# INTERNATIONAL STANDARD

# ISO 10438-2

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# Petroleum, petrochemical and natural gas industries — Lubrication, shaft-sealing and control-oil systems and auxiliaries —

## Part 2: **Special-purpose oil systems**

*Industries du pétrole, de la pétrochimie et du gaz naturel — Systèmes de lubrification, systèmes d'étanchéité, systèmes d'huile de régulation et leurs auxiliaires —*

*Partie 2: Systèmes d'huile pour applications spéciales*

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# Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 10438-2 was prepared by Technical Committee ISO/TC 67, *Materials equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 6, *Processing equipment and systems*.

This second edition cancels and replaces the first edition (ISO 10438-2:2003), which has been technically revised.

ISO 10438 consists of the following parts, under the general title *Petroleum, petrochemical and natural gas industries — Lubrication, shaft-sealing and control-oil systems and auxiliaries*:

— *Part 1: General requirements*

— *Part 2: Special-purpose oil systems*

— *Part 3: General-purpose oil systems*

— *Part 4: Self-acting gas seal support systems*

## Introduction

This International Standard was developed jointly with API 614 5th edition. ISO 10438 is divided into four parts corresponding to the four chapters of API 614.

Users of this part of ISO 10438 should be aware that further or differing requirements can be needed for individual applications. This part of ISO 10438 is not intended to inhibit a vendor from offering, or the purchaser from accepting, alternative equipment or engineering solutions for the individual application. This may be particularly appropriate where there is innovative or developing technology. Where an alternative is offered, the vendor should identify any variations from this part of ISO 10438 and provide details. This part of ISO 10438 is to be used in conjunction with 10438-1.

This part of ISO 10438 requires the purchaser to specify certain details and features.

A bullet (•) at the beginning of a clause or subclause indicates that either a decision is required or further information is to be provided by the purchaser. This information should be indicated on suitable data sheet(s); otherwise it should be stated in the quotation request (inquiry) or in the order.

In this International Standard, US Customary (USC) or other units are included in brackets for information.

# Petroleum, petrochemical and natural gas industries — Lubrication, shaft-sealing and control-oil systems and auxiliaries —

# Part 2: Special-purpose oil systems

## 1 Scope

This part of ISO 10438, in conjunction with of ISO 10438-1, specifies requirements for oil systems for special-purpose applications. These oil systems can provide lubrication oil, seal oil or both. These systems can serve equipment such as compressors, gears, pumps and drivers.

NOTE The term “special-purpose application” is defined in ISO 10438-1.

## 2 Normative references

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

ISO 10438-1:2007, *Petroleum, petrochemical and natural gas industries — Lubrication, shaft-sealing and control-oil systems and auxiliaries — Part 1: General requirements*

ISO 13706:2005, *Petroleum, petrochemical and natural gas industries — Air-cooled heat exchangers*

ISO 13709, *Centrifugal pumps for petroleum, petrochemical and natural gas industries*

ISO 4572, *Hydraulic fluid power — Filters — Multipass method for evaluating filtration performance*

API STD 611, *General- Purpose Steam Turbines for Petroleum, Chemical and Gas Industry Services*

API RP 686-96, *Machinery RP Installation and Installation Design*

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

## 3 Terms, abbreviated terms and definitions

For the purposes of this document, the terms, abbreviated terms and definitions given in ISO 10438-1 apply.

# 4 General requirements

## 4.1 General

**4.1.1** The equipment (including auxiliaries) covered by this part of ISO 10438 shall be designed and constructed for a minimum service life of 20 years and at least 5 years of uninterrupted operation.

NOTE It is recognized that this is a design criterion.

**4.1.2** The oil system shall be suitable for special-purpose applications as defined in ISO 10438-1. The system shall be designed as a separate console, or, if approved by the purchaser, it may be designed to be integral with the baseplate of the equipment it serves. The design shall allow for transfer between and shutdown of the main and spare components of the system for maintenance without interrupting the operation of the system or the equipment the system serves.

**4.1.3** Unless otherwise specified, one oil system per equipment train shall be supplied.

NOTE If equipment trains share a common oil system, damage due to cross-contamination can affect all equipment served. Block valves can be needed in supply lines that, for maintenance reasons, have the potential to be accidentally closed. Equipment location can require unacceptably long runs of piping, equipment transients and other potentially detrimental factors that it is necessary to consider.

● **4.1.4** The purchaser shall specify the equipment's normal operating point and alternate operating points including transients.

NOTE Data sheets that can be used for specifying are included in Annex A.

● **4.1.5** Control of the sound pressure level (SPL) of all equipment furnished shall be a joint effort of the purchaser and the vendor having unit responsibility. The equipment furnished by the vendor shall conform to the maximum allowable sound pressure level specified. In order to determine compliance, the vendor shall provide both maximum sound pressure and sound power level data per octave band for the equipment.

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

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

● **4.1.7** 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 owner on the basis of mutual 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.

● **4.1.8** The system shall be designed to supply oil to all equipment specified.

**4.1.9** The recycled oil shall originate upstream of the filters.

NOTE 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. This is very important, especially if explosive gas can also be present in the reservoir.

● **4.1.10** The seal-oil system 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) start-up conditions.

**4.1.11** In addition to the above requirements, seal-oil systems shall be designed to operate safely prior to 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.

**4.1.12** The arrangement of the equipment, including piping and auxiliaries, shall be developed jointly by the purchaser and the vendor. The arrangement shall provide adequate clearance areas and safe access for operation and maintenance.

● **4.1.13** If applicable, the purchaser shall specify minimum requirements for clearance around and access to components (especially clearance around and access to coolers, filters and hand valves).

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

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

● **4.1.16** The purchaser shall specify when and where double block and bleed valves are required for isolating a component and how they are arranged.

● **4.1.17** Coolers, filters, overhead oil tanks, drain traps, accumulators and other pressure vessels shall be in accordance with the specified pressure design code (Refer to ISO 10438-1:2007, 4.4). If specified by the purchaser, vessels shall be code stamped.

NOTE 1 Code stamping might not be applicable for pressure design codes other than ASME.

NOTE 2 Refer to ISO 10438-1:2007, 4.5.7. Local jurisdictions can require a code stamp and conformity assessment markings.

**4.1.18** The console shall perform on the test stand and on its permanent foundation within the specified acceptance criteria. 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.

● **4.1.19** The vendor shall advise the purchaser of, and both parties shall mutually 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. Provisions shall be adequate for coast-down time, cool-off time and block-in time as applicable; the purchaser shall specify the required block-in time. The purchaser and the vendor shall mutually agree upon the system and its components.

**4.1.20** 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.

## 4.2 Baseplates

● **4.2.1** The system shall be designed as a single console, in multiple packages or in any other arrangement as specified. Each package shall have a structural steel baseplate with all system components and related valves and manifolds mounted on the baseplate. The major component supports (pumps, filters, coolers, reservoir, etc.) shall be mounted directly on structural steel.

**4.2.2** Unless otherwise specified, package baseplates shall be of the drain-gutter type with one or more drain connections at least DN 40 (NPS 1 1/2) in size. Baseplates, mounted components and decking shall be arranged and installed to ensure drainage and to avoid the retention of liquid by sloping of the decking and gutters.

- **4.2.3** If specified, flat decking may be furnished.

NOTE Minor puddling of fluid can occur.

**4.2.4** The baseplate shall be provided with lifting lugs for at least a four-point lift. The baseplate shall be designed so that after the components and all piping mounted on it are drained of oil, the package can be lifted without permanently distorting or otherwise damaging either the baseplate or any component mounted on it.

NOTE Spreader bars can be required.

**4.2.5** Unless otherwise specified, non-skid metal decking covering all walk and work areas shall be provided on the top of the baseplate.

NOTE Examples of other options are grating or phenolic material to reduce mass for off-shore applications, or deletion of decking and a grout poured to create a walking surface.

**4.2.6** Baseplates shall be suitable for installation in accordance with API RP 686. Unless otherwise 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. Each opening shall have a clear area of no less than 125 $cm^2$ (20 $in^2$) and no dimension less than 100 mm (4 in), and each shall permit filling and venting of the entire cavity with grout under the baseplate without creating air pockets. Each hole into which the grout is poured shall be accessible: no component or piping shall be disturbed and no tripping hazards in the walk and work areas shall be created. Vent holes at least 13 mm (1/2 in) in diameter shall be provided for each bulkhead compartment. Each grout hole shall also be provided with steel curbing 13 mm (1/2 in) high to prevent accumulated oil or water from entering the grout. Vent holes shall be provided without curbing.

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

- **4.2.7** When epoxy grout is specified, the vendor shall pre-coat all the grouting surfaces of the mounting plates with a catalyzed epoxy primer applied to degreased white metal. The epoxy primer shall be compatible with epoxy grout. The vendor shall submit instructions for field preparation of the epoxy primer to the purchaser.

**4.2.8** The bottom of the baseplate between structural members shall be open. When the baseplate is installed on a concrete foundation, accessibility for grouting under all load-carrying structural members shall be provided.

- **4.2.9** If specified, the baseplate shall be designed for column mounting (that is, of sufficient rigidity to be supported at specified points) without continuous grouting under structural members. The baseplate design shall be mutually agreed upon between the purchaser and the vendor.

**4.2.10** Levelling screws shall be provided in the proximity of each hold-down bolt.

## 4.3 Oil reservoirs

### 4.3.1 General

Unless otherwise specified, reservoirs shall be separate from the baseplate for the equipment train served by the oil console and shall be rigid enough to prevent sagging and vibration. Components bolted to the reservoir shall be mounted on pads; no bolt holes shall extend into the reservoir. If reinforcing ribs are required, they shall be installed externally to avoid deposit accumulation.

NOTE For special features, see 4.3.12.

### 4.3.2 Protection from dirt and water

**4.3.2.1** Reservoirs shall be sealed to prevent dirt and water from entering. Top-surface openings shall be raised at least 25 mm (1 in) and shall have a gasket.

**4.3.2.2** Unless otherwise approved, pumps, coolers or filters shall not be mounted on top of the reservoir.

NOTE It is possible that this can be a user consideration for offshore or other installations where available space is limited.

**4.3.2.3** 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.

### 4.3.3 Oil connections and internal piping

**4.3.3.1** All oil return flow streams shall be hydraulically located as far away from the pump suction connections as possible.

NOTE The use of the term “hydraulically located as far away” is intended to convey the concept that it is possible to direct return flow streams by internal piping or baffling to avoid disturbing the oil flow at pump inlets. This internal piping or baffling can be used in lieu of external connections physically located such a distance from the pump suctions that they avoid disturbing the oil flow at the pump inlets.

**4.3.3.2** 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 B.24. Stilling tubes shall have bottom baffles.

**4.3.3.3** Control back-pressure 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 B.24. Pressurized oil shall not be returned to vented stilling tubes or degassing trays. Internal piping shall have bottom baffles.

**4.3.3.4** Pump suction connections shall be located near the high end of the sloped reservoir bottom and at least 50 mm (2 in) above it.

**4.3.3.5** Except as specified in 4.3.9, reservoir pipe connections shall be flanged.

### 4.3.4 Manways and drains

To ensure complete drainage, the bottom of each reservoir shall slope continuously, at least 1:50 (1/4 in/ft), to a low point. A flanged drain connection (with a valve and a blind flange) at least 50 mm (2 in) in diameter shall be provided. The manway openings provided shall permit unobstructed entry for inspection and cleaning of all interior compartments. Manways, where entry is required for cleaning, unless otherwise specified, shall be located on top of the reservoir and each manway shall be at least 600 mm × 600 mm or 450 mm in diameter (24 in × 24 in or 18 in in diameter). Internal manways are not acceptable.

### 4.3.5 Features and appendages

**4.3.5.1** The oil reservoir shall have the following features and appendages:

a) capacity to settle moisture and foreign matter adequately and to provide allowance for rundown from the entire system;

b) provisions to eliminate air and minimize migration of foreign matter to each pump suction;

c) a reflex-type, welding-pad oil level glass (with stainless steel weld pad and carbon steel cover) 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. 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 (see 4.3.3.1). The maximum and minimum operating levels, rundown level and suction-loss level shall be indicated on the level glass. If more than one level glass is provided, they shall be offset;

d) unless otherwise specified, a fill opening at least 50 mm (2 in) in diameter, which automatically closes (normally held shut by a spring) and is equipped with a stainless steel fine-mesh strainer basket that has an open area equal to 200 % of the internal pipe area;

NOTE Some users pipe up fill connections using the connections provided in 4.3.9. If manual fill is used, the connection described above is required.

e) blind-flanged vent connection at least 50 mm (2 in) in diameter;

f) for lube-oil reservoirs, a weatherproof, corrosion-resistant filter-breather cap at least 50 mm (2 in) in diameter with filtration rating of 10 µm beta 10 or better. (For reservoirs containing seal oil, see 4.3.5.2.);

g) internal baffles that do not trap gas;

● h) if the driver of the train is lubricated by the same system as the compressor and the oil reservoir contains the seal oil, a separate connection shall be provided on the reservoir for the compressor seal-oil return line.

NOTE 1 This line prevents pressurization of the drivers lube-oil drain header if the compressor seals fail.

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

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

### 4.3.6 Capacity and configurations

**4.3.6.1** A low-level alarm shall actuate at the minimum operating level.

**4.3.6.2** The criteria for sizing a reservoir are given in 4.3.6.3 through 4.3.6.8.

NOTE All level references refer to ISO 10438-1:2007, Figure F.1.

**4.3.6.3** The working capacity between 3 and 4 in ISO 10438-1:2007, Figure F.1 shall be sufficient for at least 5 min of normal flow.

**4.3.6.4** The minimum retention capacity shall be calculated based on 8 min of normal oil flow.

**4.3.6.5** The rundown capacity shall allow for all of the oil contained in all of the components, such as bearings and seal housings, overhead seal tanks, rundown tanks, accumulators, control elements and vendor-furnished piping that drain back to the reservoir. The rundown capacity shall also allow for at least an additional 10 % of these volumes for the purchaser's interconnecting piping.

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

**4.3.6.6** 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.

The usage rate shall be provided by the seal manufacturer. This is of special concern when the sour oil is not returned to the reservoir.

**4.3.6.7** 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.

**4.3.6.8** The free surface of the oil in the reservoir shall be a minimum of 60 $cm^2$ for each litre per minute (0.25 $ft^2$ for each gallon per minute) of normal flow.

### 4.3.7 Heating

**4.3.7.1** Heaters shall be provided if the minimum site temperature on the data sheet is less than the minimum oil start-up temperature.

Users may elect to use tempered water in the lube-oil cooler for the cooler to operate as a lube-oil heater prior to start-up. Details of this alternate operation shall be discussed and mutually agreed upon (see 4.5.1.15).

NOTE There are many factors to consider when 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.

● **4.3.7.2** Purchaser shall specify whether the heaters are steam or electric.

**4.3.7.3** Unless otherwise specified, the reservoir heat loss during heating shall be determined based on an uninsulated reservoir, the minimum site ambient temperature and a 16 km/h (10 mi/h) wind. The vendor shall provide data to support this.

**4.3.7.4** When a steam heater is specified, a removable element external to the oil reservoir shall be provided for heating the charge capacity of oil before start-up in cold weather. The device shall have the capacity to heat the oil in the reservoir from the specified minimum site ambient temperature to the minimum oil start-up temperature required by the equipment being served within 12 h while circulating oil through the system. If minimum site temperatures are lower than 10 °C (50 °F), it is necessary that the oil in the reservoir be heated to 10 °C (50 °F) before starting the pump.

NOTE Lube-oil pumps and drivers are sized for 10 °C (50 °F) oil.

**4.3.7.5** When an electric heater is specified, a thermostatically controlled removable electric immersion heating element shall be provided for heating the charge capacity of oil before start-up in cold weather. The device shall have the capacity to heat the oil in the reservoir from the specified minimum site ambient temperature to the manufacturer's required start-up temperature within 12 h while circulating oil through the system. If minimum site temperatures are lower than 10 °C (50 °F), it is necessary that the oil in the reservoir be heated to 10 °C (50 °F) before starting the pump. It shall have a maximum watt density of 2 $W/cm^2$ (15 $W/in^2$). Heater elements shall be sheathed in austenitic stainless steel or Incoloy[1)]; copper or copper-bearing materials shall not contact the oil.

Electric immersion heaters shall be interlocked by the purchaser to be de-energized when the oil level drops below the minimum operating level.

NOTE Lube-oil pumps and drivers are sized for 10 °C (50 °F) oil.

**4.3.7.6** Electric immersion heaters shall be installed in a manner that allows the heaters to be removed during operation. Top or angle-mounted direct immersion elements are preferred. If oil-filled tubes with vented expansion chambers are used, the oil inside the tubes shall be the same as in the reservoir and its temperature maintained at a minimum of 10 K (18 °R) below its flash point. If dry tube heating elements are used, the cold section of the element shall extend at least 30,5 cm (12 in) beyond the reservoir wall, and the thermostat shall be located external to the dry well. The hot section of the heater element shall be located a minimum of 50 mm (2 in) below the reservoir minimum operating level.

● **4.3.7.7** If specified, the vendor having train 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 h when ambient temperature is at the minimum specified value.

1) Incoloy is an example of a suitable product available commercially. This information is given for the convenience of users of this part of ISO 10438 and does not constitute an endorsement by ISO of this product.

This requires that the installing contractor provide details of the interconnecting piping arrangements and can result in the need for additional heating.

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

#### 4.3.8 Provision for insulation

● If specified by the purchaser, reservoirs shall be fitted with insulation clips. The purchaser shall furnish and install the insulation.

#### 4.3.9 Plugged connections

Above the rundown oil level, each reservoir shall be provided with two threaded and plugged connections that are at least 25 mm (1 in) in diameter. These two connections may be used for such services as purge gas, makeup oil supply and oil conditioner return. One connection shall be located to ensure an effective sweep of purge gas toward the vents.

#### 4.3.10 Provision for oil conditioner

● **4.3.10.1** If specified, the vendor shall provide a 25 mm (1 in) flanged, valved and blinded connection (see Figure B.24, Footnote i), located below the minimum operating level for use as an oil supply connection for an oil conditioner.

**4.3.10.2** The vendor shall also provide inside the reservoir a pipe loop with a siphon-breaker hole at the top which has a maximum diameter of 6 mm (1/4 in). 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.

#### 4.3.11 Welds

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

#### 4.3.12 Special features

**4.3.12.1** Reservoir tops shall be provided with the following:

● a) if specified, an accessible ladder with extended handrails;

● b) if specified, handrails around the perimeter of the reservoir top;

● c) if specified, non-skid surfaces decking (checker or diamond plate or hot-dipped galvanized steel grating).

**4.3.12.2** For equipment mounted on the reservoir, the reservoir shall provide sufficient structural stiffness to properly support the equipment (see 4.3.2.2).

**4.3.12.3** If the reservoir top is to be used as a personnel access area, it shall be designed to withstand a live load of 1 100 N (250 lbf) without permanent distortion.

#### 4.3.13 Materials

Unless otherwise specified, reservoirs and all appendages welded to reservoirs shall be fabricated from austenitic stainless steel in accordance with ASTM A240/A240M. Pipe connections shall be as specified in 5.1.

NOTE Carbon steel appendages, such as ladders and handrails, can be bolted to clips welded to the reservoir.

**4.3.14 Grounding**

Two grounding clips or pads diagonally opposed to each other (see Figure B.24) shall be welded to the reservoir. The pads shall accommodate a 13 mm (1/2 in UNC) bolt.

## 4.4 Pumps and pump drivers

● **4.4.1** The oil system shall include a main oil pump and a standby oil pump both suitable for continuous operation. For non shaft-driven pumps, the main and standby pumps shall be identical. The purchaser shall specify whether horizontal centrifugal or rotary pumps shall be used. Except as modified in this part of ISO 10438, pumps shall conform to ISO 13709.

NOTE For the purpose of this provision, API STD 610 is equivalent to ISO 13709.

**4.4.2** Unless otherwise specified, pumps shall be external to the reservoir.

● **4.4.3** If specified by the purchaser, 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. The purchaser and driven-equipment suppliers shall define the requirements for safe shutdown.

NOTE A lube-oil rundown tank can provide bearing oil for rundown. Sometimes an emergency oil pump with separate power source is supplied in order to allow cool-down oil after coast-down or seal oil.

**4.4.4** Unless otherwise specified, oil pumps not submerged inside the reservoir shall be equipped with mechanical seals that have carbon rings with mating tungsten or silicon carbide rings; Buna or Viton gaskets[2] and O-rings; and end plates with throttle bushings as outlined in ISO 13709.

NOTE For the purpose of this provision, API STD 610 is equivalent to ISO 13709.

● **4.4.5** Purchaser shall specify if the main oil pump shall be turbine or motor driven. 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.

**4.4.6** Each pump shall be driven separately.

**4.4.7** A shaft-driven pump may be provided when approved by the purchaser. The pump shall be positive-displacement type.

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

NOTE 2 When a shaft-driven pump is provided, consideration for a lube-oil rundown tank might not be required.

**4.4.8** When a shaft-driven pump is provided, the following pump design considerations shall be taken into consideration as a minimum:

a) NPSH;

b) priming;

c) maintenance accessibility;

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2) Buna and Viton gaskets are examples of suitable products available commercially. This information is given for the convenience of users of this part of ISO 10438 and does not constitute an endorsement by ISO of this product.

d) shaft coupling;

e) drive shaft positioning due to thermal growth.

**4.4.9** If required by area classification, motors shall comply with IEEE 841 or explosion proof NEMA MG-1.

**4.4.10** Steam turbines shall conform to API STD 611.

**4.4.11** The minimum criteria given in a) through e) shall be used when sizing pumps.

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

b) Each pump shall be capable of

   1) supplying the normal oil flow required by the equipment plus the greater of 20 % of the normal oil flow or 40 l/min (10 gal/min);

   2) transient oil requirements;

   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 4.8.1. The equipment supplier shall define all transient conditions.

d) In booster systems, the capacity of the main pump, as established in 4.4.11 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 capable of passing the total flow, as established in 4.4.11 a) and 4.4.11 b), at the relief-valve set pressure while not exceeding 90 % of the pump manufacturer's maximum differential pressure rating at the minimum operating viscosity. The pump shall also be capable of operating continuously at the normal flow, pressure-relief-valve or pressure-limiting-valve set pressure and minimum operating viscosity.

NOTE This selection criterion is required to avoid pump rotor contact during operation under extreme conditions.

**4.4.12** The normal operating capacity of the centrifugal pumps shall be within 50 % to 110 % of their best efficiency point. From their normal operating point to shutoff, centrifugal pumps shall have a continuous rise in head of at least 5 % and, with the installation of a new impeller, shall be capable of a future increase in head of at least 10 %.

