0
API 612 Special-purpose steam turbines without control oil	H.5A	LO-PRAA0-R1-HE-BP2-CS2-F2-AL-PV2B-TV3B-OTA
API 612 Special-purpose steam turbines with control oil	H.5B	LCO-PRTA0-R1-HE-BP2-CS2-F2-ALC-PV2B-TV3B-OTA
API 613 Special-purpose gears	H.6	LO-PRAA0-R1-HE-BP2-CS2-F2-A0-PV2B-TV3B-OTA
API 616 Gas turbines	—	NOTE There is no “default” minimum configuration for API 616 Gas Turbines.
API 617 Part 2—Centrifugal and axial compressors with electric motor driver	H.7A	LO-PRAA0-R1-HE-BP2-CS2-F2-A0-PV2B-TV1B-OTA
API 617 Part 2—Centrifugal and axial compressors with ST or GT driver	H.7B	LCO-PRAA0-R1-HE-BP2-CS2-F2-AC-PV2B-TV1B-OTA
API 617 Part 3—Integrally geared compressors	H.7C	LO-PRSA0-R0-HE-BP0-CS2-F2-A0-PV2B-TV1B-OT0
API 617 Part 4—Expander-compressors	H.7D	LO-PRAA0-R1-HE-BP2-CS2-F2-A0-PV2B-TV1B-OTA

Table 2—Requirements for Oil System Code by Equipment Type *(continued)*

Equipment Type ^a	Figure	System Code
API 618 Reciprocating compressors [<150 kW (200 hp) with rolling element bearings]	H.8A	LO-PRS00-R0-HE-BP2-CS1-F2-A0-PV0-TV1-OT0
API 618 Reciprocating compressors	H.8B	LO-PRSA0-R0-HE-BP2-CS1-F2-A0-PV2-TV1-OT0
API 619 Positive-displacement rotary helical-lobe compressors (oil-free)	H.9A Or H.9B (Alternate)	LO-PRAA0-R1-HE-BP2-CS2-F2-A0-PV2B-TV1B-OT0 Or LO-PRSA0-R1-HE-BP0-CS2-F2-A0-PV1B-TV1B-OT0
API 619 Positive-displacement rotary helical-lobe compressors (oil-flooded)	H.10	LO-PCAA0-R1-HE-BP0-CS1-F2-A0-PV1B-TV3B-OT0
API 672 Integrally geared centrifugal air compressors (basic)	H.11A	LO-PRSA0-R0-H0-BP0-CS1-F2-A0-PV0-TV0-OT0
API 672 Integrally geared centrifugal air compressors (special duty)	H.11B	LO-PRSA0-R1-H0-BP0-CS1-F2-A0-PV1-TV0-OT0
API 673 Centrifugal fans (general purpose)	H.12A	LO-PRAA0-R1-H0-BP1-CS1-F1-A0-PV0-TV1-OT0
API 673 Centrifugal fans (special purpose)	H.12B	LO-PRSA0-R1-H0-BP1-CS1-F2-A0-PV1-TV1-OT0
API 674 Reciprocating pumps	H.13	LO-PRS00-R0-H0-BP0-CS1-F1-A0-PV0-TV0-OT0
API 677 General-purpose gears	H.14	LO-PRS00-R0-H0-BP0-CS1-F1-A0-PV0-TV0-OT0
NOTE 1 This table is presented for guidance in the selection of a lubrication system for the above-referenced equipment.		
NOTE 2 The recommended base systems are based on the individual referenced equipment standard recommendations at the time of publication of API 614.		
^a The referenced equipment standards may suggest alternative base systems in editions published subsequent to API 614, or the user may select alternative systems based on his experience or a failure modes and effects analysis (FMEA) as described in Annex K.		

- **4.8** The purchaser and the vendor shall agree upon an acceptable system before the order is released. Diagrams of typical complete lubrication, oil-type shaft-sealing, and control-oil systems are provided in Annex H. These diagrams illustrate the general philosophy and requirements of this standard and are included to assist the purchaser in the selection of an appropriate system. Symbols shown on these diagrams are identified in Annex B.

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 subvendors.

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.2.

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.

NOTE It is recommended that this is done as early as possible and preferably in the inquiry stage.

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

NOTE The European Economic Area includes the countries of the European Union plus Norway, Iceland, and Liechtenstein and the requirements also apply in Turkey, which is not part of the European Economic Area.

5.4 Document Hierarchy

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

NOTE Typical documents include company and industry specifications, meeting notes, and modifications to these documents.

