INTERNATIONAL STANDARD

ISO 10442

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Petroleum, chemical and gas service industries — Packaged, integrally geared centrifugal air compressors

Industries du pétrole, de la chimie et du gaz naturel — Compresseurs d'air centrifuges assemblés à multiplicateur intégré

Reference number
ISO 10442:2002(E)

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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 3.

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 International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 10442 was prepared by Technical Committee ISO/TC 118, *Compressors, pneumatic tools and pneumatic machines*, in collaboration with Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 6, *Processing equipment and systems.*

Annex D forms a normative part of this International Standard. Annexes A, B and C are for information only.

Introduction

This International Standard is based on the American Petroleum Institute's API Std 672, second edition, April 1988.

Some of the content of this International Standard is identical or similar to ISO 10439, which covers centrifugal compressors for the petroleum, chemical and gas service industries.

Users of this International Standard should be aware that further or differing requirements may be needed for individual applications. This International Standard 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 applicable where there is innovative or developing technology. Where an alternative is offered, the vendor should identify any variations from this International Standard and provide details.

Petroleum, chemical and gas service industries — Packaged, integrally geared centrifugal air compressors

1 Scope

This International Standard specifies requirements and gives recommendations for the design, materials, fabrication, inspection, testing and preparation for shipment of constant-speed, packaged, integrally geared centrifugal air compressors, including their accessories, for use in the petroleum, chemical and gas service industries. It is also applicable to gas services other than air that are non-hazardous and non-toxic. It is not applicable to machines that develop a pressure rise of less than 35 kPa above atmospheric pressure, which are classed as fans or blowers.

NOTE In this International Standard, where practical, US customary units have been included in brackets for information.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 261, *ISO general-purpose metric screw threads — General plan*

ISO 262, *ISO general-purpose metric screw threads — Selected sizes for screws, bolts and nuts*

ISO 724, *ISO general-purpose metric screw threads — Basic dimensions*

ISO 965 (all parts), *ISO general purpose metric screw threads — Tolerances*

ISO 3511-1, *Process measurement control functions and instrumentation — Symbolic representation — Part 1: Basic requirements*

ISO 3744, *Acoustics — Determination of sound power levels of noise sources using sound pressure — Engineering method in an essentially free field over a reflecting plane*

ISO 5389, *Turbocompressors — Performance test code*

ISO 7005-2, *Metallic flanges — Part 2: Cast iron flanges*

ISO 9614 (both parts), *Acoustics — Determination of sound power levels of noise sources using sound intensity*

ISO 10436, *Petroleum and natural gas industries — General-purpose steam turbines for refinery service*

ISO 10438, (all parts), *Petroleum and natural gas industries — Lubrication, shaft-sealing and control-oil systems and auxiliaries*

ISO 10441, *Petroleum and natural gas industries — Flexible couplings for mechanical power transmission — Special purpose applications*

IEC 60079-10, *Electrical apparatus for explosive gas atmospheres — Part 10, Classification of hazardous areas*

ABMA[1] Std 7, *Shaft and housing fits for metric radial ball and roller bearings (except tapered roller bearings) conforming to basic boundary plan*

ABMA Std 20, *Radial bearings of ball, cylindrical roller and spherical roller types — Metric design*

AGMA[2] 2000, *Gear classification and inspection handbook*

AGMA 6011, *Specification for High Speed Helical Gear Units*

API Std 670, *Vibration, axial position, and bearing temperature monitoring systems*

API RP 520 PT I, *Sizing, selection, and installation of pressure-relieving devices in refineries, Part I, Sizing and selection*

API RP 520 PT II, *Sizing, selection, and installation of pressure-relieving devices in refineries, Part II, Installation*

ASME[3] PTC 10, *Performance test code on compressors and exhausters*

ASTM[4] A275, *Standard test method for magnetic particle examination of steel forgings*

DIN[5] 3990, *Load calculations for gearings*

NEMA[6] SM 23, *Steam turbines for mechanical drive service*

TEMA[7] *Standards of the Tubular Exchanger Manufacturers Association, eight edition*

3 Terms and definitions

For the purposes of this International Standard the following terms and definitions apply.

3.1
bull gear
low-speed rotor of the integral gear

3.2
inlet volume flow
volume flow rate determined at the conditions of pressure, temperature, compressibility and gas composition, including moisture, at the compressor inlet flange

[ISO 10439:2002, definition 3.5]

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1) American Bearing Manufacturers Association, 2025 M Street, NW. Suite 800, Washington, DC 20036, USA.

2) American Gear Manufacturers Association, 1500 King St, Suite 201, Alexandria VA 22314, USA.

3) American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017-2392, USA.

4) American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103-11887, USA.