**4.4.13** Pump drivers shall be sized according to whichever of the following requires the larger driver:

— applicable pump standard; or

— conditions given in 4.4.13 a) and 4.4.13 b).

Motor drivers for centrifugal pumps shall have a power rating which covers the end-of-curve requirements of the supplied impeller with a minimum nameplate rating of 1,0 kW for kW-rated motors or 1,0 hp for horsepower rated motors.

a) Centrifugal pumps shall deliver the specified system pressure over the pump's stable flow range when the temperature of the pumped oil is 10 °C (50 °F).

b) Rotary pumps shall be capable of operating at the specified pump pressure limiting valve setting (including accumulation) when the temperature of the pumped oil is 10 °C (50 °F).

● c) Purchaser shall specify the minimum inlet steam temperature and pressure and the highest exhaust pressure under which the turbine is expected to operate.

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

**4.4.15** Shaft-driven pumps, if provided, shall have check valves and bypasses arranged such that the shaft-driven pump continues to supply pressurized oil during periods of reverse rotation. The supplied pump shall be capable of supplying pressure while running backwards.

**4.4.16** For rotary pump systems, the vendor shall furnish external oil-pressure limiting valves that shall be installed on the components or in the piping supplied by the vendor. Oil-pressure limiting valve settings, including an allowance for accumulation, shall be determined after all of the possible equipment and component failures are considered. The settings shall protect the oil system components and piping. Fully accumulated pressure shall not exceed 110 % of the system design pressure.

**4.4.17** Oil-pressure limiting valves (PLV) shall 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 (that is, the pressure at which the valve begins to open). These devices shall be mounted external to the reservoir and shall operate smoothly, without chattering and without causing a drop in supply pressure to the equipment. Pressure-limiting valve piping shall be sized for the full flow of each pump; the valves shall not chatter and the piping shall not vibrate. The minimum pressure-limiting valve 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. To avoid unnecessary delay in opening, pressure-limiting valve takeoff points shall be located as close to the oil pump discharge as possible and below the reservoir oil level. Pressure-limiting valves shall not be used for continuous pressure regulation. For high-pressure applications (typically above 5,5 MPa (55 bar; 800 psig), where pressure-modulating valves cannot be provided, provisions for venting or otherwise relieving the pumps is required.

**4.4.18** The oil system shall be provided with pressure-regulating devices that prevent fluctuation of the oil pressure to the equipment when both the main and the standby pump are in operation or when either the main or the standby pump is in operation while the other pump is being started, brought up to operating speed or stopped. Each device shall have an adequate response time and shall operate smoothly in a stable manner, without chattering or producing pressure or flow transients that can cause the equipment to shut-down (see 7.3.3.8). These pressure-regulating devices shall be located so that an excessive rise in oil temperature resulting from a recirculation of uncooled oil is avoided (see, for example, Figure B.12, Footnote g).

**4.4.19** 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.

**4.4.20** All pumps (except shaft-driven and booster pumps) shall be installed with flooded suctions to ensure self-priming and shall be installed with suction-block valves and with discharge-block and check valves. Vertically mounted pumps shall be arranged to assure that the entire pump remains flooded. Suction piping shall be continuously vented or arranged to avoid pockets in which air can accumulate or become trapped. Each pump shall have a separate suction line from the reservoir. The pump suction lines shall be designed to avoid excessive piping loads on the pump casing flanges (see API RP 686-96, Chapter 6). 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.

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

**4.4.21** For the protection of centrifugal pumps during flushing and for the initial operation of new oil systems, a removable strainer made from austenitic stainless steel and 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 between the pump suction flange and the block valve. The temporary strainer shall be identified by a protruding tab and shall have a mesh size adequate to stop all objects that can damage the pump. The piping arrangement shall permit the removal of the strainer without disturbing the alignment of the pump. The maximum strainer hole size shall be 3 mm (1/8 in). Cone strainers shall be installed in spool pieces to minimize piping removed.

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

**4.4.22** Unless otherwise specified, for rotary pumps, a permanent Y-type strainer with an austenitic stainless steel basket with 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. The strainer shall have a mesh size in accordance with the pump manufacturer's recommendation. A blowdown/drain valve shall be provided on strainers. Strainers can require the use of a bushing for blowdown connections due to space limitations. These bushings shall be rated at 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.

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

**4.4.24** Unless otherwise specified, when a permanent strainer is being used, a compound-type pressure gauge shall be installed between it and the pump suction. The gauge shall be scaled properly to detect a fouled strainer.

**4.4.25** In order to maintain satisfactory system operation when the main pump fails to meet system requirements, the vendor shall furnish the primary element for the purchaser's start-up control for the standby oil pump. The start-up control of the standby pump shall be actuated by devices that sense low supply pressure to the equipment or low oil levels in the overhead seal-oil tanks. Motor-control centres shall be provided by the purchaser. The control system shall have a manual reset. (See ISO 10438-1:2007, 6.2.1.1, for instrumentation that allows the operation of the standby-oil-pump controls to be checked while the main pump is in operation.)

**4.4.26** For each system requiring booster pumps, the supply of low-pressure oil shall be sufficient for simultaneous operation of both the main and the standby high-pressure booster pumps. The vendor shall provide a device to alarm or to trip the booster pumps on low suction pressure (see Figure B.23).

**4.4.27** Each coupling shall have a coupling guard which is removable without disturbing the coupled elements and shall meet the requirements of a) through c).

a) Coupling guards shall enclose the coupling and the shafts to prevent personnel from contacting moving parts during operation of the equipment train. Allowable access dimensions shall comply with specified standards, such as ISO 14120 or ASME B15.1.

b) 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.

• c) 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). Guards shall be constructed of steel, brass or non-metallic (polymer) materials. Guards of woven wire shall not be used. If specified, non-sparking guards of agreed material shall be supplied.

**4.4.28** Unless otherwise specified, flexible-element couplings shall be used. Coupling hubs shall be made of steel. Metallic flexible-element types shall have elements of corrosion-resistant material. A spacer coupling shall be used unless otherwise specified. The spacer shall have a nominal length of at least 125 mm minimum (5 in minimum) or as required to remove coupling, bearings, seal and rotor as applicable, without disturbing the driver or the suction and discharge piping.

**4.4.29** Couplings shall be keyed in place. Information on shafts, keyway dimensions and shaft end movements because of end play and thermal effects shall be furnished to the vendor supplying the coupling.

**4.4.30** Couplings and coupling-to-shaft junctures shall be rated for at least the maximum driver power (including any motor service factor). Couplings shall have a minimum service factor of 1,5.

**4.4.31** To assure that the connected machinery is accurately aligned, the total indicator reading of coupling registration and alignment surfaces shall be controlled within specific limits. For all pumps, the coupling surfaces normally used for checking alignment shall be concentric with the axis of coupling hub rotation within the following limits: 13 µm (0,000 5 in) total diameter, with a minimum applicable tolerance of 25 µm (0,001 in) total indicator reading and a maximum of 75 µm (0,003 in) total indicator reading. All other diameters not used for location, registration, or alignment shall be to the coupling manufacturer's standard, provided balance requirements are met.

**4.4.32** Mounting plates shall be provided as specified below.

a) Mounting pads shall be provided for each pump and its driver. Pads shall be at least 25 mm (1 in) larger than the feet of the mounted equipment to allow for levelling of the console or package baseplate without removal of the equipment. The pads shall be fully machined flat and parallel. Corresponding surfaces shall be in the same plane within 125 µm/m (0,002 in/ft) of distance between the pads. To prevent distortion, machining of mounting pads shall be deferred until welding on the baseplate in close proximity to the mounting pads has been completed. This tolerance shall be met at the time of assembly at the vendor's shop between coupled rotating pieces of equipment. The coupled pieces shall be capable of being re-aligned in the field when the console is properly installed in accordance with API RP 686.

b) Pumps and drivers shall be mounted on a machined surface. All pads for oil pumps and drivers shall be machined to allow for the installation of stainless steel shims; shim packs, at least 3 mm (1/8 in) thick, shall be placed under the feet of each component.

NOTE Due to mounting surface tolerances on purchased pumps and drivers, the installation of shims with different thicknesses under each foot can be necessary. Additionally, shims under the pump are required to allow future shimming of a replacement pump to the inlet pipe. [IEEE 841 motor and small PD pump tolerance 130 µm (0,005 in) from foot to foot, NEMA MG-1 motor and large PD pump 260 µm (0,010 in) from foot to foot.]

c) To minimize misalignment of the pump and driver shafts due to piping load effects, the pump and its baseplate shall be constructed with sufficient structural stiffness to limit total misalignment to within acceptable limits.

d) When the pump and driver are mounted on the console without a separate sub-base, the pump and driver shall be mounted to a structural member of the console base rather than merely being attached to deckplate or other non-structural components.

e) Alignment between pump and driver shall be in accordance with API RP 686.

f) Transverse and axial alignment positioning jackscrews shall be provided for all pump drivers. The lugs holding these positioning screws shall be attached to the baseplate so that the lugs do not interfere with the installation or removal of the component. Alignment positioning screws shall be at least the same size as the jackscrews furnished with each component.

g) Supports and the design of jack screws and their attachments shall be rigid enough to permit the machine to be moved by the use of its lateral and axial jackscrews.

## 4.5 Coolers

### 4.5.1 General

**4.5.1.1** For liquid-cooled exchangers, twin coolers shall be provided and shall be piped in a parallel arrangement using a continuous-flow transfer valve (see 4.7).

**4.5.1.2** Unless otherwise specified, coolers shall be shell-and-tube type and shall be in accordance with the requirements of 4.5.1.4.

● **4.5.1.3** If specified, multi-plate frame or air coolers in accordance with 4.5.3 or 4.5.4, respectively, shall be supplied. The vendor shall include in the proposal complete details of any proposed air-cooled or plate-frame cooler.

● **4.5.1.4** If specified, the vendor shall supply connections for installation of the purchaser's air-cooled oil cooler(s) off the oil console.

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

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

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

**4.5.1.5** Unless otherwise specified for duplex cooler arrangements, the equalization/fill valve shall be locked or car sealed in the open position with the equalization/fill line orifice thermally sized by the vendor to provide thermal overprotection.

● **4.5.1.6** If specified, in lieu of the requirements of 4.5.1.5, for duplex cooler arrangements, the vendor shall provide thermal over-pressure protection of the oil side of the coolers by providing separate thermal relief valves on each cooler.

**4.5.1.7** A cooling water system or systems shall be designed for the following conditions:

| | | |
|---|---|---|
| — Velocity over heat-exchange surfaces | 1,5 m/s to 2,5 m/s | (5 ft/s to 8 ft/s) |
| — Maximum allowable working pressure, MAWP, (gauge) | ⩾ 690 kPa | (⩾ 100 psig) |
| — Test pressure (gauge) ⩾ 1,5 × MAWP | ⩾ 1,03 MPa | (⩾ 150 psig) |
| — Maximum pressure drop | 103 kPa | (15 psi) |
| — Maximum inlet temperature | 30 °C | (90 °F) |
| — Maximum outlet temperature | 50 °C | (120 °F) |
| — Maximum temperature rise | 20 K | (30 °R) |
| — Minimum temperature rise | 10 K | (20 °R) |
| — Fouling factor on water side | 0,35 $m^2$ K/kW | (0,002 h·$ft^2$ °F/Btu) |
| — Carbon steel corrosion allowance | 1,5 mm | (0,063 in) |

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

**4.5.1.9** The vendor shall notify the purchaser if the criteria for minimum temperature rise and velocity over heat-exchange surfaces result in a conflict. The criterion for velocity over heat-exchange surfaces is intended to minimize water-side fouling; the criterion for minimum temperature rise is intended to minimize the use of cooling water. The purchaser shall approve the final selection.

**4.5.1.10** Each oil cooler shall maintain the lube-oil supply temperature at or below 50 °C (120 °F).

NOTE Under certain ambient site conditions or with certain viscosities of oil, it can be necessary to operate with an oil-supply temperature greater than 50 °C (120 °F).

**4.5.1.11** Each cooler shall be sized to accommodate the total cooling load.

**4.5.1.12** Oil coolers shall not be located inside the reservoir.

**4.5.1.13** Unless otherwise specified, an oil bypass line around the cooler with a temperature-control valve shall be included to regulate the oil-supply temperature. This includes oil systems where the purchaser supplies the cooler. In no case, however, shall oil bypass the filter. The control valve shall be in accordance with the following provisions a) to d).

NOTE When fouling or freezing of the water side of a cooler is a factor and oil temperature is regulated by adjusting water flow through the cooler, it is possible for the cooler water side to silt up or freeze and break at low water flow rates.

a) Unless otherwise specified, the oil bypass valve shall be a flanged and pneumatically operated (air-to-open fail-close), two-port or three-port temperature-control valve. Failure of the control valve shall cause all the oil to pass through the cooler.

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

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

c) The temperature-control valve shall be provided with a manual override that permits operation independent of temperature conditions.

d) The temperature-control valve and piping shall be sized to handle all oil flow passing through the cooler. For a three-way temperature control valve, the pressure drop should not exceed that through the cooler. For a two-way temperature control valve, pressure drop should not exceed 50 % of the pressure drop through the cooler.

**4.5.1.14** The maximum allowable working pressure for coolers shall not be less than the maximum operating pressure of the system, less than the pressure limiting valve setting for the positive displacement pumps or less than the maximum discharge pressure (at the trip speed for the turbine drive) for the centrifugal pumps.

● **4.5.1.15** If specified, shell-and-tube or plate-frame coolers shall be suitable for use of a 150 °C (300 °F) heating medium.

Steam may be used for auxiliary heating on start-up by sparging it into the cooling water. Steam should not be introduced directly into the cooler.

**4.5.1.16** Both the water side and the oil side of the cooler shall be provided with valved vent/drain connections.

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

● **4.5.1.18** If specified, cooler oil drains shall be manifolded together with filter clean-side oil drains.

● **4.5.1.19** If specified, vents on the oil side shall be piped back to the reservoir through flow indicators.

NOTE These vent lines are normally tubed.

### 4.5.2 Shell-and-tube coolers

**4.5.2.1** In addition to the requirements of the general cooler section, shell-and-tube coolers shall be in accordance with 4.5.2.2 through 4.5.2.7.

**4.5.2.2** Shell-and-tube coolers shall have water on the tube side. Unless otherwise specified, a removable-bundle design is required for coolers with more than 0,5 m$^2$ (5 ft$^2$) of heat-transfer area. Removable-bundle coolers shall be in accordance with TEMA class C or other code specified for heat-exchangers and shall be constructed with a removable channel cover. Nominal tube outside diameter shall be at least 16 mm (5/8 in) and nominal tube wall thickness shall be at least 18 BWG [1,245 mm (0,049 in)]. U-bend tubes may be supplied with purchaser's approval (see 4.5.2.6).

**4.5.2.3** With purchaser's approval, alternative designs to 4.5.2.2 may be offered for high-pressure oil coolers [pressures greater than 3 MPa (30 bar; 500 psig)].

**4.5.2.4** To prevent the oil from being contaminated if the cooler fails, the oil-side operating pressure shall be higher than the water-side operating pressure.

**4.5.2.5** Cooler tubes shall be bare or of integrally finned (lofin) design.

● **4.5.2.6** U-bend tubes are permitted when approved by the purchaser.

**4.5.2.7** Unless otherwise specified, cooler shells, channels and covers shall be of steel; tube sheets shall be of brass; and tubes shall be of a copper/zinc/tin non-ferrous material, such as UNS C44300 (ASTM B111) (inhibited admiralty).

Alternative materials should be considered for salt and brackish water services. Tube materials such as 90-10 copper-nickel may be an appropriate choice for such services.

NOTE High-pressure oil coolers can require steel tubes and tubesheets.

### 4.5.3 Multi-plate type coolers

**4.5.3.1** If specified, and in addition to the requirements of the general cooler section, multi-plate type coolers shall be in accordance with 4.5.3.2 and 4.5.3.3.

**4.5.3.2** Multi-plate coolers shall have plates of austenitic stainless steel for fresh-water cooling or titanium for brackish or salt water, or as specified by the purchaser.

**4.5.3.3** To prevent the oil from being contaminated if the cooler fails, the oil-side operating pressure shall be higher than the water-side operating pressure.

### 4.5.4 Air cooled heat exchangers

#### 4.5.4.1 General

Air coolers are infrequently required on these systems and, when provided, are commonly specified using purchaser's specifications. Guidance when a detailed specification is not available is given in 4.5.4.2 to 4.5.4.4.

**4.5.4.2** Unless otherwise specified, air-cooled heat exchangers shall be provided in a single bank of tubes with 10 % extra tubes to allow for plugging tubes in the event of tube leaks.

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

**4.5.4.4** If specified, and in addition to the requirements of the general cooler section, air coolers shall be in accordance with the following provisions a) to g).

a) The cooler shall be provided with two fans. Each fan shall be capable of 100 % of the duty requirement.

● b) If specified, the cooler tubes shall be austenitic stainless steel.

● c) If specified, the header boxes shall be made of hardened stainless steel plate. The header plug material shall be selected to prevent galling.

d) Two separate headers shall be provided for each cooler.

e) Electronic vibration switches shall be provided for each fan and shall alarm on high vibration.

f) Refer to ISO 13706:2005, 7.2.8.2, for belt drive requirements.

NOTE For the purposes of this provision, API STD 661 is equivalent to ISO 13706.

g) Turbulence promoters may only be used with purchaser approval. When supplied, turbulence promoters shall be austenitic stainless steel.

## 4.6 Filters

**4.6.1** Duplex full-flow filters with replaceable elements or cartridges shall be provided. Filters shall provide a minimum particle removal efficiency, $E_{PR}$, of 90 % for 10 µm particles ($\beta_{10} \geqslant 10$) and a minimum $E_{PR}$ of 99,5 % for 15 µm particles ($\beta_{15} \geqslant 200$), both in accordance with ISO 4572 when tested to a minimum terminal (end-of-test-run) differential pressure of 350 kPa (3,5 bar; 50 psi). Filter installations shall be in accordance with the following provisions a) to g).

NOTE 1 See ISO 10438-1:2007, Annex D, for additional information concerning filter ratings.

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

a) The filters shall be located downstream of the coolers.

NOTE Coolers can trap and release dirt and debris.

b) The filters shall be piped in a parallel arrangement using a continuous-flow transfer valve (see 4.7).

c) Filter cases and heads shall be suitable for operation at the maximum discharge pressure (at the trip speed for turbine drives) of centrifugal pumps or at a pressure not less than the pressure-limiting device setting of positive displacement pumps.

d) Filters that have covers weighing more than 15 kg (35 lb) shall have cover lifters.

e) The filters shall not be equipped with differential pressure-limiting valves or other valves that can cause bypass of unfiltered (dirty) oil around the filter elements.

f) The filters shall be equipped with valved vents and clean- and dirty-side valved drain connections. The dirty-side connections shall be located lower in the housing than the filter elements or cartridge support bases to allow complete drainage of the dirty side.

g) Unless otherwise specified, the equalization/fill valve shall be locked or car sealed in the open position with the equalization/fill line orifice thermally sized by the vendor.

NOTE This provides thermal over-protection of the standby filter in addition to the primary function of pressure equalization for filling and switching filters.

● **4.6.2** If specified for duplex filter arrangements where the filters are not in accordance with 4.6.1 g), the vendor shall provide thermal over-pressure protection of the offline filter.

● **4.6.3** If specified, duplex oil filter clean-side oil drains shall be manifolded together with duplex cooler drains.

● **4.6.4** If specified, the filter vents shall be routed back to the oil reservoir through flow indicators.

NOTE These filter vent lines are normally run with tubing.

**4.6.5** Oil filter design shall be in accordance with the following provisions a) to h).

a) Oil shall flow from the outside inward toward the centre of the filter element.

b) Oil flow from the centre towards the outside of the filter element may be provided with purchaser's approval.

c) Adequate support of the filter elements shall be provided to prevent them from rupturing or to prevent unfiltered (dirty) oil from bypassing the elements and reaching the equipment.

d) Centre posts and other hardware in contact with filtered oil but not integral with the filter housing shall be made of austenitic stainless steel.

e) The maximum number of filter cartridges permitted in one stack is two.

f) If the cartridge-to-cartridge joint is not self-aligning, a collar shall be used between the stacked cartridges to ensure alignment.

g) Filter stacks shall not exceed 1 m (3 ft).

h) Stacked cartridges shall have adequate support and maintainable alignment.

**4.6.6** Filter cartridge materials shall be water- and corrosion-resistant and in accordance with the following provisions a) to d).

a) Water-resistant filter cartridges shall not deteriorate if water contamination in the oil reaches 5 % by volume and the operating temperature reaches as high as 70 °C (160 °F).

● b) If specified, filter-element media shall be non-hydroscopic. If water contamination in the oil reaches 5 % for extended periods of time (up to 3 months), clean filter cartridges shall not have a clean-filter pressure drop greater than 60 kPa (0,60 bar; 10 psi) at rated oil viscosity, flow and temperature.

NOTE This is a design requirement for filter elements and not for system operation.

● c) When a specific filter element or cartridge is required, the purchaser shall completely specify the make, the model number and the type of construction.

d) Metal mesh or stainless metal filter elements are not acceptable.

**4.6.7** The pressure drop for clean filter elements or cartridges shall not exceed 30 kPa (0,30 bar; 5 psi) at an operating temperature of 40 °C (100 °F) and normal flow.

Pressure drop across the total filter system may exceed these values by the amount of pressure drop across the transfer valve and other filter system components.

NOTE The 30 kPa (0,30 bar; 5 psi) is the difference between the drop across the filter housing with no elements installed and the drop across the filter housing with clean elements installed.

**4.6.8** Elements or cartridges shall have a minimum collapsing differential pressure of 500 kPa (5,0 bar; 70 psi).

**4.6.9** When the tops of filter housing covers are more than 1,2 m (4 ft) above the console base, the vendor shall provide a step to facilitate their maintenance.

**4.6.10** Systems with booster pumps shall be provided with twin filters downstream of the pumps.

NOTE This is to protect the equipment from damage from particles resulting from pump wear.

● **4.6.11** When required, or if specified, more stringent requirements for control-oil filtration shall be provided.

Filtration requirements of serviced equipment, such as hydraulic servo-valves, should be utilized in determining filtration requirements.

## 4.7 Transfer valves

**4.7.1** Unless otherwise specified, the vendor shall supply individual transfer valves independently serving each cooler set and each filter set (see Figure B.20).

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

a) Tapered plug-type valves shall have provisions for plug lifting.

b) Valves shall be designed so that, if the internal valve mechanisms fail, both flow paths shall not be blocked.

c) Valves and assemblies shall be designed to prevent incorrect assembly.

d) Transfer valves with resilient seats shall be capable of transfer without sliding contact. Resilient seats shall be positively retained.