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.

NOTE 1 Each of these are methods to specify a lube-oil system. A completed API 614 data sheet provides the most detailed and flexible method for specifying the purchaser's preferred system.

NOTE 2 Default configuration code definitions are given in Table 2 for various driven equipment types. The purchaser can use these codes as needed to describe the preferred oil system. Features not covered by the code are described in 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, during which time the equipment should not require shut down to perform maintenance or inspection.

NOTE 1 It is realized that there are some services where this objective is easily attainable and others where it is difficult.

NOTE 2 Auxiliary system design and design of the process in which the equipment is installed are very important in meeting this objective.

- **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 691 can provide guidance.

- **6.1.3.1** If specified, the vendor shall provide the documentation to demonstrate that all equipment proposed qualifies 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 explanation 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.

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 now part of API 614 and is located in informative 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 (eyebolts, hoist rings, etc.) 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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6.2 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. Annexes A.1 and A.2 are intended to assist in this definition.

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

6.2.2 If components are spared, the design shall allow for 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 Unless otherwise specified, 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.

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. In addition, 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.

- **6.2.6** The purchaser shall specify the driven equipment's normal operating point and alternate operating points, including transients.

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

NOTE Annex C contains piping and instrument diagrams (P&IDs) for typical arrangements.

- **6.2.8** 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 purchaser 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.

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

6.2.10 Recirculated bypass oil shall originate upstream of the filters.

NOTE 1 This is 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. Annex L includes a discussion of static build-up.

NOTE 2 Due to potential static electricity, there is a possibility to ignite an explosive mixture if present in the reservoir.

NOTE 3 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.

NOTE 4 Instrument bleeds are not considered recirculated bypass.

NOTE 5 Recirculation bypass downstream of the filters can create excessive pressure drop when both pumps are running, risking filter collapse.

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

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

- **6.2.13** If specified, 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).

6.2.14 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.

- **6.2.15** If specified, 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.

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

6.2.17 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.

- **6.2.18** 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.

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

6.2.20 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, interconnecting piping, etc., might not be installed on test.

- **6.2.21** 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.

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

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

6.2.22 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.

6.2.23 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.

- **6.2.24** If specified, a dynamic simulation shall be performed for the oil system. The purchaser shall define the scope of the study and any verification testing requirements.

NOTE Dynamic simulations typically cover the operating modes and transient conditions such as pump changeover, valve transfer, filter transfer, hydraulic governor transient, etc.

6.3 Pressure Design Code

- **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** If specified by the purchaser, vessels indicated on the data sheet shall be code stamped.

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 2 Some facilities do not require code stamped filters.

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

NOTE 4 Subsection 5.3 of this standard addresses statutory 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, nonpressure 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 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 Baseplates shall extend under all mounted components to contain and drain any leakage.

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

6.5.3.2 Unless otherwise specified, single-piece package 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 baseplate shall be provided with lifting attachments for at least a four-point lift.

6.5.6.1 Lifting attachments on the 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 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 Design of lifting attachments can be in accordance with standards such as ASME BTH-1 *Design of Below-the-Hook Lifting Devices*.

NOTE 3 Some equipment with integrated reservoirs is sometimes designed to be shipped with oil in the reservoir.

- **6.5.6.3** If specified, the lifting lugs or trunnions that are attached by welding and have continuous welds shall be 100 % NDE tested in accordance with the applicable code.

6.5.6.4 Unless otherwise agreed, 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** If specified, 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 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 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 catalysed 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.

- **6.5.13** If specified, the 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.

6.6 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 ($1/8$ in./ft).

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 ($1\frac{1}{2}$ in.) and larger shall be flanged.

- ♦ **6.6.2.10** If specified, all reservoir pipe connections shall be flanged, except as specified in 6.6.10 (plugged threaded connections) or 8.3.5 (threaded thermowell connections).

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.

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 to settle moisture and foreign matter adequately and to provide allowance for rundown from the entire system.

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

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

6.6.4.3 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.

- ◆ **6.6.4.3.1** 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.

6.6.4.3.1.1 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.

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

6.6.4.3.1.3 If more than one level glass is provided, they shall be offset.

- **6.6.4.3.2** If specified, alternate means of level indication, such as magnetic type level indicator with stainless steel float chamber, shall be supplied.

6.6.4.3.2.1 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.

6.6.4.3.2.2 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.