5) Deutsches Institut für Normung E.V., Beuth Verlag GmbH, Burggrafenstrasse 6, D10787, Berlin, Germany.

6) US National Electrical Manufacturers Association, 1300 North 17th Street, Suite 1847, Rosslyn, Virginia 22209, USA.

7) US Tubular Exchanger Manufacturers Association, 25 N Broadway, Tarrytown, New York, NY 10007, USA.

3.3
maximum allowable temperature
maximum continuous temperature for which the manufacturer has designed the equipment (or any part to which the term is referred) when handling the specified fluid at the specified pressure

[ISO 10439:2002, definition 3.6]

3.4
maximum allowable working pressure
maximum continuous pressure for which the manufacturer has designed the equipment (or any part to which the term is referred) when operating at the maximum allowable temperature

[ISO 10439:2002, definition 3.7]

3.5
normal operating point
point at which usual operation is expected and optimum efficiency is desired

NOTE This will usually be the point at which the vendor certifies that performance is within the tolerances stated in this International Standard.

[ISO 10439:2002, definition 3.11]

3.6
pinion
high-speed rotor, or rotors, of the integral gear

3.7
piping design code
recognized piping standard specified or agreed by the purchaser

EXAMPLE ASME B31.3.

3.8
pressure casing
composite of all the stationary pressure-containing parts of the unit

3.9
pressure design code
recognized pressure vessel standard specified or agreed by the purchaser

EXAMPLE ASME Boiler and Pressure Vessel Code, Section VIII.

[ISO 10439:2002, definition 3.14]

3.10
rated discharge pressure
highest pressure required to meet the specified operating conditions

3.11
rated operating point
operating point at which the rated volume flow and the rated discharge pressure are attained

3.12
rated operating speed
speed required to meet the conditions specified by the purchaser for the intended service

NOTE This speed is equal to the maximum continuous speed for constant speed compressor units.

3.13
rated volume flow
inlet volume flow required by the specified operating conditions

3.14
standby service
service condition in which a normally idle or idling piece of equipment is capable of immediate automatic or manual start-up and continuous operation

3.15
trip speed
speed at which the independent emergency overspeed device operates to shut down a prime mover

NOTE For constant speed motor drivers, this is the speed corresponding to the synchronous speed of the motor at the maximum frequency of the electrical supply.

[ISO 10439:2002, definition 3.19]

4 Basic design

4.1 General

4.1.1 Purchaser decision or information

A bullet (●) at the beginning of a clause indicates that the purchaser is required to make a decision or provide information. This information should be indicated on the data sheets (see annex A).

4.1.2 Packaged equipment

The vendor shall provide, as a minimum, the following equipment (referred to herein as a package), packaged to meet the specified operating conditions:

a) centrifugal compressor with integral speed-increasing gear unit;

b) intercoolers, moisture separators and V-notched gate drain valves;

c) inlet throttle device (valve or variable-inlet guide vanes);

d) driver (motor or turbine as specified);

e) couplings and guards;

f) “lube”-oil system;

g) vibration monitoring system;

h) controls and instrumentation;

i) instrument and control panel;

j) common baseplate.

If requested by the purchaser, the layout of the package shall be agreed by the purchaser.

4.1.3 Shipped loose equipment

The vendor shall provide the following accessory equipment, either packaged or included within the scope of supply and shipped loose, to meet the specified operating conditions:

a) aftercooler with moisture separator and V-notched gate drain valve;

b) discharge check valve;

c) discharge blowoff or by-pass valve;

d) air inlet filter-silencer;

e) blowoff or by-pass silencer.

4.1.4 Other equipment

- Any other equipment required shall be specified by the purchaser and included in the vendor's proposal.

4.1.5 Standby service

If standby service is specified, the vendor shall provide all necessary controls and protective systems to allow automatic or manual start-up.

4.1.6 Turbine-driven equipment

All turbine-driven equipment shall be designed to run without damage to the trip speed of the driver.

4.1.7 Normal operating point

- The purchaser shall specify the normal operating point on the data sheets.

4.1.8 Environmental conditions

- The purchaser shall specify whether the installation is indoors (heated or unheated) or outdoors (with or without a roof), as well as the weather and environmental conditions in which the package must operate (including maximum and minimum temperatures and unusual humidity or dust problems). The package and its accessories shall be suitable for operation under these specified conditions. For the purchaser's guidance, the vendor shall list in the proposal any special protection that the purchaser is required to supply.

4.1.9 Engineering coordination

The vendor shall assume responsibility for the engineering coordination of the package and all accessories included in the scope of the order.

4.1.10 Package arrangement

The arrangement of the package, including piping, coolers, pumps and controls, shall provide adequate clearance areas and safe access for operation and maintenance.