**4.7.3** Transfer valves shall have steel bodies. Valve stems and valve plugs or balls shall be made of austenitic stainless steel.

● **4.7.4** Spectacle blinds shall be provided if specified to assure tight shutoff.

NOTE 1 Transfer valves are not intended for use as tight shutoff devices for the maintenance of filters and coolers [see 7.3.3.8 h)].

NOTE 2 Transfer valves with resilient seats provide tighter shutoff.

## 4.8 Accumulators

**4.8.1** An accumulator shall be provided if it is needed to maintain the turbine control-oil pressure during servo control transients or to maintain lube- or seal-oil pressure while the standby pump accelerates from an idle condition to operating speed. The control pressure shall be maintained above the equipment manufacturer's minimum specified supply pressure for all operating conditions (including transients). Typically, this is within 10 % of the normal system pressure when a servomotor makes a full stroke in 1 s.

**4.8.2** The system delivery pressure shall be maintained above the shutdown settings during standby pump acceleration or for at least 4 s for motor-driven pumps [see 7.3.3.8 e)].

**4.8.3** Unless otherwise specified, accumulator vessels shall be made of austenitic stainless steel.

● **4.8.4** For direct-contact-type accumulators, a manual precharge valve or a constant-pressure regulating system shall be furnished as specified by the purchaser (see Figure B.19).

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

NOTE Purchaser might want to give consideration to a non-glass level indicating device.

**4.8.6** A connection for a pressure gauge shall be provided for checking the precharge pressure in the accumulator.

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

● **4.8.8** If specified, the accumulator shall be equipped to maintain the contained oil at the required system oil temperature. The purchaser shall provide the details of the required temperature-control system.

**4.8.9** Unless otherwise specified, direct-contact-type accumulators provided with a constant-pressure regulating system for pump switchover or other purposes shall automatically vent and automatically reset.

● **4.8.10** If specified, bladder-type accumulators provided with a constant-pressure regulating system for pump switchover or other purposes shall automatically vent and automatically reset. Accumulators shall be provided with a gas-side anti-extrusion feature and adequately sized for the charge-gas regulator and piping.

**4.8.11** Accumulator designs shall not allow precharge gas to be delivered with the oil to the equipment or to impair the flow of the oil to the equipment. Bladder-type accumulators shall be furnished with an oil-side anti-extrusion feature (see Figure B.18).

**4.8.12** Accumulators shall be isolated (for example, by a check valve; see Figure B.12) from the standby oil pump start controls to eliminate delay in the actuation of the starting signal.

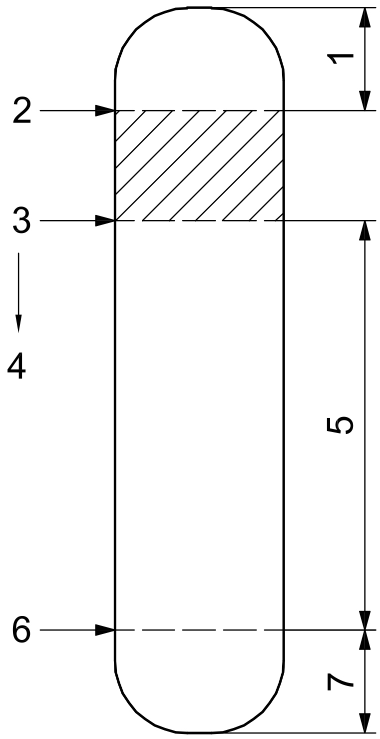
## 4.9 Overhead tanks

### 4.9.1 Seal-oil tanks

**4.9.1.1** Separately mounted or equipment-mounted overhead tanks shall be provided when they are required by the designs of the seals and the seal-oil control systems. Unless otherwise specified, the tanks shall be made of austenitic stainless steel.

● **4.9.1.2** Each overhead seal-oil tank (see Figure 1) shall be sized so that the oil capacity above the low-level alarm setting is equal to a 2 min flow at normal seal-oil rates, and each tank shall have the capacity for a 10 min flow from low-level alarm to low-low-level shut-down plus sufficient time (as specified by the purchaser but not less than 3 min at normal flow rates after shut-down) for coast-down, block-in and depressurization of the equipment. Larger tanks can be required for special operating conditions, such as rapid depressurization of high-pressure equipment. The vapour column above the high-level alarm setting shall be no less than 1 min of normal flow.

The purchaser and the manufacturer together shall determine the required capacity after trip, based on the compressor block-in and blowdown and the seal-oil flow rate for various conditions.




**Key**

1 vapour volume (equivalent to a 1 min supply)
2 high-level alarm
3 low-level alarm
4 auxiliary pump start
5 emergency operating range (10 min supply)
6 low-level shutdown
7 coast-down and block-in (minimum 3 min supply)

**Figure 1 — Overhead seal-oil tank**

● **4.9.1.3** Overhead seal-oil tanks shall be designed in accordance with the specified pressure design code and, if specified, shall be code stamped.

**4.9.1.4** Overhead seal-oil tanks shall be provided with the following items a) to g):

a) one bottom outlet nozzle, at least DN 150 (NPS 6) in size, which shall not extend inside the vessel; this nozzle shall be used for internal access and inspection;

b) one reference gas connection at least DN 25 (NPS 1) in size;

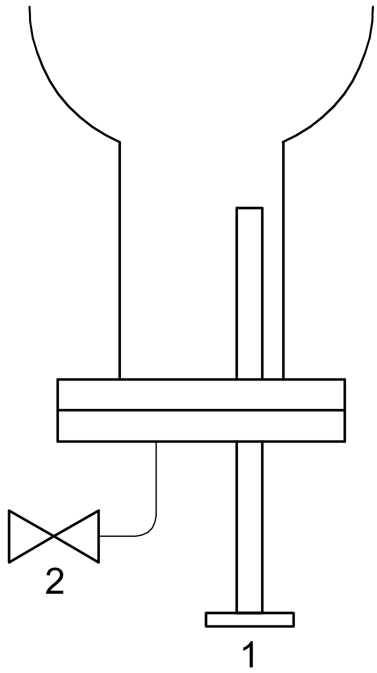
c) reference line that shall be routed to prevent traps that can accumulate liquid;

d) full-length reflex-type level glass that extends from 25 mm (1 in) above the high-level alarm to 25 mm (1 in) below the low-level shutdown;

e) one DN 150 × DN 50 (NPS 6 × NPS 2) flanged reducing spacer that is 450 mm (18 in) long and is fitted to the bottom outlet connection;

● f) if specified, e.g. for dirty, sludge-building gas service, the reducing spacer shall project into the bottom nozzle and a valved blowdown connection shall be provided (see Figure 2); the nozzle shall be at least 200 mm (8 in) long;

g) level transmitter externally mounted to the tank and provided with isolation valves, a vent connection and a valved drain.




**Key**

1 blowdown connection

2 drain valve

**Figure 2 — Blowdown connection**

The presence of free water, dirt, and dissolved gases in lubrication, control, and seal oil can contribute to accelerated wear, corrosion, sludge formation and sticking of hydraulic controls. Dilution or contamination of compressor seal oil by hydrocarbons, hydrogen sulphide, and other contaminates also causes a reduction in viscosity and flashpoint. Oil-condition maintenance procedures and equipment should be considered during project planning.

**4.9.1.5** If specified, the reference gas shall be isolated from the seal oil by a bladder of material suitable for the service (see Figure B.17).

### 4.9.2 Lube-oil rundown tanks

● **4.9.2.1** If specified, a separately mounted emergency lube-oil rundown tank (either atmospheric or pressurized) shall provide oil for the coast-down period specified by the purchaser. This tank shall be sized for not less than 3 min of normal operating lube-oil flow (see Figures B.15 and B.16). Unless otherwise specified, the tank shall be made of austenitic stainless steel.

Coast-down time shall be provided by the purchaser (normally the supplier of the equipment served by the oil system).

NOTE The minimum sizing criteria results in more than 3 min of coast-down oil flow due to supply pressure decay.

**4.9.2.2** A rundown tank shall be provided with a sight flow glass in the tank overflow line. The sight flow glass shall be located in an area that can be readily observed, such as the oil reservoir or equipment operating deck. A DN 150 (NPS 6) nozzle for accessing and inspecting the interior of the rundown tank shall be provided. Alternatively, for atmospheric rundown tanks, a bolted cover can be provided in lieu of the DN 150 (NPS 6) nozzle for access and inspection. The vendor shall specify the allowable minimum and maximum height of the bottom outlet nozzle above the machine centreline; the maximum static head shall be less than the lube-oil trip pressure but not less than 30 kPa (0,3 bar; 5 psig) at the beginning of coast-down.

**4.9.2.3** When an atmospheric rundown tank is provided in accordance with Figure B.15, it shall be provided with low-level alarm and high-level permissive start functions. These functions may be served by a common device.

**4.9.2.4** A pressurized tank (see Figure B.16) shall be designed in accordance with the specified pressure design code and, if specified, shall be code stamped.

NOTE Code stamping might not be applicable for pressure design codes other than ASME.

## 4.10 Seal-oil drain traps

**4.10.1** One drain trap per seal shall be provided. An emergency line and isolating valves and valve to cross-connect trap inlets and permit trap maintenance shall be provided where seals operate at the same oil-sealing pressure (see Figure B.14).

● a) If specified, spectacle blinds shall be provided to isolate individual seal-oil drain traps during maintenance.

b) Drainer bypass orifices shall be a minimum of 1 1/2 mm (1/16 in).

c) Automatic seal traps are required. For gas pressures less than or equal to 5 MPa (50 bar; 725 psig), mechanical float-type traps are permitted. The float and trim shall be the single-lever, stainless steel design and arranged so that the gas flow does not impinge upon the float or float mechanisms.

   Level transmitter control-type traps should be used when gas fouling can interfere with the operation of mechanical float-type traps.

d) For pressures greater than 5 MPa (50 bar; 725 psig), snap-acting level transmitter/controllers and separate control valves shall be used.

e) Drain traps shall be pre-piped and mounted in a package arrangement. All appurtenances shall be located within the confines of the package base. Manually operated drain valves shall be provided on each trap.

**4.10.2** Traps shall be furnished with reflex-type gauge glasses. The inlet piping shall enter the seal traps above the oil level of the traps.

Special consideration should be given to the level device at higher-pressure applications.

**4.10.3** Unless otherwise specified, seal-trap vents shall be equipped with mist eliminators (with appropriate connections) to agglomerate the residual oil before the vent gas is recycled to the compressor suction or vented to other disposal outlets. Mist eliminators shall be self-draining or provided with separate automatic drain traps.

● **4.10.4** The seal-gas vent piping arrangement shall be jointly developed by the purchaser and the vendor. Consideration should be given to avoid pocketing of liquids, system backpressure, motive flow available and other issues.

NOTE The arrangement of seal-gas vent piping is important to the proper function of the compressor shaft seals.

● **4.10.5** The drain line for each trap shall be piped to a proper disposal system, to the degassing drum or to the reservoir, as specified.

● **4.10.6** If specified, drain lines for each trap shall be piped separately.

NOTE Separate piping of the drain lines allows the leakage from each seal to be monitored.

**4.10.7** A level-transmitter-controller-type drain trap shall be designed in accordance with the specified pressure-vessel design code and, if specified by the purchaser, shall be code stamped.

NOTE Code stamping might not be applicable for pressure design codes other than ASME.

## 4.11 Degassing drum

● **4.11.1** If specified, seal-oil degassing facilities shall be provided. Unless otherwise specified, the tank and internals shall be made of austenitic stainless steel.

**4.11.2** The degassing drum shall be a single-chamber tank (see Figure 3) provided with the following features a) to g):

a) sloped inlet tray, extending below the operating level, which ensures that the oil enters the tank in a thin layer;

   NOTE Having the oil enter in a thin layer facilitates degassing.

b) oversized gas-vent connection to handle the flow of gas from the seals through the oil drains; the size of the connection shall be at least DN 50 (NPS 2) and flanged; the purchaser shall pipe the vented gas to a safe location;

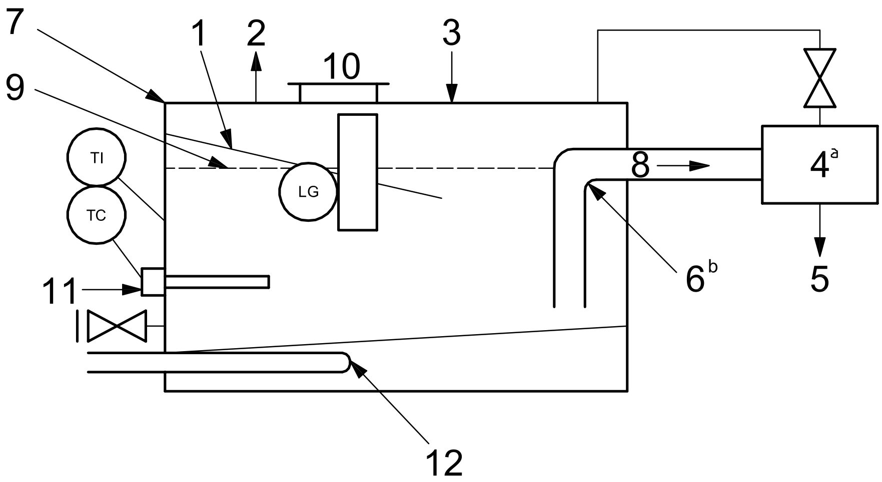
c) purge connection with a minimum size of DN 25 (NPS 1);

d) cleanout opening and a valved, low-point drain;

e) weld-pad reflex level glass extending a minimum of 50 mm (2 in) above and 50 mm (2 in) below the operating level;

f) temperature indicator with a thermowell;

g) level device with high alarm.




**Key**

1 degassing tray
2 gas vent
3 inert gas purge
4 trap
5 to reservoir
6 3 mm (1/8 in) hole (vacuum break)
7 oil from traps
8 outlet
9 oil level
10 manway
11 electric heater (optional)
12 steam heater (optional)

[a] Refer to 4.11 for design details.

[b] Provide a 3 mm (1/8 in) hole inside the degassing tank. The trap prevents the gas from entering the reservoir via the hole.

**Figure 3 — Typical degassing drum arrangement**

● **4.11.3** If specified, an electric immersion heater, steam heater or some other method of heating shall be provided to assist in degassing the oil. If a steam heater is used, it shall be external to the drum and shall be removable. If an electric immersion heater is used, its heat flow (power) density shall not exceed 2 W/cm$^2$ (15 W/in$^2$). Electric heater elements shall be sheathed in austenitic stainless steel; copper or copper-bearing materials shall not contact the oil. The vendor shall provide temperature element and controls for the heater as mutually agreed upon with the purchaser.

Electric immersion heaters should be interlocked by the purchaser to be de-energized when the oil level drops below the heater.

**4.11.4** A level device shall be provided where electric immersion heaters are used.

**4.11.5** The drum shall have a 4 h minimum retention time, based on the guaranteed total inner-seal-oil leakage rate or a minimum liquid volumetric capacity of 60 l (15 gal) per compressor body.

● **4.11.6** If specified, the degassing drum shall be designed and constructed for pressurized service in accordance with the specified code and, if specified by the purchaser, shall be code stamped. The degassing drum shall permit discharge of the gas to the compressor suction or to a disposal outlet.

# 5 Piping

## 5.1 General

All piping shall be in accordance with ISO 10438-1:2007, Clause 5, unless otherwise specified in 5.2 to 5.5 of this part of ISO 10438.

## 5.2 Oil piping

Piping shall be in accordance with ISO 10438-1:2007, Tables 4, 5 and 6.

## 5.3 Instrument piping

Piping shall be in accordance with ISO 10438-1:2007, Tables 4, 5 and 6.

## 5.4 Process piping

Piping shall be in accordance with ISO 10438-1:2007, Tables 1, 5 and 6.

## 5.5 Water piping

Piping shall be in accordance with ISO 10438-1:2007, Tables 3, 5 and 6.

# 6 Instrumentation, control and electrical systems

## 6.1 General

**6.1.1** As a minimum, the vendor shall furnish and mount devices to facilitate the alarm and shutdown functions specified in Table 1. The alarm setting shall precede the shutdown setting.

**6.1.2** Instrumentation shall be in accordance with ISO 10438-1:2007, Clause 6, except as modified in 6.2 to 6.4.

**Table 1 — Conditions requiring alarms and shutdowns**

| Condition | Alarm | Shutdown |
|---|---|---|
| Low control oil pressure [a] | x | — |
| Low pressure to start standby oil pump | x | — |
| Low pressure at lubricated equipment | x | x |
| Pump running for each stand-by and emergency pump [b] | x | — |
| High oil temperature leaving cooler | x | — |
| Low level for oil reservoir | x | — |
| Low level for each seal-oil overhead tank or low seal-oil differential pressure for each seal-oil level [a] | x | x |
| High level for overhead seal tank [a] | x | — |
| High level for atmospheric lube-oil rundown tank (permissive) [a] | x | — |
| High differential pressure for each oil-filter set | x | — |

[a] If applicable.

[b] Not required if the purchaser's alarms are from the motor-control centre.

## 6.2 Arrangement 1

● If specified, both shutdown and alarm switches shall be connected through normally energized, fail-safe circuits. The shutdown circuit's wiring shall be completely independent from the alarm circuit wiring and shall be mechanically protected.

## 6.3 Arrangement 2

**6.3.1** Shutdown functions shall be initiated by local direct-acting switches connected in normally de-energized circuits.

**6.3.2** Alarm functions shall be comprised of locally mounted transmitters (electronic or pneumatic, as specified) connected to separate panel-mounted switches, a multipointed scanning-type instrument, a PLC or plant DCS.

**6.3.3** Where multipoint, scanning-type instruments are used, the alarm setting for each function shall be separately and independently adjustable.

## 6.4 Arrangement 3

**6.4.1** Each function for which both an alarm and a shutdown have been specified shall be provided with three separate and independent transmitters (electronic unless specified otherwise).

**6.4.2** Each transmitter shall be independently connected to one of three multipoint, electronic, scanning-type instruments for each transmitter's input.

**6.4.3** Each multipoint instrument shall provide both alarm and shutdown settings, separately and independently adjustable, for each transmitted input.

**6.4.4** The shutdown and alarm function outputs from the three multipoint instruments shall be connected through “two-out-of-three” voting logic. The arrangement shall allow operation of any one alarm or shut-down function that initiates an alarm; operation of two shutdown functions monitoring the same parameter shall initiate a separate alarm and shall cause the served equipment to shut down.

**6.4.5** Alarm functions not associated with a shutdown function shall be provided with one single transmitter. These alarm transmitters may be connected to one of the three alarm/shutdown multipoint instruments or to a separate multipoint instrument. The detailed arrangement should be jointly developed between the purchaser and the vendor or vendors of the oil system and the served equipment.

NOTE Arrangement 3 has the following advantages:

a) any shutdown or alarm function can be tested at any time with the equipment in service without the need to disarm any part of the system;

b) failure of any one component initiates an alarm but does not result in equipment shutdown;

c) use of modern, digital-instrument technology is facilitated.

If the circuit is normally energized, this shall be a fail-safe arrangement to avoid spurious trips (e.g., 2-out-of-3 voting, DC power supply, UPS).

## 6.5 Instrumentation

Instrumentation shall be in accordance with ISO 10438-1:2007, 6.3.

## 6.6 Electrical systems

Electrical systems shall be in accordance with ISO 10438-1:2007, 6.4.

# 7 Inspection, testing and preparation for shipment

## 7.1 General

Inspection, testing and preparation for shipment shall be in accordance with ISO 10438-1:2007, Clause 7, unless otherwise specified in this clause.

## 7.2 Inspection

The oil system furnished shall meet the inspection requirements of ISO 10438-1:2007, 7.2.

## 7.3 Testing

### 7.3.1 General

**7.3.1.1** Equipment shall be tested in accordance with 7.3.2 and 7.3.3. Other tests may be specified and shall be jointly developed by the purchaser and the vendor.

● **7.3.1.2** The purchaser shall specify whether the purchased oil system shall be used during the shop testing of the equipment.

● **7.3.1.3** Complete-unit tests or other tests of the oil system and the equipment it serves shall be performed in place of or in addition to separate tests of the oil system as specified by the purchaser. Details of these tests shall be developed jointly by the purchaser and the vendor.

### 7.3.2 Hydrostatic test

The hydrostatic test shall be performed in accordance with ISO 10438-1:2007, 7.3.2.

### 7.3.3 Operational tests

**7.3.3.1** The complete oil system shall be run in the vendor's shop to test its operation and cleanliness. The oil used shall be as mutually agreed upon and shall be compatible with the system oil (see 4.1.7).

**7.3.3.2** System cleanliness shall be demonstrated by the vendor after the operational and sound-level tests.

**7.3.3.3** The running tests shall be conducted under normal system operating conditions for at least 4 h. The operational tests may be done concurrently within the 4 h.

**7.3.3.4** If console-mounted, the low-oil-pressure alarm, the standby-pump start and the shutdown devices purchased for the project shall be used for the operational tests. Otherwise, the vendor shall provide shop devices for the tests.

NOTE Some of these devices are normally mounted near the equipment rather than on the console.

**7.3.3.5** All oil pressures, viscosities and temperatures shall be within the range of operating values recommended in the vendor's operating instructions for the specific unit being tested.

**7.3.3.6** All filter elements shall be installed prior to all operational tests.

**7.3.3.7** Steam turbine pump drivers shall be mechanically tested. If the turbine has been previously tested, a test motor may be considered to replace the turbine during the console operational tests.

**7.3.3.8** The operational testing of the oil system shall be conducted in the sequence given in a) through h) below.

a) The oil system shall be thoroughly checked for leaks; all leaks shall be corrected prior to testing.

b) The limiting pressures shall be determined so that the subsequent proper operation of each pressure limiting valve may be verified.

c) A filter-cooler changeover shall be accomplished without the system delivery pressure dropping to the automatic-start setting of the standby pump.

d) If applicable, it shall be demonstrated that the control valve or valves can handle a simulated governor-transient step change on the main equipment drive turbine without the pressure-limiting valves lifting and without the delivery pressure dropping to the automatic-start setting of the standby pump.

e) It shall be demonstrated that, after a failure or trip of the main oil pump, the standby pump starts automatically and returns the system to normal operating pressure without the delivery pressure dropping as follows:

   1) in a single-level oil-pressure system, below the midpoint between the standby pump's automatic-start setting and the equipment's shutdown pressure;

   2) in a multilevel oil pressure system, below the midpoint between the equipment's normal operating and shutdown pressures.