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

NOTE Examples of oil reservoirs that commonly receive alternative level indication are reservoirs located inside enclosures or within equipment baseplates. This indication may be visible only at the control panel.

6.6.4.4 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.

6.6.4.4.1 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.)

6.6.4.4.2 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.

- ♦ **6.6.4.5** If specified, a fill opening at least 50 mm (2 in.) in diameter that automatically closes (normally held shut by a spring) and is 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 shall be provided.

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 aluminium material, which are not suitable for some environments.

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

6.6.4.7 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.

6.6.4.8 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.

6.6.4.9 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.

6.6.4.10 The vendor shall provide the purchaser with the vent size and the sizing criteria.

6.6.4.11 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.

- **6.6.4.12** 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** If specified, 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.

NOTE 1 Mist eliminators can reduce oil mist emissions, recover oil, and help prevent oil leaks.

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

NOTE 3 Some environments that contain corrosive gases, particulates, dust, excessive humidity, etc. 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 vendor having 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 (gearbox housing, coupling guard, etc.) 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.

- **6.6.5.8** If specified, 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 nonvented 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 μm .

NOTE 99.97 % for droplet size 0.3 μm 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 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** If specified, oil mist eliminator arrangements shall be fitted with suitable isolation and bypass valves to enable maintenance while in operation.
- **6.6.5.14** If specified, 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** If specified, 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

- **6.6.6.1** If specified, 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.

NOTE The flame arrestor points 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, Figure G.1.

6.6.7.2 The working capacity between G.3 and G.4 in Figure G.1 shall be sufficient for at least 3 minutes of normal flow.

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 G.3 and G.4 in Figure G.1 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 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, air-cooled heat exchangers, control elements, and vendor-furnished piping.

6.6.7.7 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 1 Rundown can cause some backup in the drain lines entering the reservoir.

NOTE 2 Especially long distances between the oil system and equipment can require greater than 10 % of the volumes defined in 6.6.7.6.

6.6.7.8 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 (transmitters, etc.).

6.6.7.9 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 usage 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.

6.6.7.10 The usage rate shall be provided by the seal manufacturer.

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

- ♦ **6.6.7.11** If specified, a low-level alarm that actuates at the minimum operating level shall be provided, regardless of whether a heater is included.
- ♦ **6.6.7.12** 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 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** The purchaser shall specify whether the heaters are steam or electric.

6.6.8.2.1 If heaters are required, they shall be provided for heating the charge capacity of oil before start-up in cold weather.

6.6.8.2.2 The device 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 12 hours while circulating oil through the system.

NOTE Subsection 6.7.15 provides minimum oil temperatures for starting pumps.

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

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

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

6.6.8.3 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.

6.6.8.4 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.

- ♦ **6.6.8.5** 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.

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

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

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

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

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

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

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

- **6.6.8.7** 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.

6.6.8.7.1 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.

- **6.6.8.7.2** 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.

NOTE Oil "coking" is a degradation of oil from excessive high temperature exposure resulting in carbon particle formation and deposits. Oil coking degradation reduces the heat transfer from the heater elements. For typical petroleum and paraffinic base stock oils, coking can occur at temperatures as low as 150 °C (300 °F), whereas their associated flash points are typically in the 175–195 °C (350–380 °F) range. Synthetic blend oils or other heat transfer fluids can have higher temperature values.

- **6.6.8.8** 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 12 hours if the equipment temperature is at the minimum specified machinery ambient temperature.

6.6.8.8.1 The analysis shall be provided to the purchaser.

6.6.8.8.2 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.

NOTE Consideration of lighter-viscosity oil compatible with the entire train can allow the permissive starting temperature to be lowered.

6.6.9 Provision for Insulation

- **6.6.9.1** If specified, reservoirs shall be fitted with insulation clips.

6.6.9.2 The purchaser shall furnish and install the insulation.

6.6.10 Plugged Connections

- ♦ **6.6.10.1** If specified, each reservoir shall be provided with one threaded and plugged connection above the rundown oil level that is at least 25 mm (1 in.) in diameter. This connection may be used for such services as purge gas, makeup oil supply, and oil conditioner return.

6.6.10.2 This connection 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** If specified, 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 specified, an accessible ladder with extended handrails shall be provided.
- **6.6.13.2** If specified, handrails around the perimeter of the reservoir top shall be provided.
- **6.6.13.3** If specified, nonskid surface decking (checker or diamond plate or hot-dipped galvanized steel grating) shall be provided on the top of the reservoir.

NOTE 1 Safety requirements often dictate that 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.