   Verification of this criteria requires test instrumentation, such as a switch or other device, with a response time adequate to record the transient pressures during pump switchover. (The response time of switches is typically under 25 ms.)

f) It shall be demonstrated that the control valve(s) is/are capable of controlling the oil pressure when only one pump (either the main or the standby pump) is operating at minimum oil requirements and when both pumps are operating at minimum oil requirements, defined as the sum of the normal bearing and seal-oil requirements and the steady-state control-oil requirements. The test shall be considered satisfactory when no abnormal conditions occur during the operational test (see 4.4.18).

   NOTE Some typical abnormal conditions encountered are system instability, an excessive drop in delivery pressure, alarm or shutdown signals or other conditions that require operator attention.

g) All warning, protective and control devices shall be checked and adjustments shall be made as required.

h) While the system is at maximum operating pressure, the internal side-to-side leakage around the plugs of continuous-flow transfer valves shall be demonstrated to be less than the drainage capability of the inactive filter housings. Leakage shall not exceed the expected or specified rates.

**7.3.3.9** Conformity to the criteria for system cleanliness listed below in a) and b) shall be demonstrated.

a) After 1 h of oil circulation at the design flow rate and a temperature of 66 °C to 71 °C (150 °F to 160 °F) or lower, as component design dictates, screens placed at all discharge terminations from the console or the packages and at other strategic points mutually agreed on by the purchaser and the vendor shall be within the particle-count limits listed in ISO 10438-1:2007, Table D.6. The screen mesh shall be No. 100 plain-weave, stainless steel wire with a diameter of 0,1 mm (0,004 in) and a 0,15 mm (0,006 in) opening. The greatest dimension of the particles shall not exceed 0,25 mm (0,010 in), and the particles shall be randomly distributed on the screen. Piping, coolers and valves shall be hammered frequently during the test.

   NOTE Typically, screens are mounted such that the flow entering the screen is in a vertical downward direction to prevent debris from escaping the screen.

b) To further verify cleanliness, the system shall be visually inspected at two to six points selected by the inspector. The system shall be considered clean when foreign matter, such as scale, rust, metal shavings and sand, are not visible to the eye and grittiness is not detectable to the touch. This verification shall not require a re-hydrotest nor necessitate the installation of screens.

**7.3.3.10** If dismantling of the oil system is required to make modifications to improve operation, the initial running test shall not be conclusive and final tests shall be run only after corrections are made. In any event, the demonstration of cleanliness shall be conducted only after the final assembly.

● **7.3.3.11** If specified, the vendor, by unbolting and re-bolting pump inlet and discharge piping, shall demonstrate that the pump on its baseplate is in compliance with API RP 686 alignment requirements.

### 7.4 Preparation for shipment

The oil system shall be prepared for shipment in accordance with ISO 10438-1:2007, 7.4.

## 8 Vendor's data

### 8.1 General

A coordination meeting shall be held, preferably at the vendor's plant, within 4 weeks to 6 weeks after order commitment. Unless otherwise specified, the vendor shall prepare and distribute an agenda prior to this meeting, which, as a minimum, shall include review of the following items a) to j):

a) purchase order, scope of supply, unit responsibility, sub-vendor items and lines of communication;

b) data sheets;

c) applicable specifications and previously agreed upon exceptions;

d) schedules for transmittal of data, production and testing;

e) quality assurance program and procedures;

f) inspection, expediting and testing;

NOTE Annex C contains an inspector's checklist to assist in defining inspection requirements.

g) schemas and bills of material;

h) physical orientation of the components and piping, including access for operation and maintenance;

i) plot plan and equipment layout;

j) other technical items.

NOTE For special-purpose oil systems, the coordination meeting is typically held in conjunction with the coordination meeting for the main equipment. This is typically held at the plant of the vendor having prime responsibility for the equipment.

### 8.2 Proposals

Proposals shall be prepared in accordance with ISO 10438-1:2007, 8.2.

# Annex A
(informative)

# Datasheets

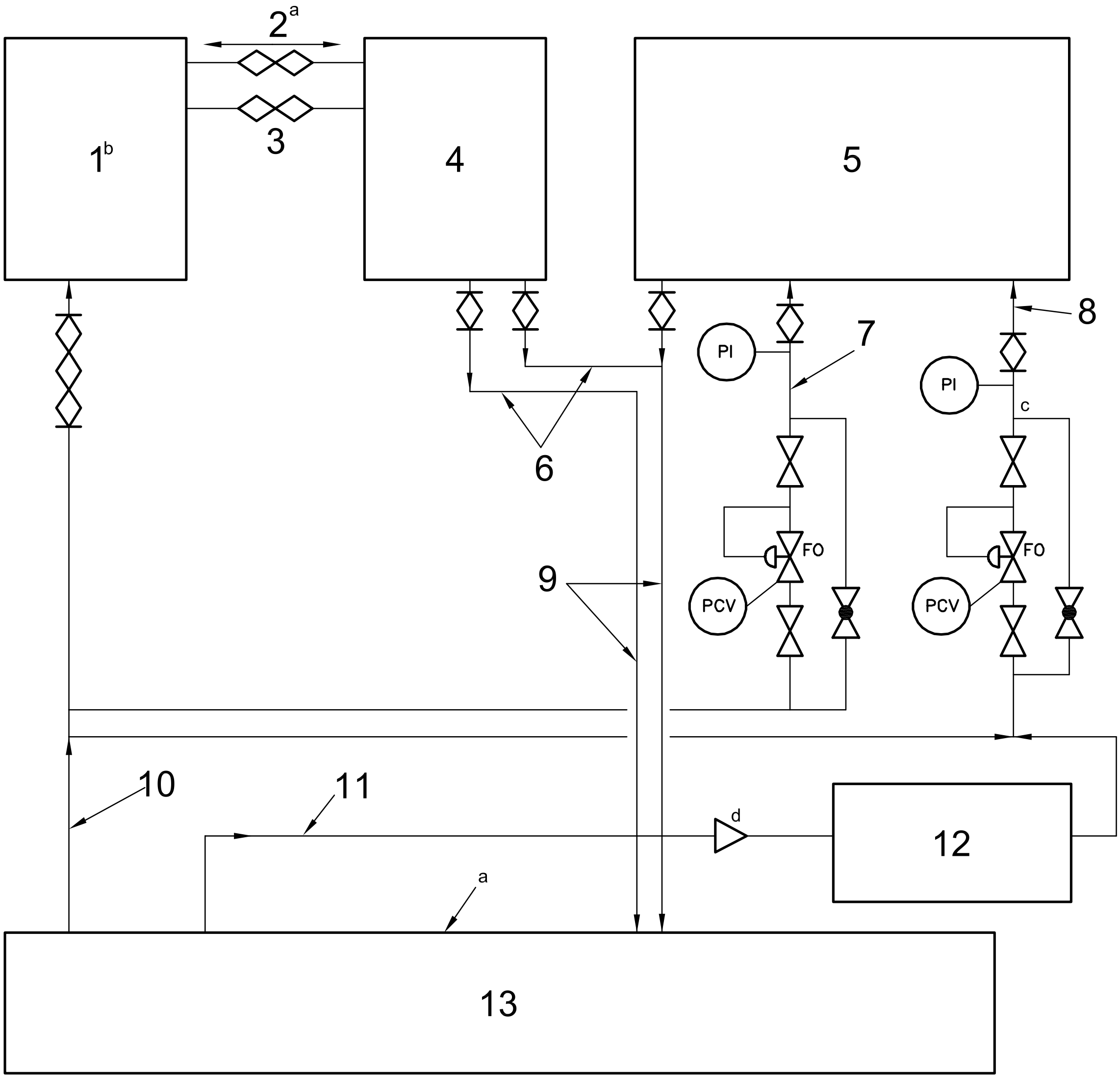
This annex contains a link to datasheets in both SI and USC units, together with an explanatory note. To access the appropriate datasheet, click on "Datasheet", then the first page tab for Figure A.1 — Scope and attachments. Select the appropriate set of units from the menu available.

The options for units are the following:

- USC units;
- SI units (MPa);
- SI units (kPa);
- metric ($kg/cm^2$);
- hybrid.

# Annex B
(informative)

# Piping and instrument diagrams




**Key**

1 overhead-tank module
2 gas reference
3 seal-oil supply
4 seal-oil system module (Figure B.9)
5 main equipment lube- and control-oil module (Figure B.10)
6 drain
7 lube oil
8 control oil
9 oil-return headers
10 oil-supply header
11 alternative control-oil flow
12 twin filter and cooler set (Figure B.20 or B.21)
13 basic oil-supply module (Figure B.12)

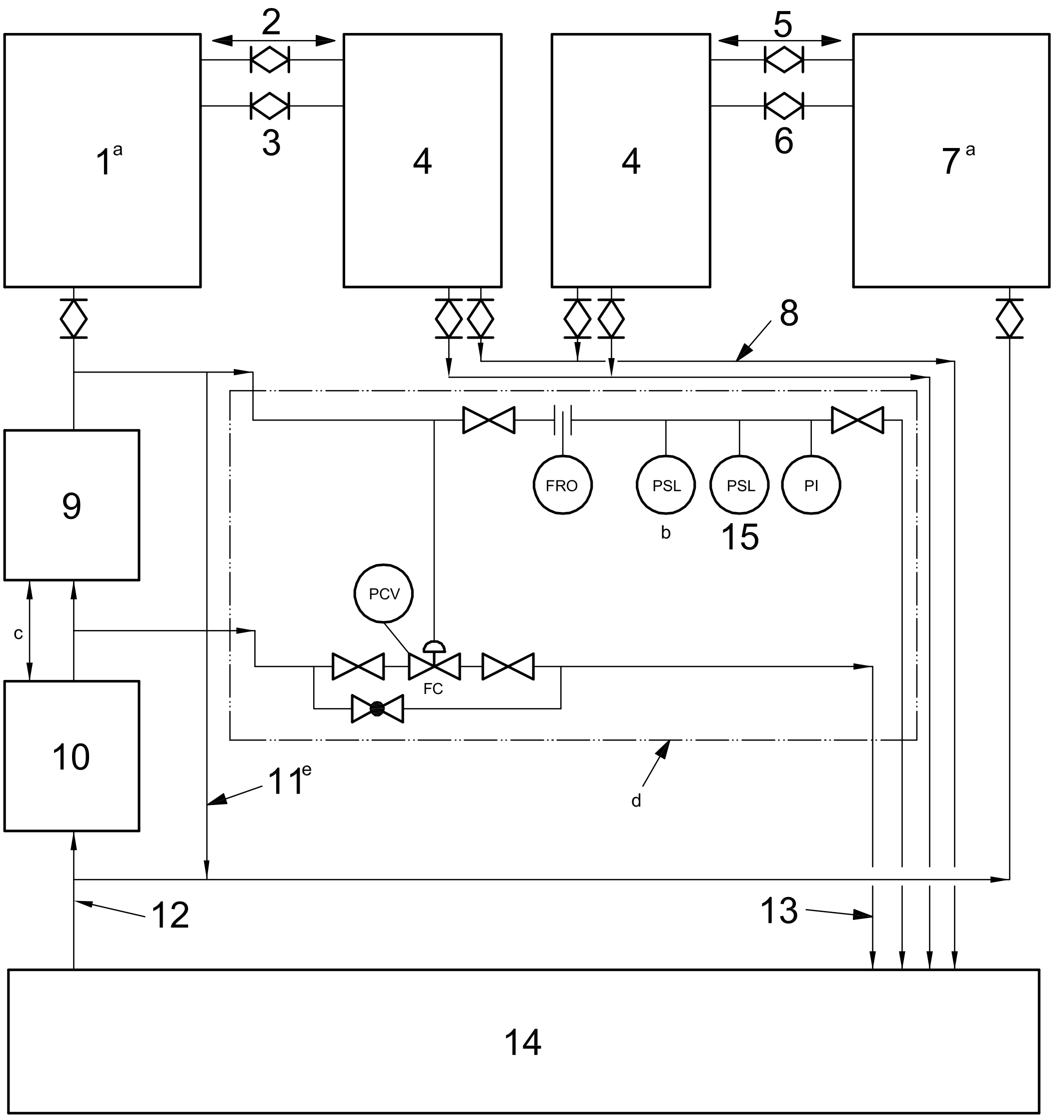
[a] Figure B.1, option A: For systems without overhead seal-oil tanks, the gas reference is connected to a direct-acting differential-pressure control valve. The alternative arrangement is shown in Figure B.12.

[b] The overhead-tank module may be either upstream (Figure B.4) or downstream (Figure B.5) of the seal-oil system module.

[c] This arrangement is valid only when the minimum seal-oil supply pressure is higher than the control-oil pressure.

[d] The check valve is omitted if an accumulator is not used.

**Figure B.1 — Combined seal-oil, lube-oil, and control-oil system**




**Key**

1 high-pressure overhead-tank module (Figure B.17)
2 high-pressure gas reference
3 high-pressure seal-oil supply
4 seal-oil module (Figure B.9)
5 low-pressure gas reference
6 low-pressure seal-oil supply
7 low-pressure overhead-tank module (Figure B.17)
8 drain
9 filter and cooler module (Figure B.20 or B.21)
10 booster pump (Figure B.23)
11 alternative low-pressure seal-oil supply lines
12 oil-supply header
13 oil-return headers to reservoir
14 basic oil-supply module (Figure B.12)
15 alarm

a The overhead-tank module may be either upstream (see Figure B.4) or downstream (see Figure B.5) of the seal-oil system module.

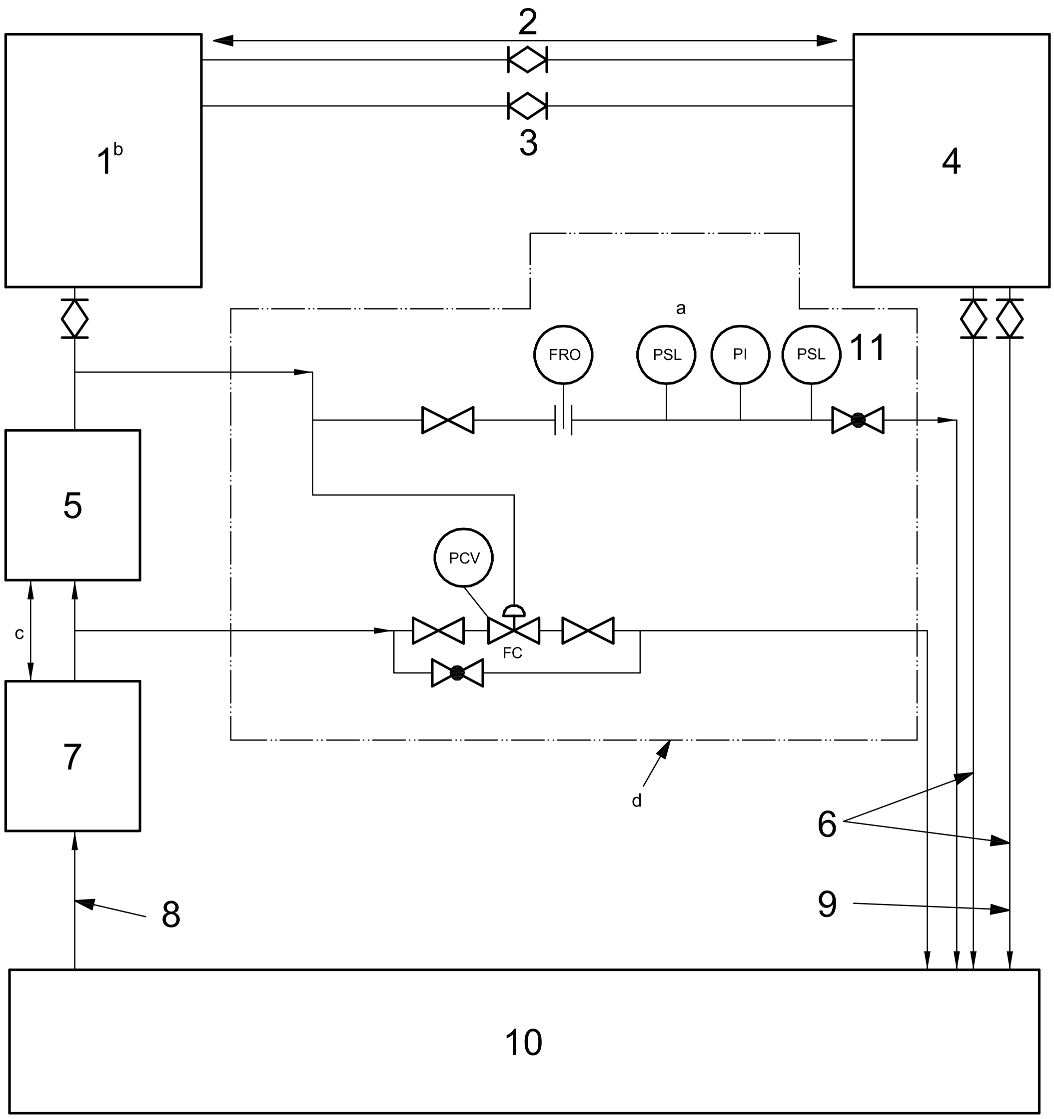
b Figure B.2, option A: A switch is included to start the standby booster pump.

c Figure B.2, option B: The booster pump and filter are omitted if the basic oil-supply system is specified to provide the required pressure.

d Figure B.2, option C: The pressure control valve and associated switches and pressure indicator may be deleted when the equipment has seals that take the total flow of oil from the pumps without the need for back-pressure regulation.

e The source for low-pressure seal oil depends on the required pressure.

**Figure B.2 — Seal-oil system only, with overhead tanks for equipment with more than one pressure level**




**Key**

1 overhead-tank module (Figure B.17)
2 gas reference
3 seal-oil supply
4 seal-oil module (Figure B.9)
5 filter and cooler module (Figure B.20 or B.21)
6 drain
7 booster pump (Figure B.23)
8 oil-supply header
9 oil-return headers to reservoir
10 basic oil-supply module (Figure B.12)
11 alarm

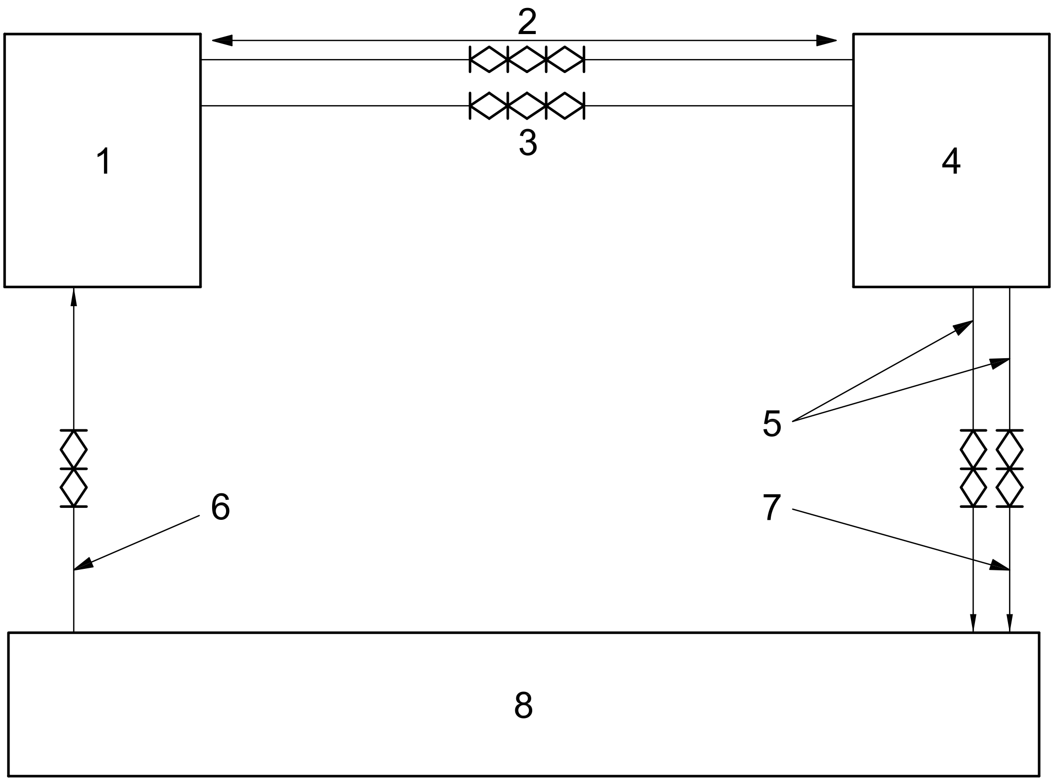
[a] Figure B.3, option A: A switch is included to start the standby booster pump.

[b] The overhead tank module may be either upstream (see Figure B.4) or downstream (see Figure B.5) of the seal-oil module.

[c] Figure B.3, option B: The booster pump and filter are omitted if the basic oil-supply system is specified to provide the required pressure.

[d] Figure B.3, option C: The pressure control valve and associated switches and pressure indicator may be deleted if the equipment seals utilize the total flow of oil from the pumps (e.g., for cooling purposes).

**Figure B.3 — Seal-oil system only, with overhead tank for equipment with one pressure level**




**Key**

1 overhead-tank module (Figure B.17)

2 gas reference

3 seal-oil supply

4 seal-oil module (Figure B.9)

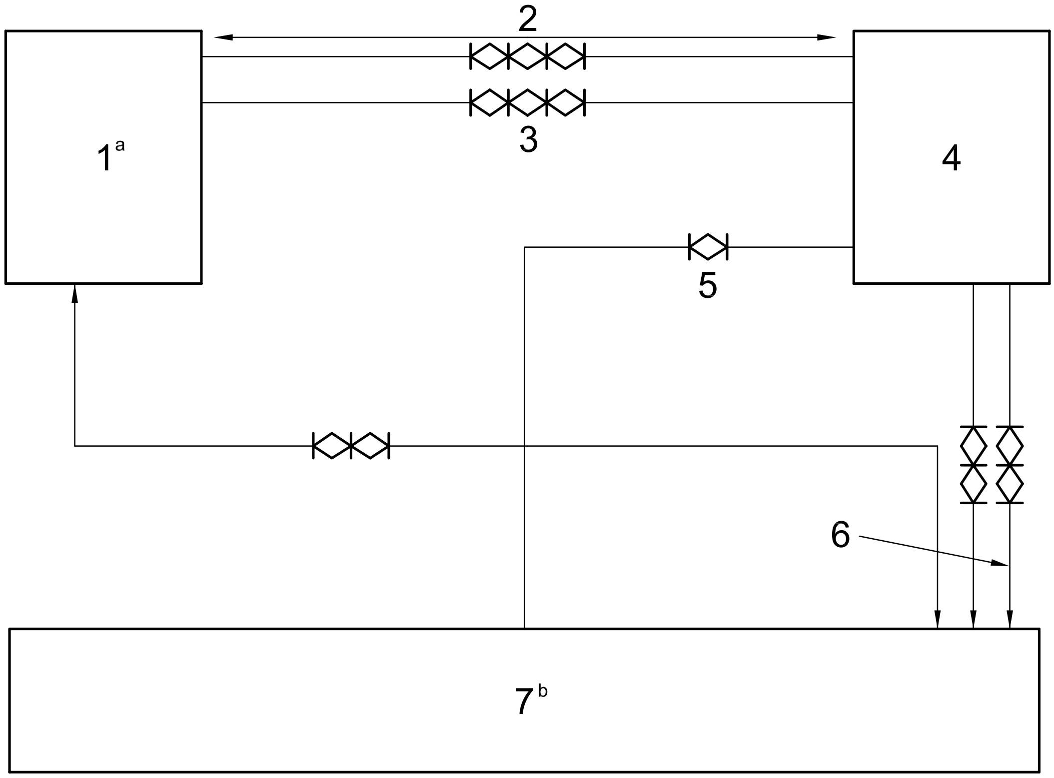
5 oil-return headers to reservoir

6 oil-supply header

7 oil-return headers to reservoir

8 basic oil-supply module (Figure B.12)

**Figure B.4 — Seal-oil system only, for equipment with liquid film-type seals — Overhead tank upstream of seals**



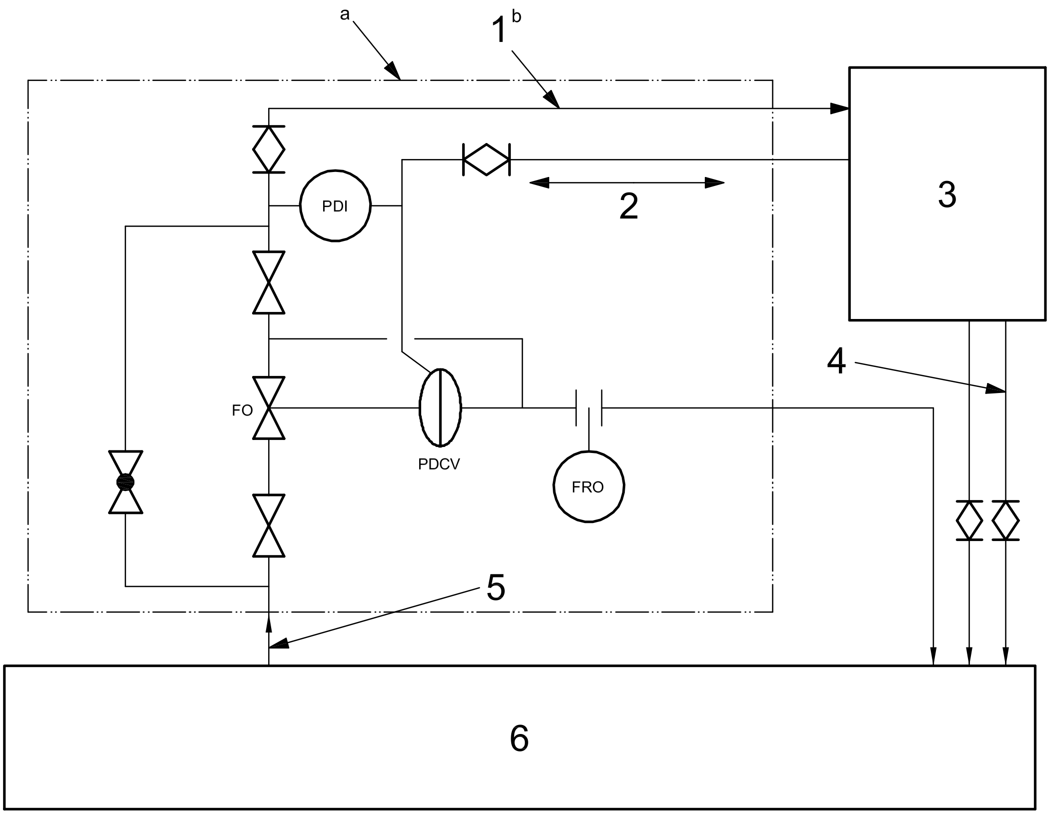

**Key**

1 overhead-tank module (Figure B.17)
2 gas reference
3 oil out
4 seal-oil module (Figure B.9)
5 seal-oil supply
6 oil-return headers to reservoir
7 basic oil-supply module (Figure B.12)

a The check valve shown in Figure B.17 is omitted from the overhead-tank module.

b The direct-acting pressure-control-valve circuit shown in Figure B.12 is omitted.

**Figure B.5 — Seal-oil system only, for equipment with liquid film-type seals — Overhead tank downstream of seals**



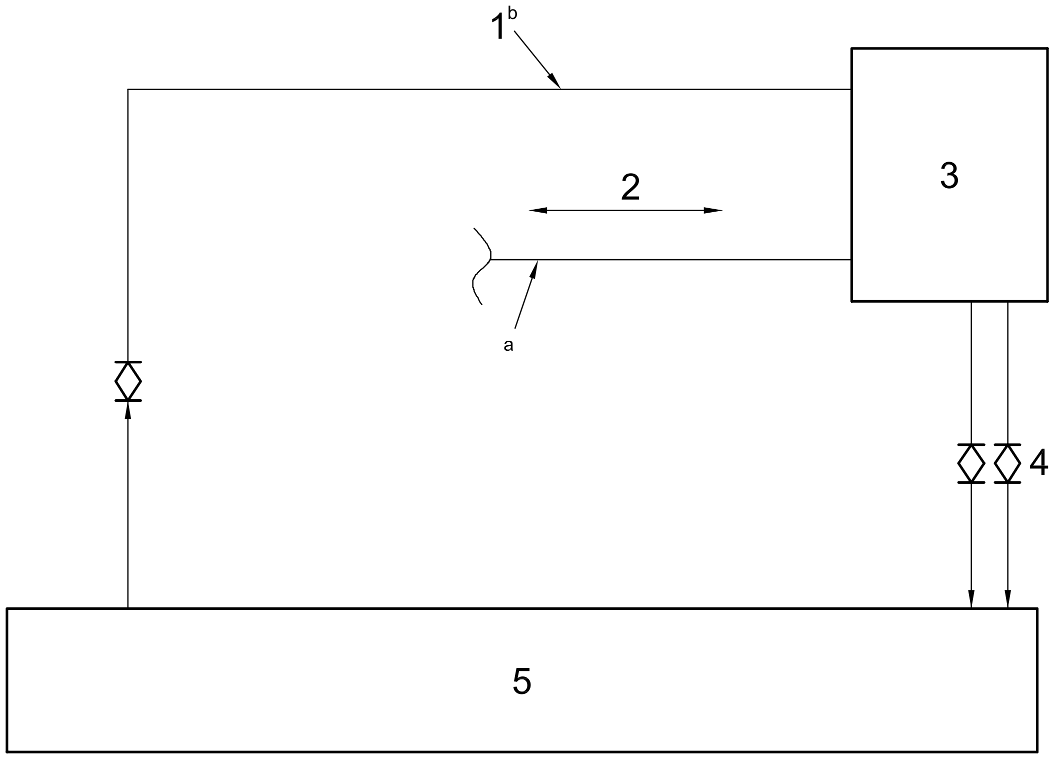

**Key**

1 seal-oil supply
2 gas reference
3 seal-oil module (Figure B.9)
4 oil-return headers to reservoir
5 oil-supply header
6 basic oil supply module (Figure B.12)

a The purchaser and vendor may agree upon an alternative arrangement.

b This arrangement is valid only when the pressure of the seal-oil supply at the compressor is lower than the pressure of the cooling water. If the pressure of the cooling water is lower, refer to Figure B.7.

**Figure B.6 — Seal-oil system with oil pressure lower than cooling water pressure**



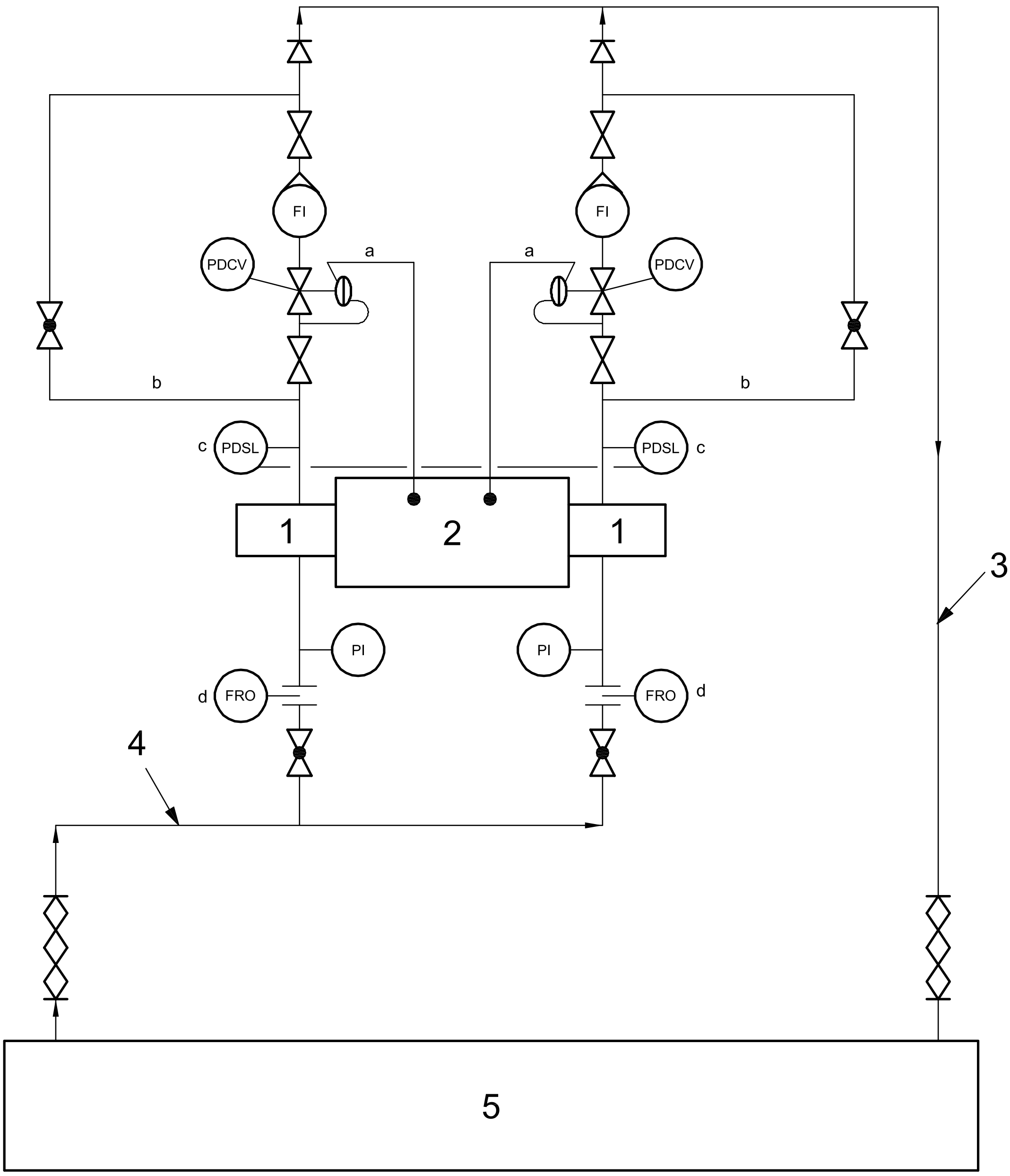

**Key**

1 seal-oil supply
2 gas reference
3 seal-oil module (Figure B.9)
4 oil-return headers to reservoir
5 basic oil-supply module (Figure B.12)

[a] A direct-acting differential-pressure control valve is used according to the alternative arrangement shown in Figure B.12.

[b] This arrangement is valid only when the pressure of the seal-oil supply is higher than the pressure of the cooling water. If the pressure of the cooling water is higher, refer to Figure B.6.

**Figure B.7 — Seal-oil system with oil pressure higher than cooling water pressure**




**Key**

1 seal

2 equipment

3 oil-return header to reservoir

4 oil-supply header

5 basic oil-supply module (Figure B.12)

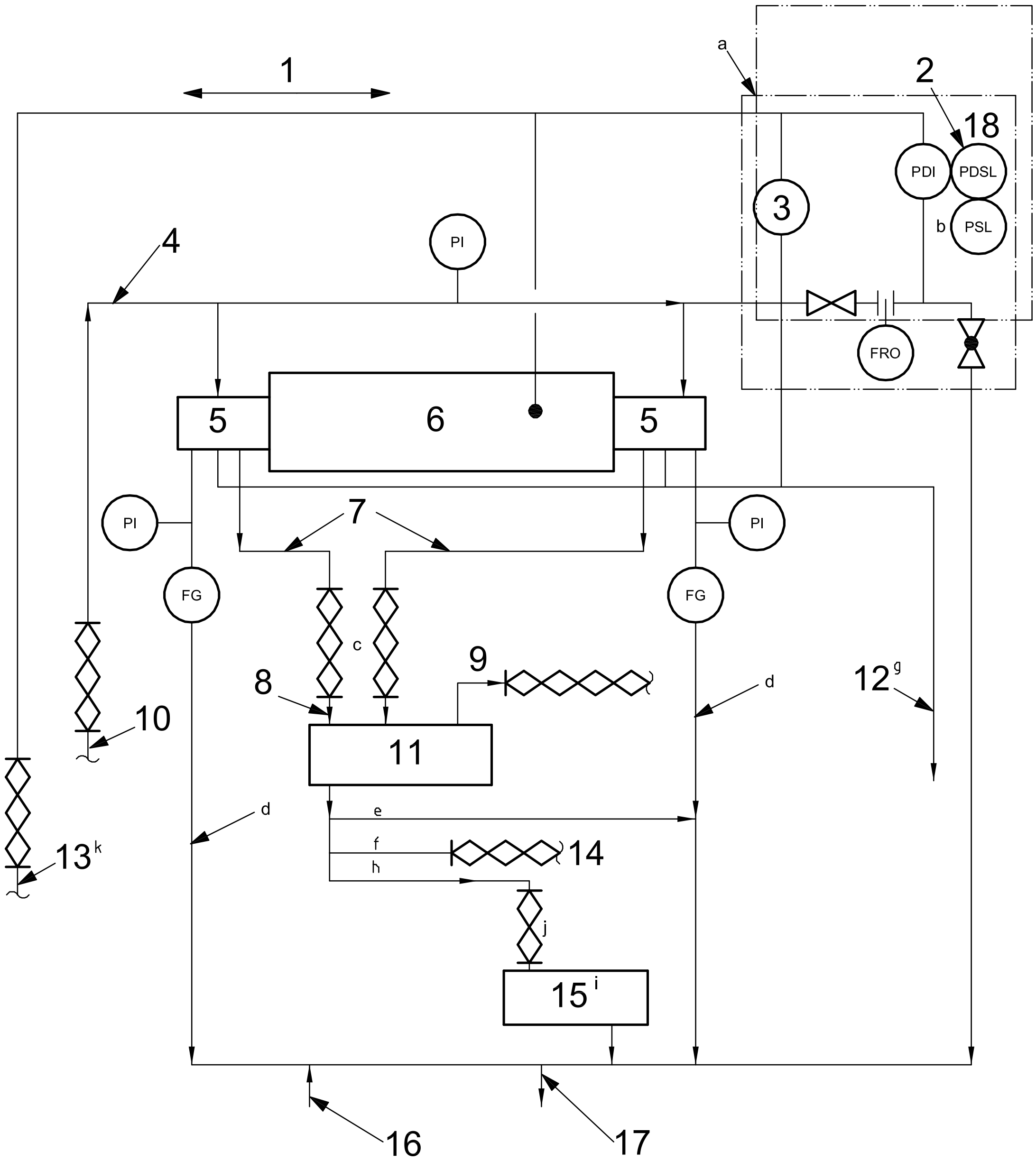
a Each direct-acting differential-pressure control valve shall be referenced to sense the working-fluid pressure acting at the corresponding mechanical seal.

b Block, isolation, and vent-bleed valves can be omitted for all instruments in trip service with owner's approval.

c Figure B.8, option A: A switch to alarm or trip or both is/are included.

d Figure B.8, option B: A flow-restriction orifice is included.

**Figure B.8 — Seal-oil circulation system for equipment with double mechanical seals or multiple sealing pressure levels**




**Key**

1 gas reference
2 to start standby pump
3 PDSLL to trip main driver
4 seal-oil supply header
5 seal
6 equipment
7 inner seal-oil drains
8 drain
9 vent
10 seal-oil supply
11 inner oil seal drain traps (Figure B.14)
12 seal-oil return header
13 gas reference to differential control or overhead tank
14 purchaser's drains
15 degasifier
16 drain header (lube drain for combined lube- and seal-oil systems)
17 oil return(s) to reservoir
18 alarm

**Figure B.9** (*continued*)

[a] The indicated components are omitted if they are furnished separately on the overhead tank.

[b] The low-pressure switch is not required if the module is supplied with a back-pressure regulator circuit (see Figure B.12).

[c] This piping is furnished by the vendor when the drainers are mounted on a compressor baseplate.

[d] On combined lube- and seal-oil systems, the outer seal drain may be combined with the lube-oil drain inside the compressor.

[e] Figure B.9, option A: A drain to the reservoir is included.

[f] Figure B.9, option B: A drain to the purchaser's drains is included.

[g] Alternate seal-oil drain arrangement. For this arrangement, sensing instruments (key items 2 and 3) are referenced to a pressure-controlled header, either upstream or downstream of the seals, as agreed.

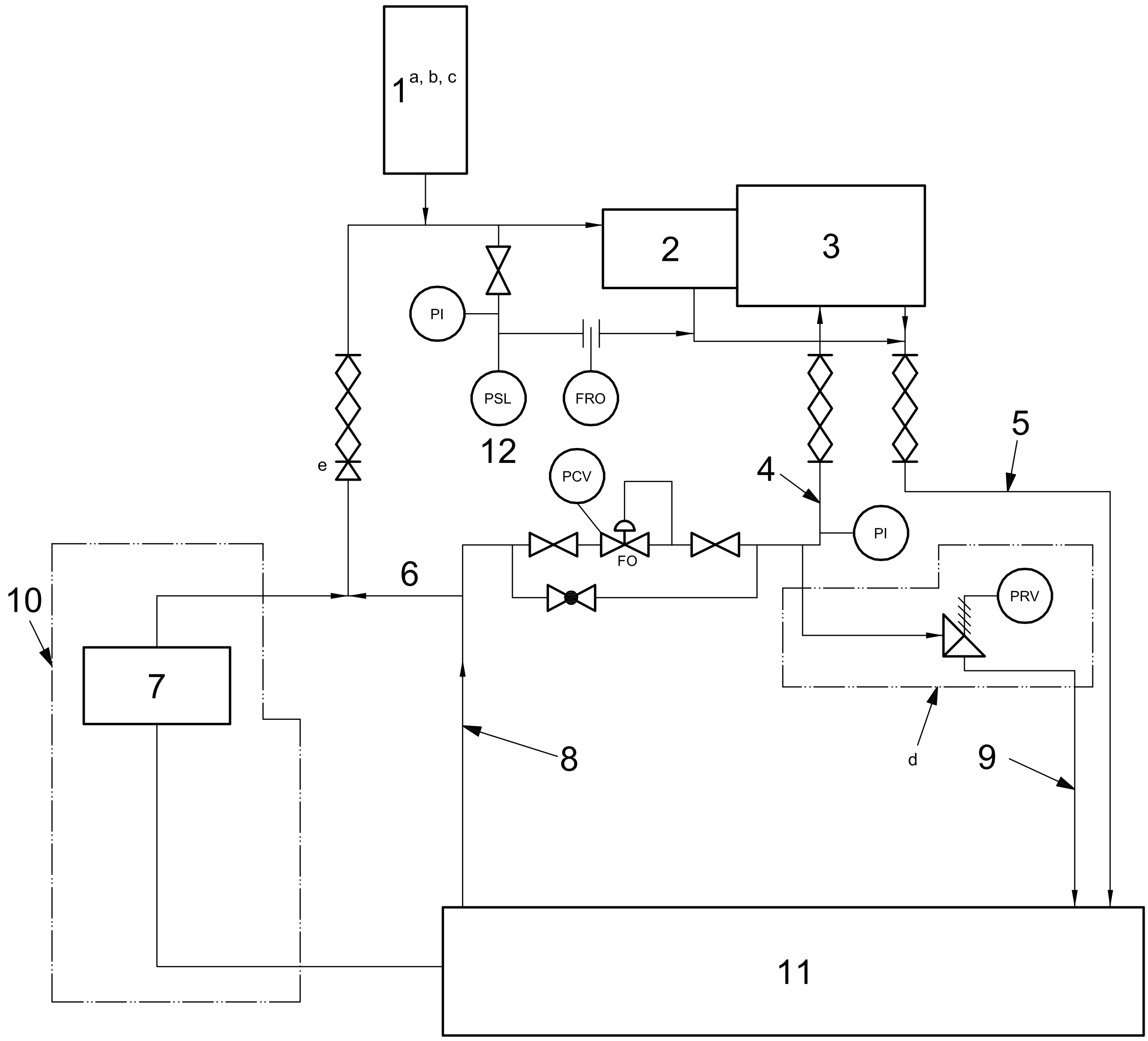
[h] Figure B.9, option C: A drain to the degassing drum is included.

[i] Figure B.9, option D: A degassing drum (see Figure 3) is included.

[j] This piping is furnished by the vendor if the degassifier is mounted on a compressor baseplate supplied by the vendor.

[k] Each direct-acting differential-pressure-control valve shall be referenced to sense the working-fluid pressure acting at the corresponding seal.

**Figure B.9 — Seal-oil module at equipment**




**Key**

1 accumulator
2 control system
3 equipment lube-oil module (Figure B.13)
4 lube-oil supply
5 drain
6 control-oil supply
7 filter and cooler module (Figures B.20 and B.21)
8 oil-supply header
9 oil-return headers
10 alternative control-oil supply flow
11 basic oil supply module (Figure B.12)
12 alarm

[a] A control-oil accumulator shall be supplied if one is required to maintain the control-oil pressure.