NOTE 2 Local safety regulations and/or purchaser's risk assessment determine the necessity and features of ladders and handrails (see 5.3).

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

6.6.13.5 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.

- **6.6.13.6** If specified, 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 Unless otherwise specified, reservoirs and all features welded to reservoirs shall be fabricated from austenitic stainless steel in accordance with ASTM A240/A240M, Type 304.

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, is sometimes available only in alternate materials, such as cast iron.

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 ($1/2$ in. UNC) bolt.

6.6.15.3 Two grounding clips or pads on diagonally opposite sides of the 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** If specified, pumps shall comply with API 610, ASME B73.1, ASME B73.2, or API 676.

NOTE Manufacturer standard pumps can be adequate for some systems.

- ♦ **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.

- ♦ **6.7.2** If specified, pumps shall be external to the reservoir.

NOTE 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.

NOTE 1 A lube-oil rundown tank can provide bearing oil for rundown.

NOTE 2 Sometimes an emergency oil pump with separate power source is supplied in order to allow cool-down oil subsequent to coast-down.

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 as outlined in API 610.

6.7.6 Submerged pump casings may be made of cast iron.

- **6.7.7** Main oil pump shall be steam turbine driven.

6.7.7.1 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.

NOTE 3 Steam turbine-driven main oil pumps are often used in oil systems serving steam turbine-driven main equipment.

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.

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

- a) net positive suction head or net positive inlet pressure;

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

- b) 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.

- c) maintenance accessibility;

- d) shaft coupling;

- e) drive shaft positioning due to thermal growth;

- f) 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.
- 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** If specified, 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.

- ♦ **6.7.18** If specified, 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.

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 on each pump or in the piping supplied by the vendor.

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.

6.7.22.2 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.

6.7.22.3 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.

- ♦ **6.7.22.4** If specified, PLVs shall not be used for continuous pressure regulation.

6.7.22.5 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.

- **6.7.22.6** If specified, PLVs shall be tight shutoff and design code compliant.

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

- **6.7.22.7** If specified, manual bypass valves shall be provided around PLVs. See Figure C.21 and Figure C.22.

6.7.23 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.

6.7.23.1 Each device shall have an adequate response time and 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)].

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

6.7.24 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.

6.7.25 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.

6.7.26 All pumps (except shaft-driven pumps) shall be installed with flooded suctions to ensure self-priming and shall be installed with suction-block valves (unless the pumps are inside the reservoir) and with discharge-block and discharge check valves.

NOTE Reference can be made to API 686 for piping design for pump installation.

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

6.7.26.2 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 shall have a separate suction line from the reservoir.
- c) The pump-suction lines shall be 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) shall avoid the possibility of overpressure caused by leaking discharge check valves.

6.7.27 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 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.

6.7.27.1 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.

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

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

- ◆ **6.7.27.4** 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.

6.7.28 Unless otherwise specified, 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.

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

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

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

6.7.28.4 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 1 Strainer bodies can require removal from the system for basket access.

NOTE 2 Elimination of these bushings can raise pump suction connections.

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

- ◆ **6.7.30** If specified, if a permanent strainer is being used, a compound-type pressure gauge shall be installed between a permanent strainer and the pump suction.

6.7.31 When specified by 6.7.30, the gauge shall be scaled properly to detect a fouled strainer.

NOTE Subsection 6.7.30 typically does not apply to submerged pumps that have a permanent strainer and no provisions for a gage.

6.7.32 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.

6.7.32.1 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.

6.7.32.2 Motor control centers shall be provided by the purchaser.

6.7.32.3 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.

6.7.32.4 Scope of supply for controls and reset should be determined by the purchaser and the vendor.

6.7.33 Each exposed coupling shall have a coupling guard that is removable without disturbing the coupled elements and shall meet the requirements of 6.7.33.1 through 6.7.33.5.

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.

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

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

6.7.33.3 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.

6.7.33.4 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.).

6.7.33.5 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 Nonspacer elastomeric couplings may be used for driver power ratings up to 22 kW (30 hp).

- **6.7.35** If specified, for driver power ratings below 22 kW (30 hp), couplings shall meet the requirements of 6.7.34.

6.7.36 For driver power ratings 22 kW (30 hp) and larger, 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.

NOTE The DBSE dimension usually corresponds to the nominal coupling spacer 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.

NOTE One way of achieving this is to provide at least 25 mm (1 in.) of bare shaft between the coupling hub and the bearing housing where alignment brackets are located.