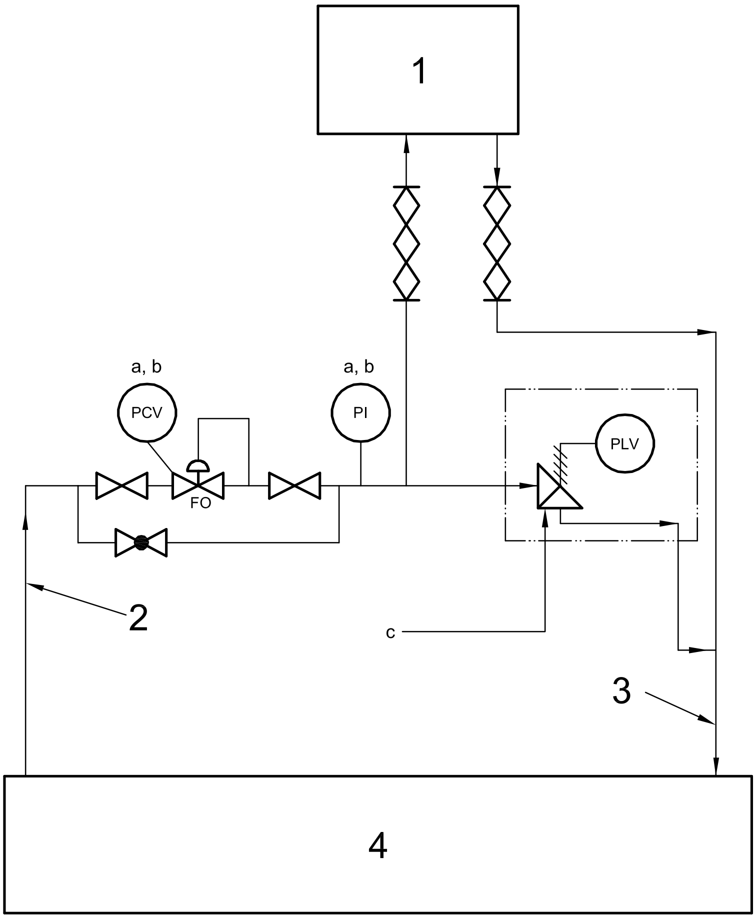
[b] The accumulator shall be mounted as close as possible to the main equipment.

[c] When required, the accumulator shall be of the bladder (Figure B.18) or direct-contact (Figure B.19) type.

[d] This represents a typical arrangement that includes an additional pressure-limiting valve (PLV) for any system in which failure of a control valve can jeopardize or damage a low-pressure system.

[e] The check valve is omitted if an accumulator is not used.

**Figure B.10 — Lube-oil and control-oil systems only**




**Key**

1 equipment lube-oil module (Figure B.13)

2 oil supply header to equipment

3 oil return header from equipment

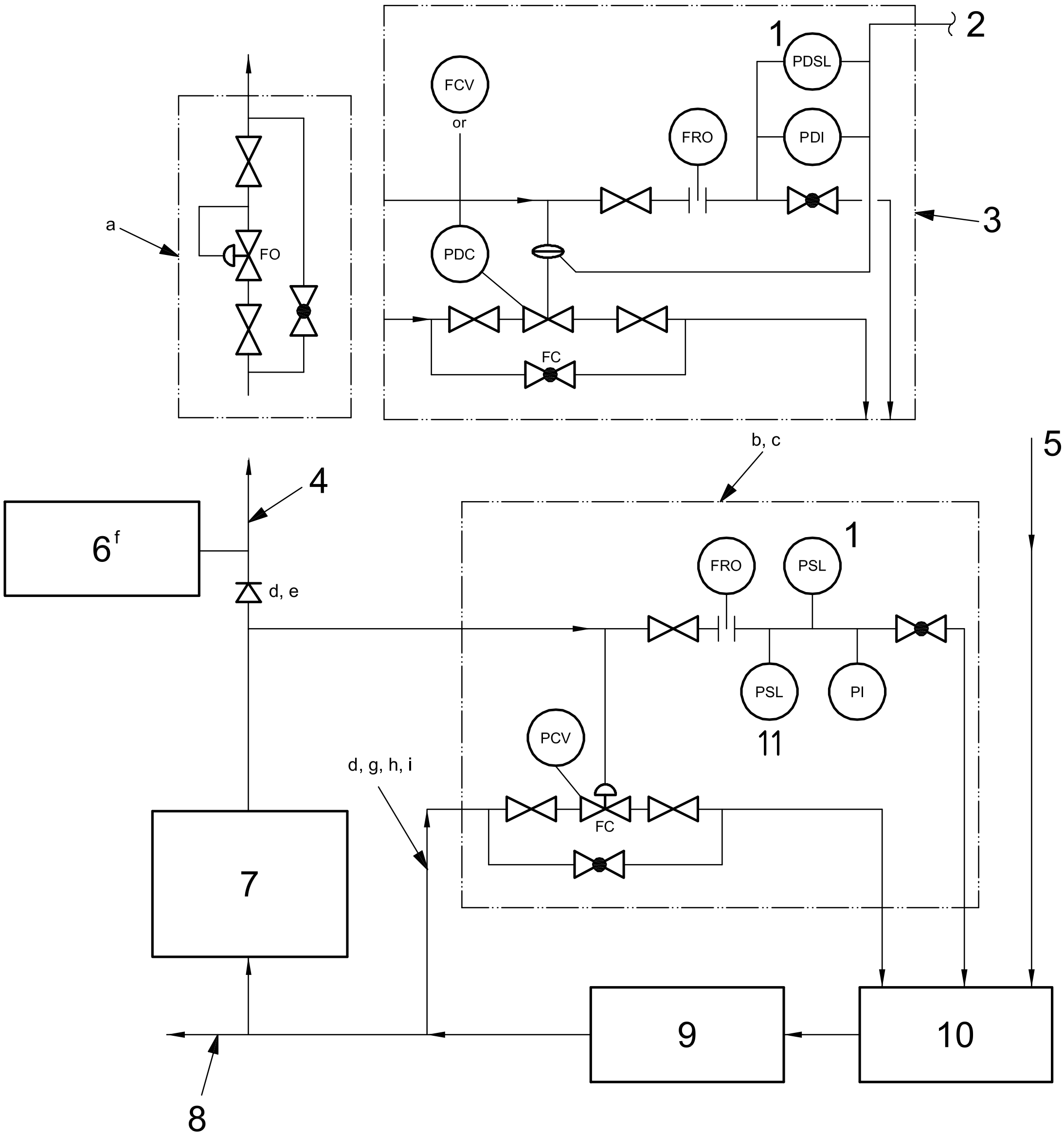
4 basic oil-supply module (Figure B.12)

a The direct-acting pressure-control valve and the pressure indicator are omitted when the pressure of the lube-oil supply is higher than the pressure of the cooling water.

b A direct-acting pressure-control valve is required if centrifugal pumps are used.

c This represents a typical arrangement that includes an additional pressure-limiting valve (PLV) for any system in which failure of a control valve can jeopardize or damage a low-pressure system.

**Figure B.11 — Equipment lube-oil system only**




**Key**

1 to start standby pump
2 gas reference (Figure B.1) or downstream of flow element
3 alternate arrangement
4 oil-supply header to equipment
5 oil-return header from equipment
6 accumulator
7 filter and cooler module (Figure B.20 or Figure B.21)
8 alternative control oil
9 primary pumps (Figure B.22)
10 reservoir (Figure B.24)
11 alarm

**Figure B.12** (*continued*)

[a] Provision can be required to ensure adequate lube- and/or control-oil pressure when the seal-oil supply pressure is low relative to the lube- and/or control-oil pressure or to maintain the required oil-pressure differential above the cooling-water pressure.

[b] When the module is specified for seal-oil applications, a direct-acting differential-pressure control valve or regulator shall be used.

[c] The bypass valve may be deleted for a separate seal-oil system that utilizes the total oil flow from the pumps.

[d] The check valve is omitted when (1) an accumulator is not used, (2) a direct-acting pressure control valve circuit is used, or (3) an emergency rundown tank is not used.

[e] The check valve is omitted when a rotary primary pump or an accumulator is not used.

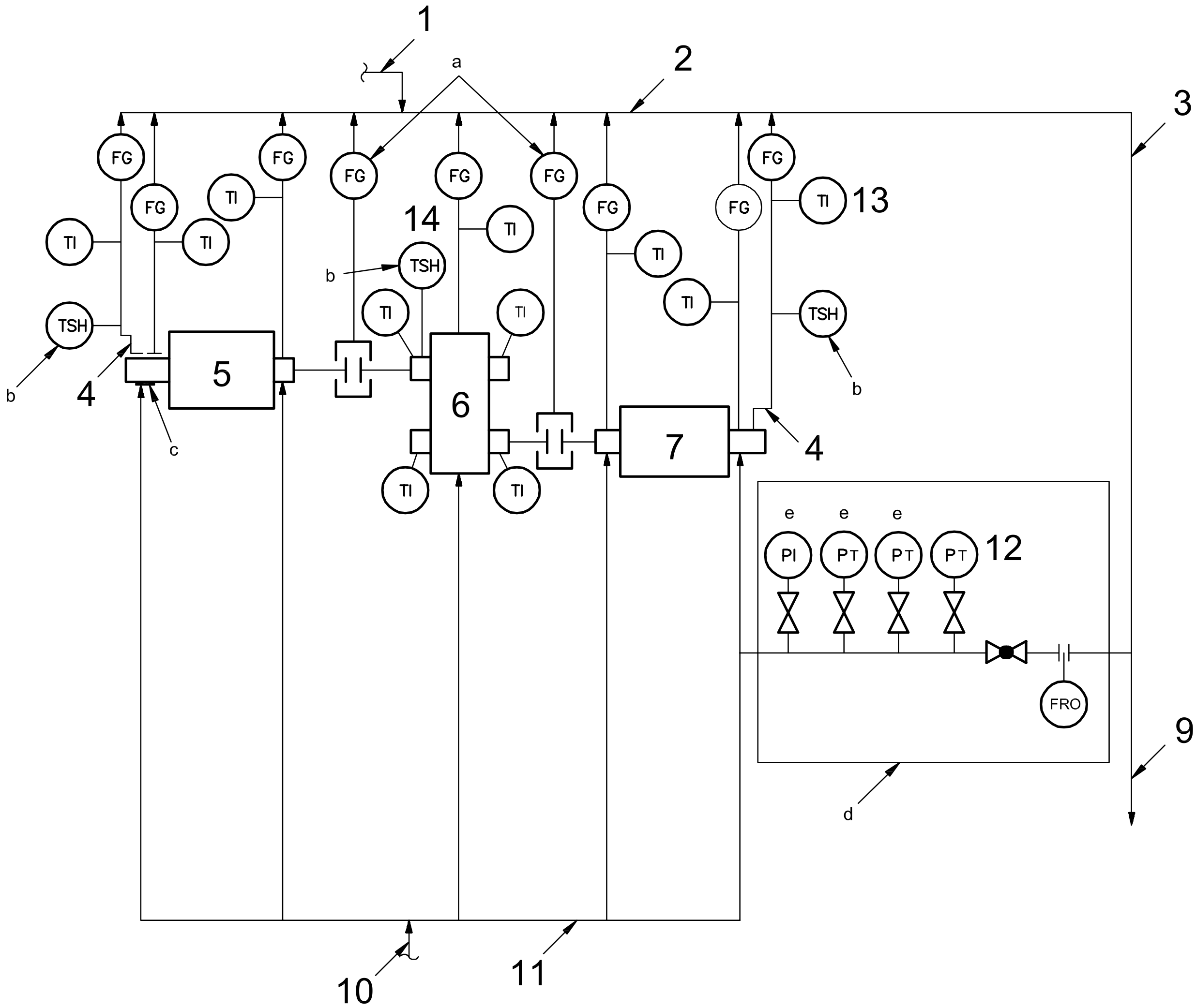
[f] When required, the accumulator shall be of the bladder (Figure B.18) or direct-contact (Figure B.19) type.

[g] The heat load can require that the supply to the direct-acting pressure control valve be downstream of the coolers.

[h] The direct-acting pressure-control valve circuit is omitted when the module is specified for seal-oil systems (Figures B.4 and B.5).

[i] The bypass direct-acting pressure control valve circuit is omitted when centrifugal pumps are used.

**Figure B.12 — Basic oil supply module**




**Key**

1 from equipment outer-seal drains, control-oil drains, and the like, as necessary
2 lube-drain header
3 oil-return header
4 thrust drain
5 driver
6 gear
7 driven unit
8 low lube-oil supply pressure trip
9 drain
10 oil in
11 lube supply header
12 low lube-oil supply pressure alarm
13 alarm
14 thrust alarm

[a] Drains are required on closed coupling guards. Figure B.13, option A: Flow glasses may be provided as an option.

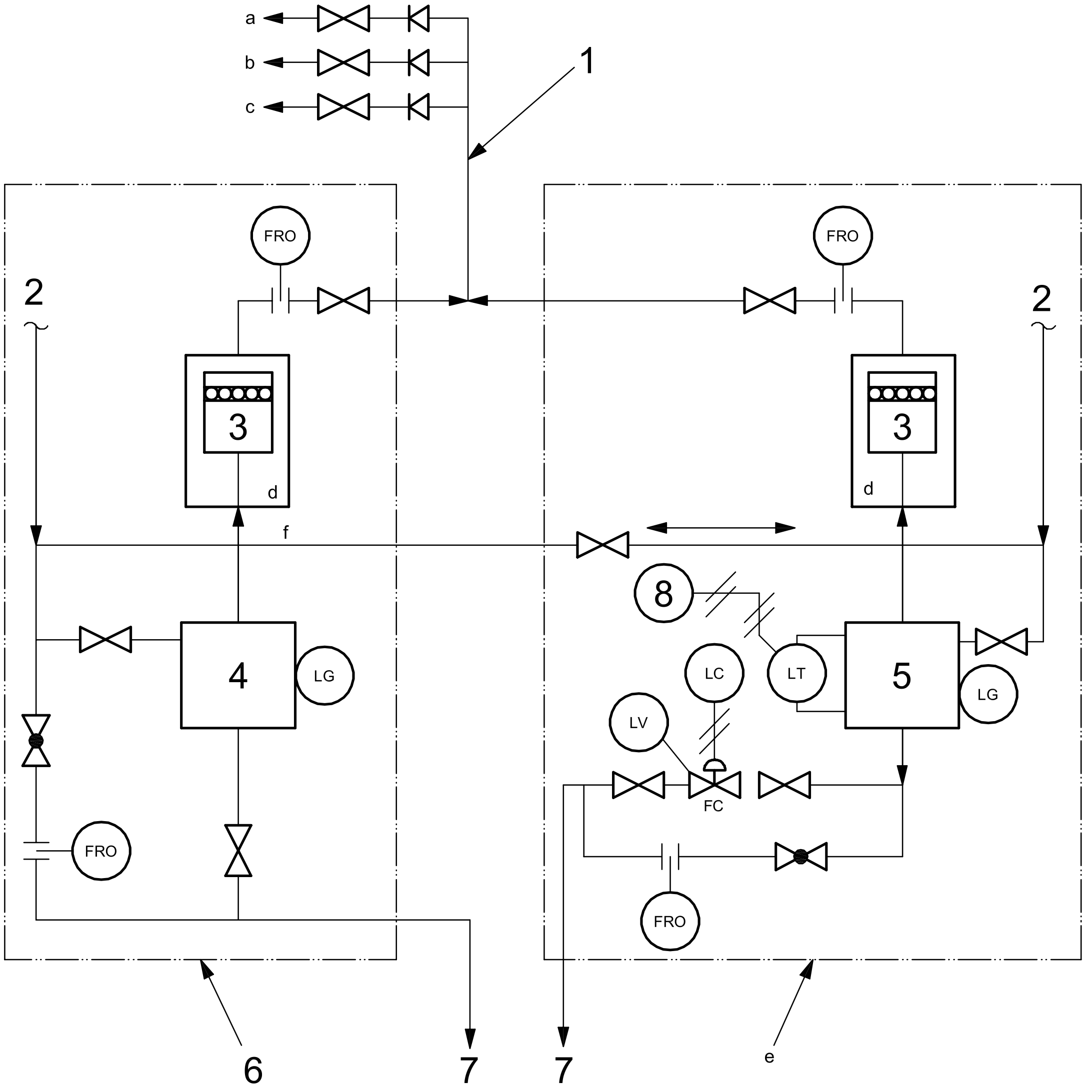
[b] An oil-drain high-temperature switch is not required if a thrust-bearing metal temperature detector is specified.

[c] If required by the motor design, all connections shall be electrically insulated.

[d] These components may be located on the gauge board.

[e] Redundant transmitters may be provided for 2-out-of-3 voting.

**Figure B.13 — Equipment lube-oil supply and drain headers**




**Key**

1 vent

2 from inner seal

3 mist eliminator

4 float trap

5 drain pot

6 typical arrangement for mechanical-float type traps

7 separate drain outlet for each drain pot

8 high-level alarm

[a] Figure B.14, option A: The purchaser may specify a vent to the flare.

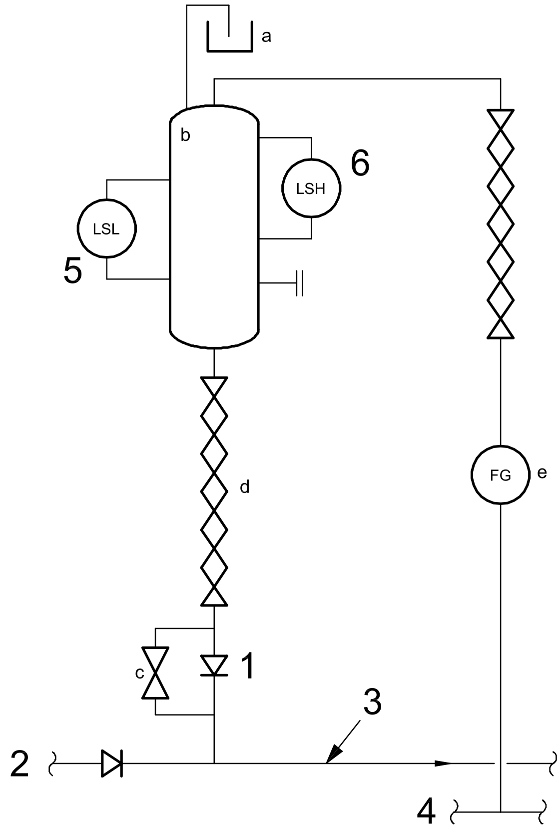
[b] Figure B.14, option B: The purchaser may specify a vent to the gas system.

[c] Figure B.14, option C: The purchaser may specify a vent to the suction of a lower pressure casing.

[d] Figure B.14, option D: The purchaser may specify mist eliminators.

[e] This line is omitted when the seals are not at the same pressure.

**Figure B.14 — Inner oil seal drain traps**




**Key**

1 drilled check valve
2 lube-oil supply
3 to equipment
4 to reservoir or drain header
5 low-level alarm
6 permissive start

[a] Figure B.15, option A: The purchaser may specify an atmospheric breather valve.

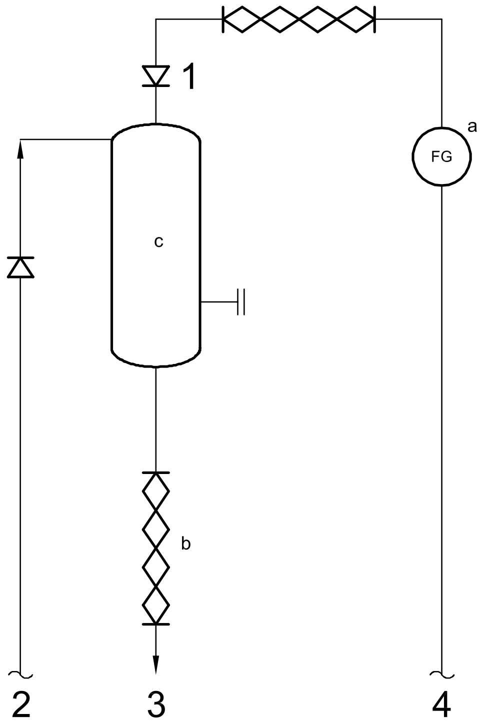
[b] This tank shall be located at an elevation such that the static head is less than the equipment lube-oil trip pressure.

[c] This valve is normally closed; it is opened only to fill the tank before the equipment is started. Figure B.15, option B: This valve may be solenoid-controlled to allow an automated start.

[d] To reduce pressure-line losses, locate and design interconnecting piping as per system designer's recommendations.

[e] Sight glass should be located near the reservoir in a visible location.

**Figure B.15 — Emergency lube-oil atmospheric-type rundown tank**




**Key**

1 float-type check valve

2 lube-oil supply

3 to equipment

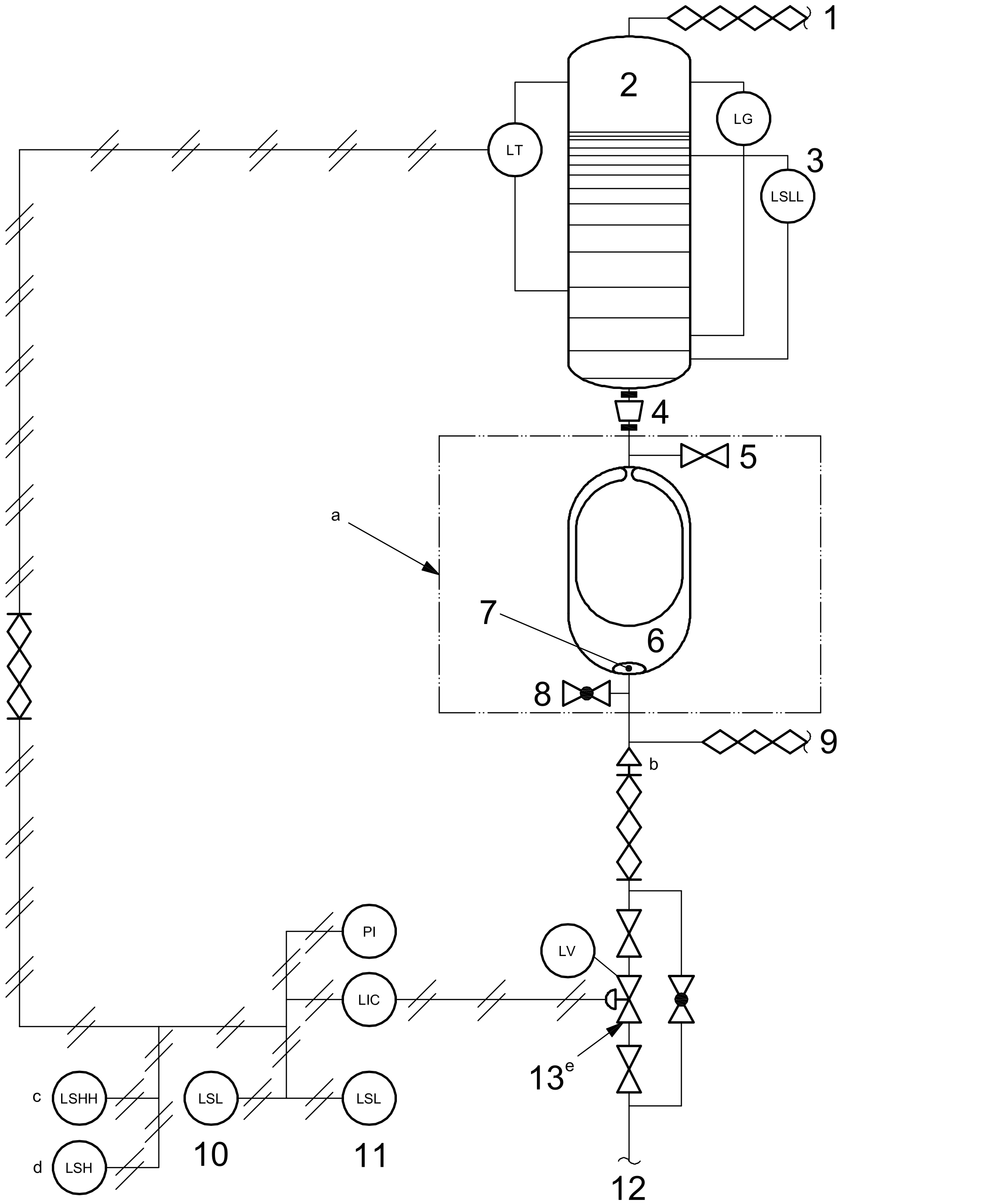
4 to reservoir or drain header

[a] Locate site glass near the reservoir in a visible location.

[b] To reduce pressure-line losses, locate and design interconnecting piping as per system designer's recommendations.

[c] This tank shall be located at an elevation such that the static head is less than the equipment lube-oil trip pressure.

**Figure B.16 — Emergency lube-oil pressurized-type rundown tank**




**Key**

1 gas reference
2 overhead tank
3 low low level to trip main driver
4 bottom outlet nozzle [⩾ 150 mm (6 in)]
5 drain or fill connector
6 transfer-type (bladder-type) vessel
7 bladder-limiter device
8 vent
9 to supply header or return header
10 low-level alarm
11 to start standby pump
12 oil-in or oil-return header
13 control valve

a Figure B.17, option A: The purchaser may specify an accumulator with an isolation bladder.

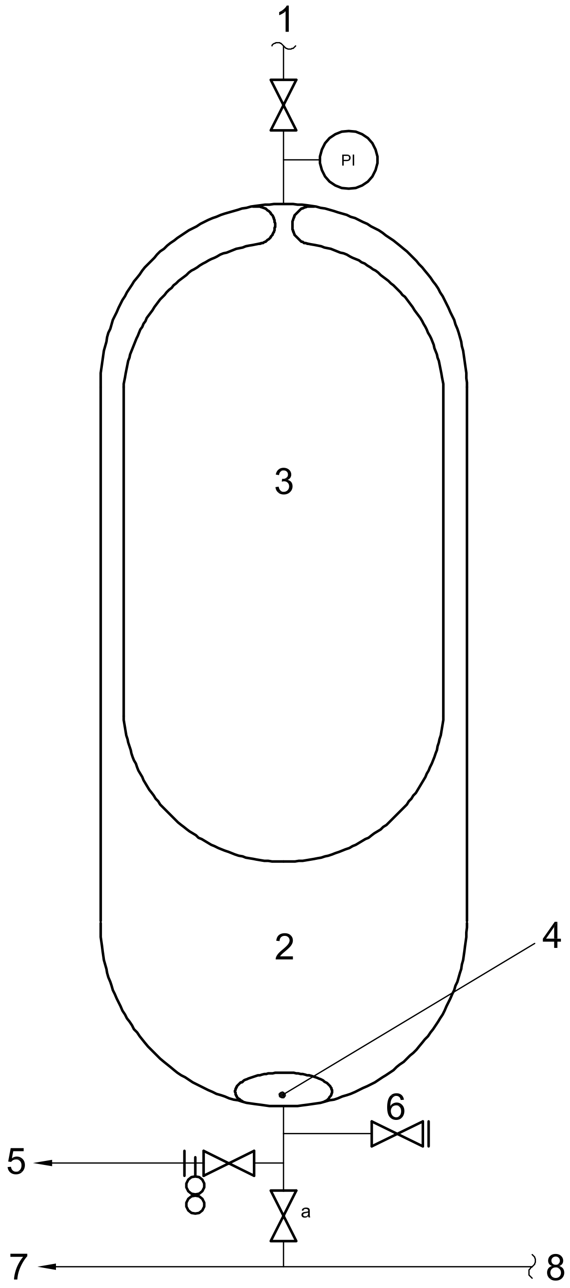
b The check valve is omitted when the overhead tank module is downstream of the seals.

c Figure B.17, option B: When the pump is for seal oil only, the purchaser may specify a signal to stop the pump.

d Figure B.17, option C: When the pump is for a combined lube- and seal-oil system, the purchaser may specify an alarm.

e Control valve should be in FO or FL position. Figure B.17, option D: The following are the failure actions for the loop-actuated control valve: FO in the supply header and FC in the return header.

**Figure B.17 — Direct-contact-type overhead-tank module for seal-oil system, including optional transfer barrier (bladder-type) vessel**

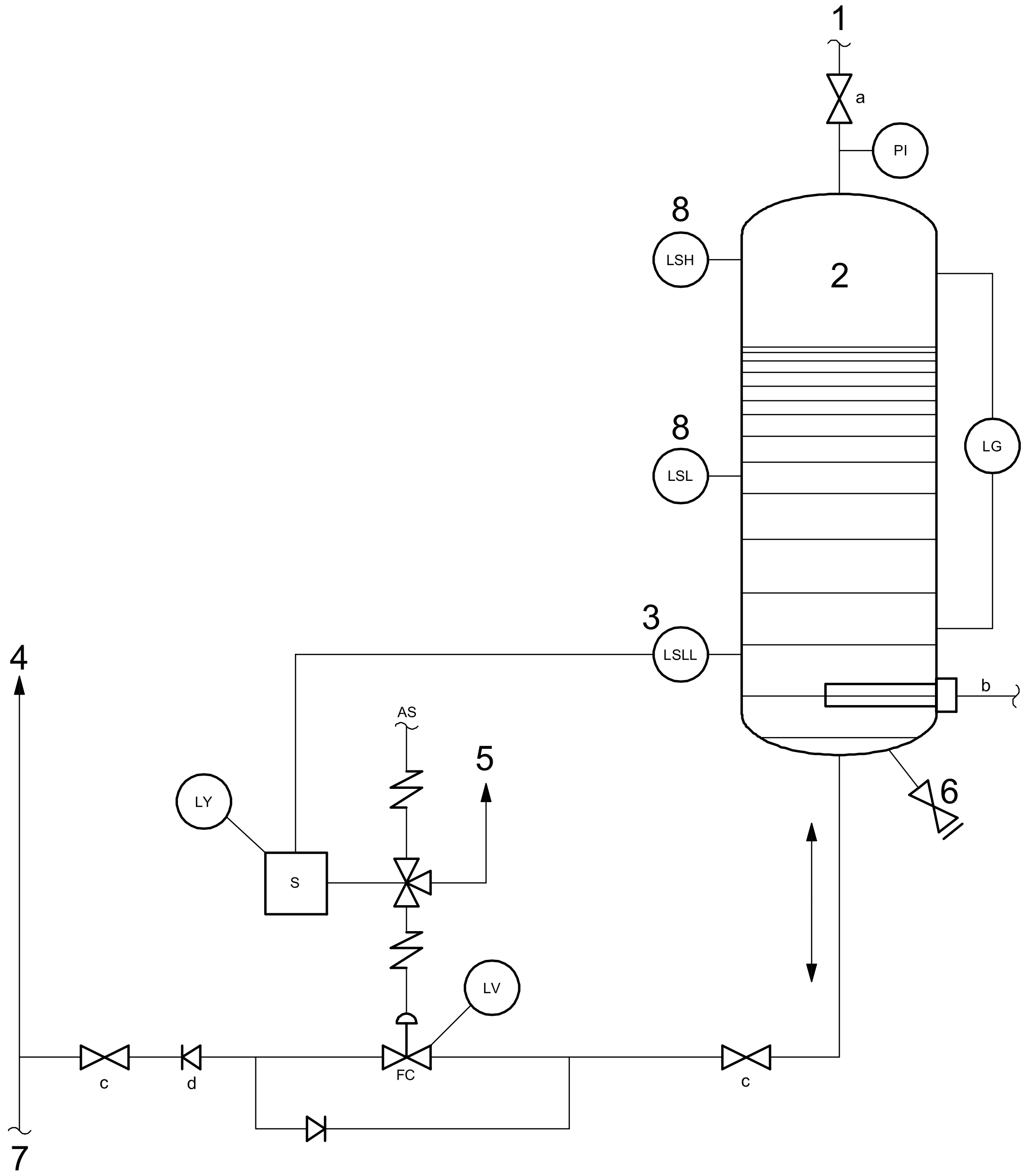



**Key**

1 charge gas
2 accumulator
3 bladder
4 bladder-limiter device
5 drain to reservoir
6 vent
7 oil out
8 oil in

a The block valve may be locked open.

**Figure B.18 — Accumulator — Manual precharge, bladder type**




**Key**

| | | | |
|---|---|---|---|
| 1 | charge gas | 5 | vent |
| 2 | accumulator tank | 6 | drain |
| 3 | to close valve | 7 | oil in |
| 4 | oil out | 8 | alarm |

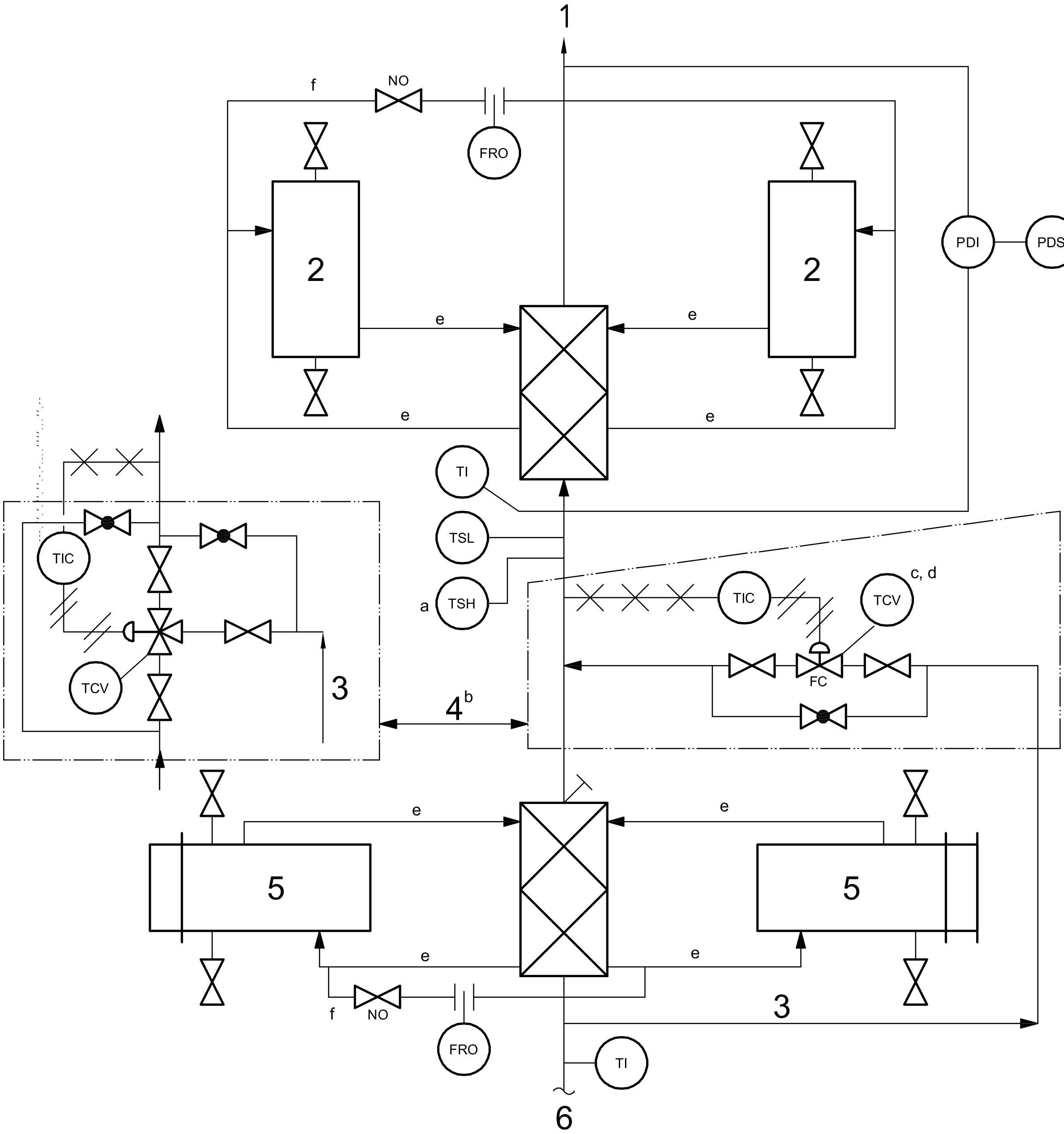
[a] Figure B.19, option A: The purchaser may specify a constant-pressure regulating system.

[b] Figure B.19, option B: The purchaser may specify an electric heater.

[c] The block valve may be locked open.

[d] Figure B.19, option C: A check valve with its seat or disk drilled reduces the recharging rate after an upset of the oil system. The purchaser should recognize that this can reduce the attenuation of pressure pulsations during system recovery.

**Figure B.19 — Accumulator — Direct-contact, manual-precharge type**




**Key**

| | | | |
|---|---|---|---|
| 1 | oil out | 4 | alternative arrangement |
| 2 | filter | 5 | cooler |
| 3 | bypass | 6 | oil in |

[a] Figure B.20, option A: The purchaser may specify a high-temperature switch (TSH) and/or a low-temperature switch (TSL).

[b] Figure B.20, option B: The purchaser may specify a constant-temperature, three-way control valve as an alternative.

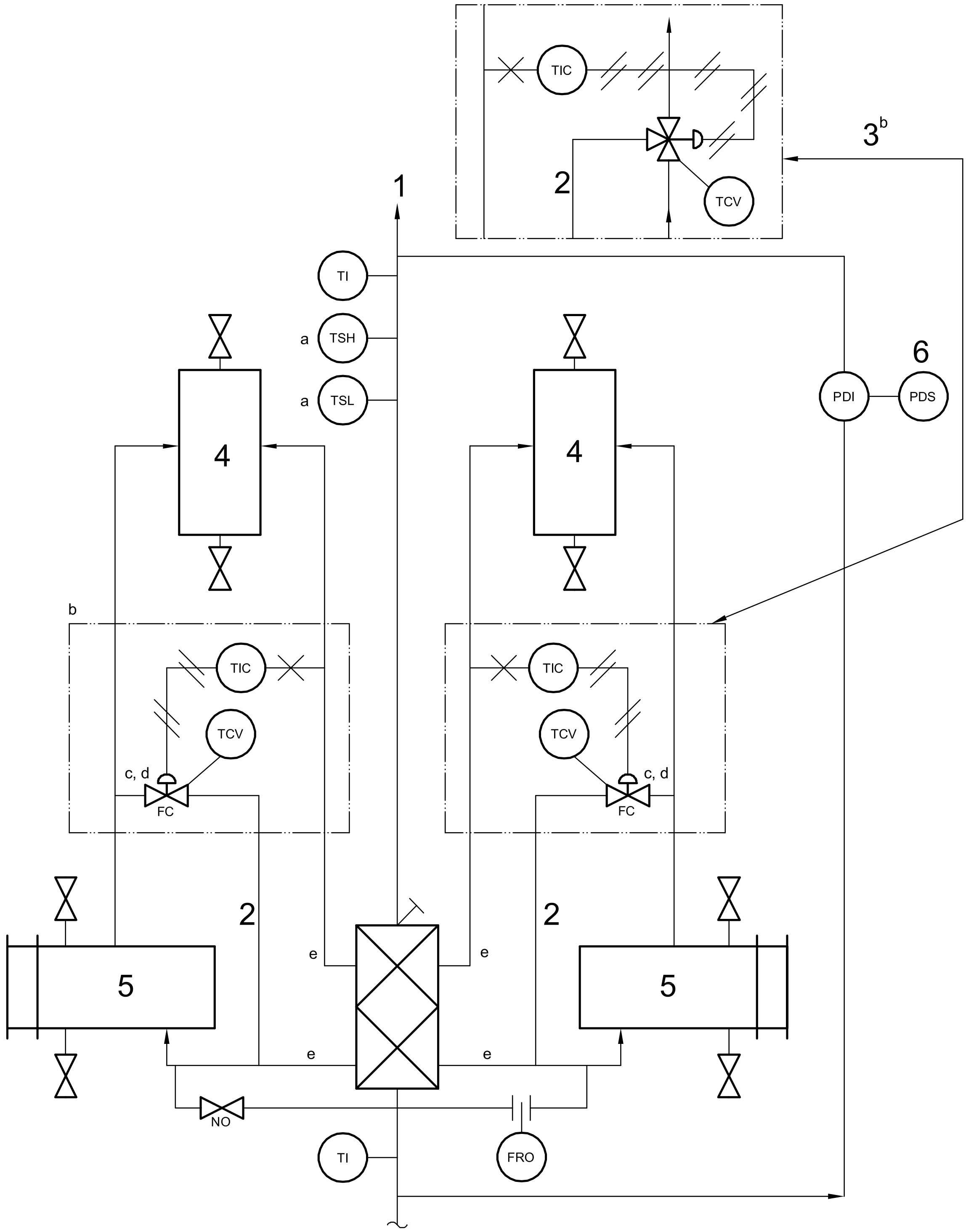
[c] Figure B.20, option C: The purchaser may specify a bypass oil line and a constant-temperature, two-way control valve.

[d] Figure B.20, option D: If the fail-closed (FC) feature of the direct-acting temperature-control valve is not acceptable, the purchaser may specify a valve with a FL feature.

[e] Figure B.20, option E: The purchaser may specify tight shutoff requiring spectacle blinds.

[f] The equalization/fill line between twin coolers and filters can be piped by the console vendor or can be integral with the transfer valve.

**Figure B.20 — Twin oil coolers and filters with separate, continuous-flow transfer valves**




**Key**

| | | | | | |
|---|---|---|---|---|---|
| 1 | oil out | 3 | alternate arrangement | 5 | cooler |
| 2 | bypass | 4 | filter | 6 | alarm |

a Figure B.21, option A: The purchaser may specify a high-temperature switch (TSH) and/or a low-temperature switch (TSL)

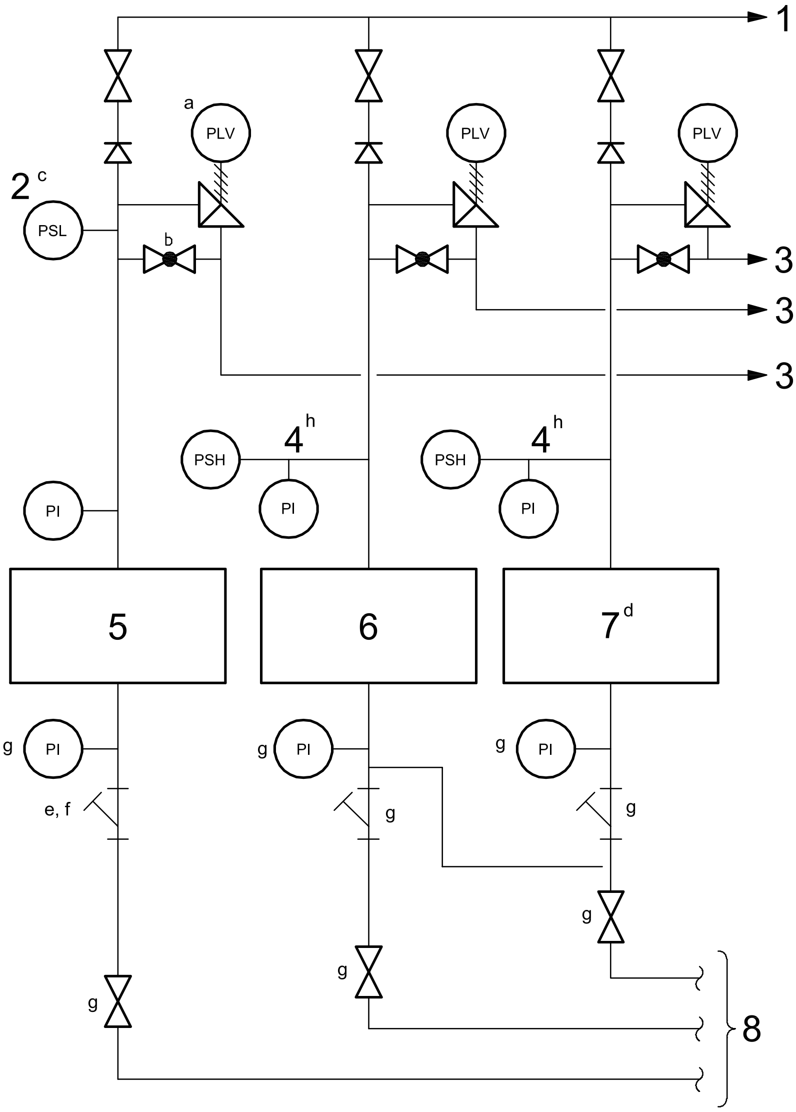
b Figure B.21, option B: The purchaser may specify a constant-temperature, three-way control valve as an alternative.

c Figure B.21, option C: The purchaser may specify a bypass oil line and a constant-temperature, two-way control valve.

d Figure B.21, option D: If the FC feature of the direct-acting temperature control valve is not acceptable, the purchaser may specify a valve with a FL feature.

e Figure B.21, option E: The purchaser may specify tight shutoff requiring spectacle blinds.

**Figure B.21 — Twin oil coolers and filters with a single, continuous-flow transfer valve**




**Key**

| | | | |
|---|---|---|---|
| 1 | to downstream equipment | 5 | main pump |
| 2 | to start standby pump | 6 | standby pump |
| 3 | individual return lines to reservoir | 7 | emergency pump |
| 4 | pump running alarm | 8 | pump suction from reservoir |

[a] The pressure-limiting valves (PLV) are omitted for centrifugal pumps.

[b] Figure B.22, option A: The purchaser may specify a bypass valve to start.

[c] Figure B.22, option B: The purchaser may specify an additional switch to start the standby pump (see Figure B.12).

[d] Figure B.22, option C: The purchaser may specify an emergency pump.

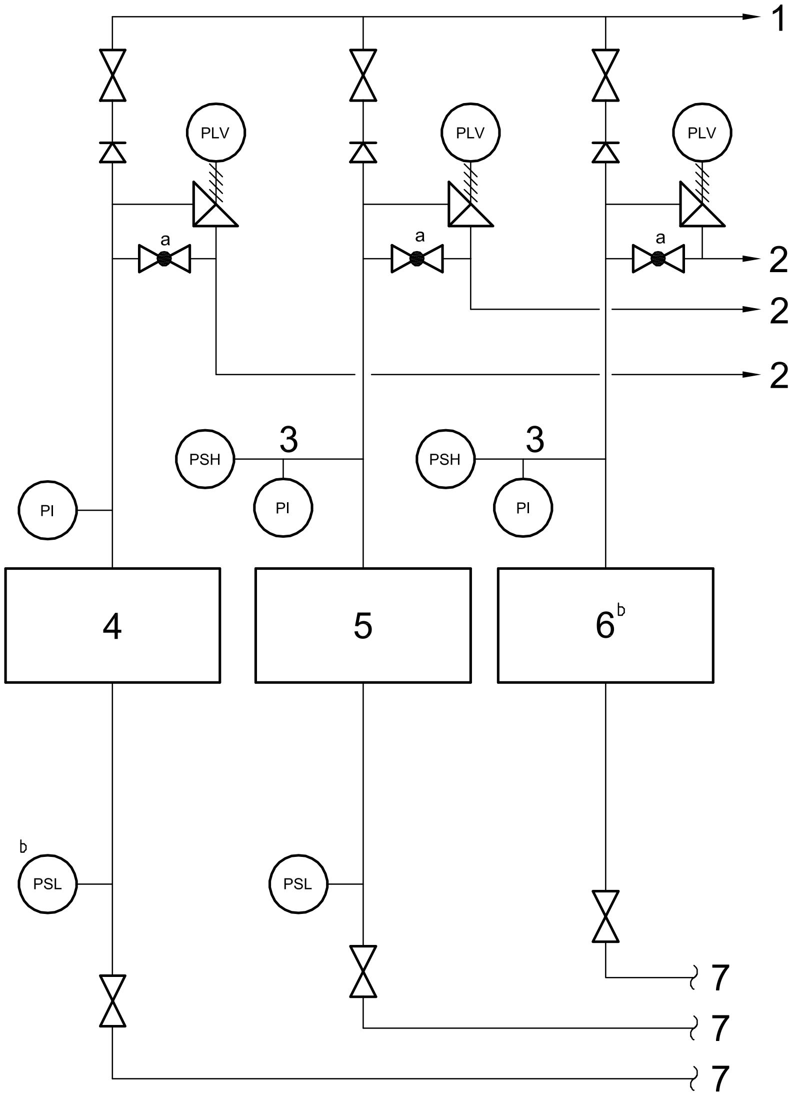
[e] For centrifugal pumps, the line strainers are omitted and temporary screens are provided.

[f] A basket-type screen shall be used instead of a line strainer for the suction of pumps submerged in the reservoir.

[g] These components are omitted for pumps submerged in the reservoir.

[h] The pump running alarm can alternatively be accomplished in the motor control centre.

**Figure B.22 — Primary (centrifugal or rotary) pump arrangement**



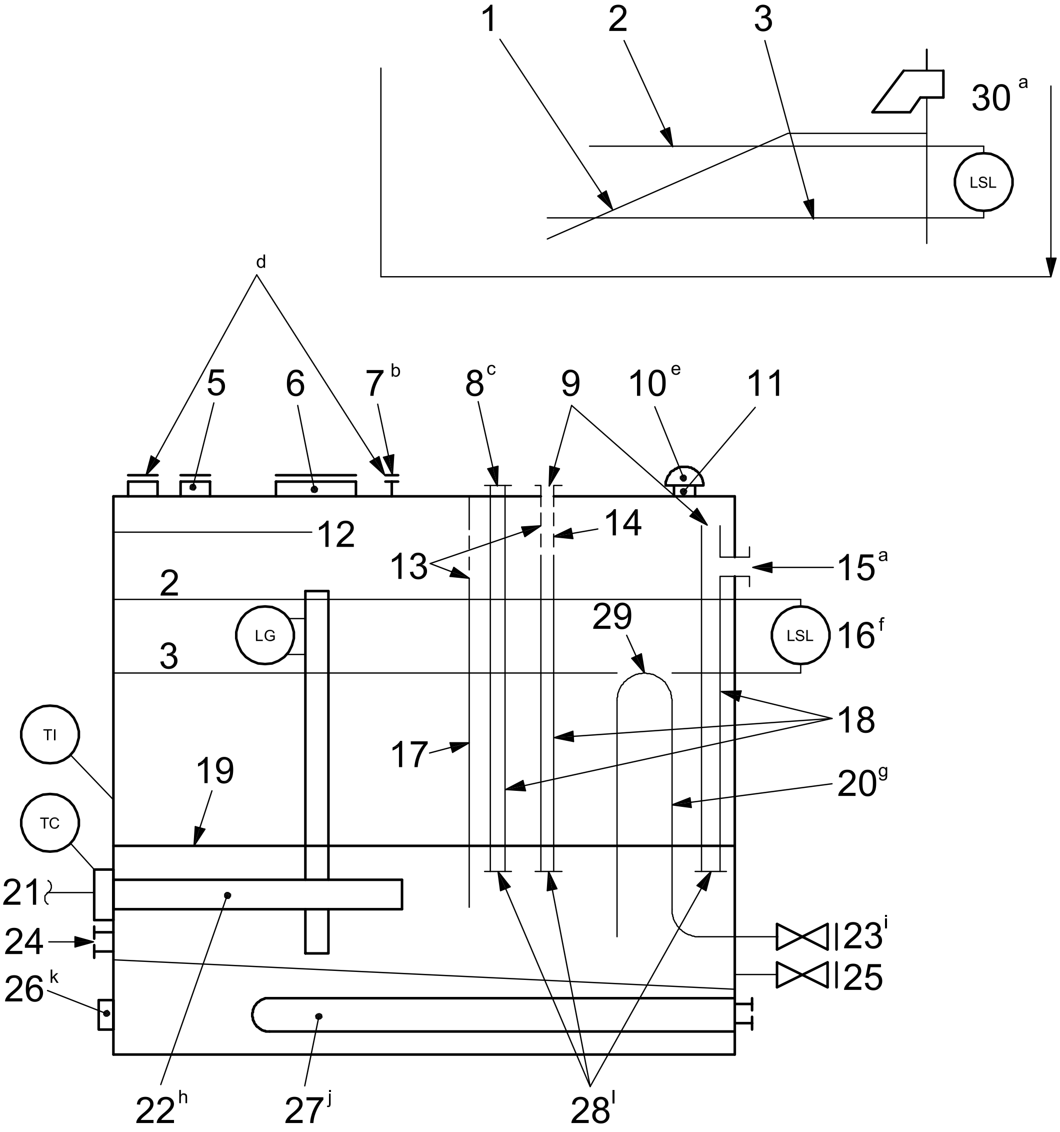

**Key**

1 to downstream equipment
2 individual return lines to reservoir
3 pump running alarm
4 main booster pump
5 standby booster pump
6 emergency booster pump
7 pump suction from reservoir

a Figure B.23, option A: The purchaser may specify a bypass valve to start.

b Figure B.23, option B: The purchaser may specify an alarm and/or a permissive start for the booster pumps or a low-pressure trip.

**Figure B.23 — Booster (rotary) pump arrangement**




**Key**

1 sloped degasification tray
2 maximum operating level
3 minimum operating level
4 spare plugged connection
5 plugged purge connection
6 manway
7 vent connection
8 relief valve, control valve, conditioner and other pressurized oil returns
9 open top
10 filter-breather cap
11 fill opening with strainer
12 rundown level
13 equalizing vent holes
14 vent holes above rundown level to allow venting of rundown tank
15 individual pressurized returns
16 internal- or external-type float level indicator
17 baffle
18 stilling tube and static equalizer
19 pump minimum suction level
20 siphon breaker
21 electric supply
22 electric heater
23 conditioner suction connection
24 pump-suction connections
25 blind, flanged drain connection
26 two tapped grounding pads
27 steam heater
28 baffle attached to stilling tubes and pressurized oil returns to prevent stirring of bottom sediments
29 hole, ⩽ 6 mm to vent siphon breaker
30 alternative arrangement

**Figure B.24** (*continued*)

a For non-pressurized gravity oil-return lines and fill openings, a stilling tube or sloped degasification tray arranged to prevent splashing and provide free release of foam and gas is required for every return inlet and spare connection.

b A blind flange shall be provided for venting the reservoir. For seal-oil reservoirs, this vent shall be piped to a safe location by the purchaser.

c Figure B.24, option A: The purchaser may specify a particular oil conditioner and other pressurized oil returns in addition to the spare top connection.

d Purge and vent connections shall enter the top of the reservoir. No extension tubes or seals are permitted.

e A filter-breather cap is not permitted on a reservoir containing seal oil.

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

g Figure B.24, option B: The purchaser may specify a siphon breaker when an oil-conditioner suction connection is specified.

h Figure B.24, option C: The purchaser may specify an electric heater.

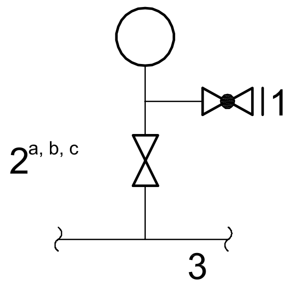
i Figure B.24, option D: The purchaser may specify an oil-conditioner suction connection.

j Figure B.24, option E: The purchaser may specify a steam heater.

k Figure B.24, option F: When specified, two tapped grounding pads positioned diagonally to each other shall be provided.

l Individual oil returns shall be located away from the pump suction and arranged to provide the maximum residence time.

**Figure B.24 — Oil reservoir**




**Key**

1 vent/bleed

2 block

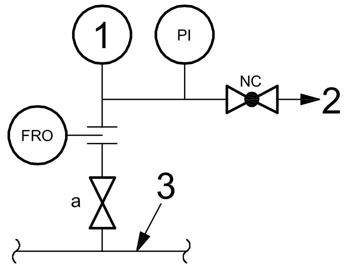
3 service line

a Figure B.25, option A: If approved by the purchaser, a combination block and bleed gauge valve may be substituted for individual block and vent/bleed valves, except as specified in Footnote b.

b Block, isolation and vent-bleed valves can be omitted for all instruments in trip service with owner's approval.

c For services of less than or equal to 1 400 kPa (14 bar, effective; 200 psig), bleed valves may be omitted, except for arrangements shown in Figures B.26 and B.27 or when Footnote b applies.

**Figure B.25 — Local instrument piping details — Pressure gauges, switches, and transmitters**




**Key**

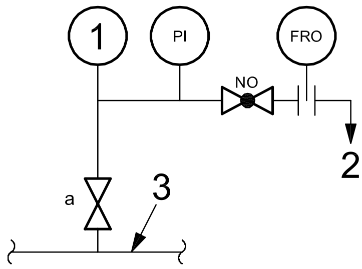
1 alarm(s)

2 to reservoir or drain line

3 service line

a The block valve may be locked open.

**Figure B.26 — Local instrument piping details — Combined instrument system for low-pressure alarms and pump-start switches (typical design)**




**Key**

1 alarm(s)

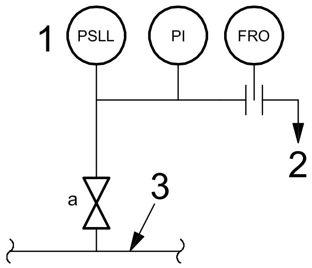
2 to reservoir or drain line

3 service line

a Figure B.27, option B: The purchaser may specify a block valve. The block valve may be locked open.

NOTE This design is intended for cold climates and for pump-running alarm switches (high-pressure switches).

**Figure B.27 — Local instrument piping details — Combined instrument system for low-pressure alarms and pump-start switches (alternative design)**




**Key**

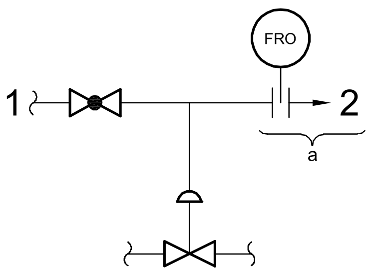
1 trip

2 to reservoir or drain line

3 service line

[a] The block valve may be locked open.

**Figure B.28 — Local instrument piping details — Low-pressure trip switch (alternative design)**




**Key**

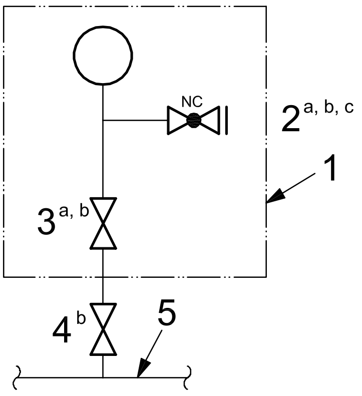
1 signal

2 to reservoir

[a] The reservoir and flow-restriction orifice are for oil service.

NOTE A diaphragm actuator is not required for air signals unless other devices are receiving the same signals.

**Figure B.29 — Instrument piping details — Diaphragm actuator**




**Key**

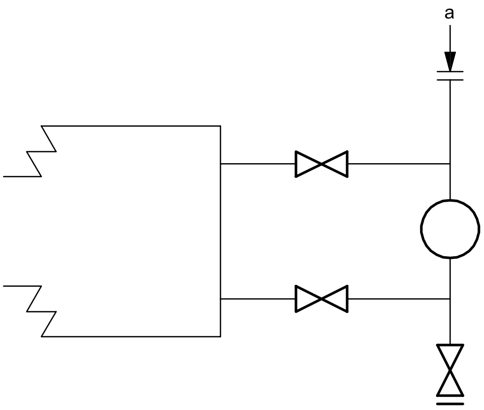
1 gauge board
2 vent/bleed
3 isolation valve
4 block valve
5 service line

a Combination isolation/bleed valve may be used.

b Block, isolation and vent-bleed valves can be omitted for all instruments in trip service with owner's approval.

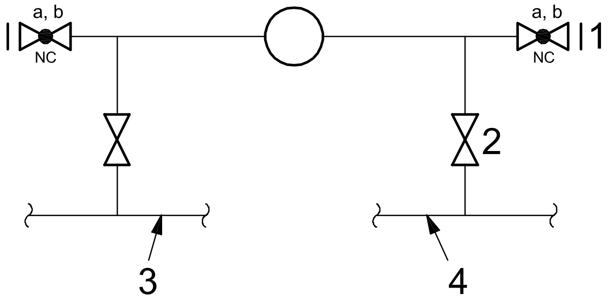
c For services of less than or equal to 1 400 kPa (14 bar, effective; 200 psig), bleed valves may be omitted, except for arrangements shown in Figures B.26 and B.27 or when Footnote b applies.

**Figure B.30 — Remote instrument piping details — Panel- and board-mounted gauges, switches and transmitters**




a This connection may be added to facilitate cleaning of the level indicator.

**Figure B.31 — Instrument piping details — Externally connected level instruments**




**Key**

1 vent/bleed

2 block

3 source a

4 source b

a Block, isolation and vent-bleed valves can be omitted for all instruments in trip service with owner's approval.

b For services of less than or equal to 1 400 kPa (14 bar, effective; 200 psig), bleed valves may be omitted, except for arrangements shown in Figures B.26 and B.27 or when Footnote a applies.

**Figure B.32 — Local instrument piping details — Differential instruments, diaphragm actuators, indicators, switches, and transmitters**

# Annex C
(informative)

# Inspector's checklist

**Table C.1 — Inspector's checklist**

| Item | Date Inspected | Inspected By | Status |
|---|---|---|---|
| 1) Sound pressure level requirements met (4.1.5) | | | |
| 2) Oil characteristics: | | | |
| a In accordance with specification (4.1.7) | | | |
| b Hydrotest compatible (ISO 10438-1:2007, 7.3.2.1) | | | |
| c Run-test compatible (7.3.3.5) | | | |
| 3) Compatible rust preventatives used [ISO 10438-1:2007, 7.4.3 c), 7.4.3 d)] | | | |
| 4) Lube-oil/seal-oil separation demonstrated, if applicable (4.1.6) | | | |
| 5) System arrangement (4.1.12): | | | |
| a In accordance with drawings | | | |
| b Providing adequate clearances | | | |
| c Providing safe access | | | |
| d Adequate for maintenance (4.1.12, 4.1.13) | | | |
| 6) ASME code stamp, if applicable (4.1.17): | | | |
| a Coolers | | | |
| b Filters | | | |
| c Accumulators | | | |
| d Lube-oil rundown tanks (4.9.2) | | | |
| e Drain traps | | | |
| f Other pressure vessels | | | |
| g Overhead seal-oil tanks (4.9.1.3) | | | |
| h Degassing drum (4.11.6) | | | |
| 7) Welding operators and procedures qualified, e.g. Section IX of ASME Code: | | | |
| a Welding of pressure vessels (ISO 10438-1:2007, 4.6.1) | | | |
| 1 Coolers | | | |
| 2 Filters | | | |
| 3 Accumulators | | | |
| 4 Lube-oil rundown tanks | | | |
| 5 Seal-oil tanks | | | |
| 6 Degassing drum | | | |
| 7 Other pressure vessels | | | |
| 8 Oil conditioner | | | |

**Table C.1** (*continued*)

| Item | Date Inspected | Inspected By | Status |
|---|---|---|---|
| b Welding of oil piping (10438-1:2007, 4.6.1) | | | |
| c Welding of oil reservoir, if specified, (4.3.11) | | | |
| d Dissimilar-metal welding and weld repairs (10438-1:2007, 4.6.1) | | | |
| e Verification of welds (ISO 10438-1:2007, 7.2.3.3) | | | |
| 8) Welding procedures (other than above) (10438-1:2007, 4.6.3): | | | |
| a Baseplates | | | |
| b Panels | | | |
| c Non-pressure ducting | | | |
| d Other | | | |
| 9) Baseplates: | | | |
| a Major components mounted directly on structural steel (4.2.1) | | | |
| b Adequate drain gutter (4.2.2) | | | |
| c Adequate lifting lug (distortion, damage) (4.2.4) | | | |
| d Metal decking (4.2.5) | | | |
| e Precoat for epoxy grout (4.2.7) | | | |
| 10) Reservoir top sealed and sloped properly (4.3.2.1, 4.3.2.3) | | | |
| 11) Manway openings adequate (4.3.4) | | | |
| 12) Reservoir heaters adequate for the application (4.3.7) | | | |
| 13) Clips provided: | | | |
| a Insulation clips (4.3.8) | | | |
| b Grounding clips (4.3.14) | | | |
| 14) Pumps: | | | |
| a Piping vented or arranged to avoid air pockets (4.4.20) | | | |
| b Strainers installed and tabbed (4.4.21) | | | |
| c Alignment checked (4.4.31) | | | |
| d Mounting surfaces flat and parallel [4.4.32 a)] | | | |
| e Shims installed [4.4.32 b)] | | | |
| f Bolting and unbolting of piping demonstrated (7.3.3.11) | | | |
| g Jackscrews adequate [4.4.32 g)] | | | |
| 15) Oil filters | | | |
| Drainability demonstrated [7.3.3.8 h)] | | | |
| 16) Oil conditioner siphon breaker installed and demonstrated (4.3.10.2) | | | |
| 17) Piping: | | | |
| a Examined and inspected in accordance with ISO 15649 (ISO 10438-1:2007, 5.1.1) | | | |
| b Fabricated in accordance with specification (ISO 10438-1:2007, 5.1.6) | | | |
| 18) Oil drains shown to run not more than half full (ISO 10438-1:2007, 5.2.1) | | | |

**Table C.1** (*continued*)

| Item | | Date Inspected | Inspected By | Status |
|---|---|---|---|---|
| 19) | Electrical systems/panels (ISO 10438-1): | | | |
| a | Wiring suitable (10438-1:2007, 6.4) | | | |
| b | Spare terminal points adequate (10438-1:2007, 6.4.9) | | | |
| c | Clearances adequate for maintenance (10438-1:2007, 6.4.10) | | | |
| d | Fungus/corrosion protection provided (10438-1:2007, 6.4.11) | | | |
| e | Wiring clearly labeled and isolated (10438-1:2007, 6.4.12) | | | |
| 20) | Material inspected as specified (list each component) (ISO 10438-1:2007, 7.2.2) | | | |
| 21) | Verification of compliance for buy-out items: | | | |
| a | Equipment | | | |
| b | Instrumentation | | | |
| c | Piping, tubing, flanges and fittings | | | |
| d | Electrical components | | | |
| 22) | Components inspected for cleanliness (list each) (ISO 10438-1:2007, 7.2.3.2) | | | |
| 23) | Hydrostatic tests: | | | |
| a | Hydrotests certified (list each component) (ISO 10438-1:2007, 7.3.2.1) | | | |
| b | Assembled oil system hydrostatic test performed (ISO 10438-1:2007, 7.3.2.1) | | | |
| c | Chlorides in hydrotest liquid addressed adequately (ISO 10438-1:2007, 7.3.2.4) | | | |
| d | Test pressures verified (ISO 10438-1:2007, 7.3.2.1, 7.3.2.3) | | | |
| 24) | Operational tests: | | | |
| a | System cleanliness verified after operational tests (7.3.3.2). | | | |
| b | All leaks corrected before starting [7.3.3.8 a)] | | | |
| c | Limiting pressures verified [7.3.3.8 b)] | | | |
| d | Filter-cooler changeover performed [7.3.3.8 c)] | | | |
| e | Control valve response and stability demonstrated [7.3.3.8 d), 7.3.3.8 e)] | | | |
| f | Pressure drop on pump trip checked/demonstrated [7.3.3.8 e)] | | | |
| g | Transfer valve leakage demonstrated [7.3.3.8 h)] | | | |
| h | System cleanliness after test demonstrated (7.3.3.9, 7.3.3.10) | | | |
| 25) | Painting [ISO 10438-1:2007, 7.4.3 a)] | | | |
| 26) | Preparation for shipment (ISO 10438-1): | | | |
| a | Equipment cleaned and prepared properly [7.4.3 c)] | | | |
| b | Items properly tagged [7.4.3 i)] | | | |
| c | Storage/handling/installation instructions received (7.4.2, 7.4.7) | | | |
| d | Piping and components adequately protected [7.4.3 j)] | | | |
| e | Connections properly tagged (7.4.5) | | | |
| f | Shipping documents included [7.4.3 i)] | | | |

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