4.1.11 Oil reservoirs and housings

Oil reservoirs and compressor housings that enclose moving lubricated parts (such as bearings, shaft seals, highly polished parts, instruments and control elements) shall be designed to minimize contamination by moisture, dust and other foreign matter during periods of operation and idleness.

4.1.12 Motors and electrical components

- Motors and all other electrical components and installations shall be suitable for the area classification (zone) specified by the purchaser on the data sheets (see annex A), shall meet the requirements of IEC 60079-10 and shall comply with applicable local codes and regulations specified by the purchaser.

4.1.13 External parts

External parts that are subject to rotary or sliding motions (such as control linkage joints and adjusting mechanisms) shall be of corrosion-resistant materials suitable for the site environment and shall be of sufficient hardness to resist wear.

4.1.14 Service life

The equipment (including auxiliaries) covered by this International Standard shall be designed and constructed for a minimum service life of twenty years and at least three years of uninterrupted operation.

4.1.15 Performance criteria

The package shall perform on the test stand and on its permanent foundation within the specified acceptance criteria. After installation, the performance of the package shall be the joint responsibility of the purchaser and the vendor having package responsibility.

4.1.16 Sound pressure level

Control of the sound pressure level (SPL) of all equipment furnished shall be a joint effort of the purchaser and the vendor. The equipment furnished by the vendor shall conform to the maximum allowable sound pressure level specified by the purchaser.

4.1.17 Pressure design code

- The pressure design code shall be specified or agreed by the purchaser.

Pressure components shall comply with the pressure design code as well as the requirements of this International Standard.

4.1.18 Heat exchangers

4.1.18.1 Cooling water systems, if required, shall be designed for the conditions specified in Table 1 unless otherwise specified. Provision shall be made for complete venting and draining of the system.

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 overheat exchange surfaces is intended to minimize the use of cooling water. The purchaser shall approve the final selection.

4.1.18.2 The coolers shall be of a water-cooled, shell-and-tube type, or a suitable air-cooled type, as specified. A removable-bundle design is required for coolers with more than 0,50 m^2 of surface, unless otherwise specified. Removable-bundle coolers shall be in accordance with TEMA Class C unless otherwise specified, and shall be constructed with a removable channel cover. Tubes shall not have an outside diameter of less than 16 mm (5/8 in), and the tube wall shall not have a thickness of less than 1,25 mm (0,05 in). Unless otherwise specified, cooler shells, channels and covers shall be of steel, tube sheets shall be of brass, and tubes shall be of inhibited admiralty. U-bend tubes are not permitted. Each cooler shall be sized to accommodate the total cooling load.

Table 1 — Cooling water systems — Design requirements

Velocity over heat exchange surfaces	1,5 m/s to 2,5 m/s (5 ft/s to 8 ft/s)
Maximum allowable gauge working pressure	$\geqslant$ 500 kPa (75 psi)
Test gauge pressure	$\geqslant$ 750 kPa (110 psi)
Maximum inlet temperature	30 °C (90 °F)
Maximum temperature rise	20 K (35 °F)
Fouling factor on water side	0,35 $m^2 \cdot K/kW$ (0,002 $h \cdot ft^2 \cdot °F/Btu$)
Maximum pressure drop	100 kPa (15 psi)
Maximum outlet temperature	50 °C (120 °F)
Minimum temperature rise	10 K (20 °F)
Shell corrosion allowance	3,0 mm (⅛ in)

4.1.18.3 The package shall provide complete venting and draining of the cooling system. This shall include vent and drain connections on both the air/oil and water sides.

4.1.18.4 The vendor shall include in the proposal complete details of any proposed air-cooled cooler.

4.1.19 Special tools and fixtures

4.1.19.1 If special tools and fixtures are required to disassemble, assemble or maintain the unit, they shall be included in the quotation and furnished as part of the initial supply of the package. For multi-unit installations, the requirements for quantities of special tools and fixtures shall be mutually agreed upon by the purchaser and the vendor. These or similar special tools shall be used during shop assembly and post-test disassembly of the equipment.

4.1.19.2 If special tools are provided, they shall be packaged in separate, rugged boxes and marked "special tools for (tag/item number)". Each tool shall be stamped or tagged to indicate its intended use.

4.1.20 Preliminary review

Many factors (such as piping loads, alignment at operating conditions, supporting structure, handling during shipment, and handling and assembly at the site) may adversely affect site performance. To minimize the influence of these factors, the vendor shall review and comment on the purchaser's piping and foundation drawings, and the vendor's representative shall observe a check of the piping performed by parting the flanges. If specified, the vendor's representative shall be present during the initial alignment check and shall check alignment at the operating temperature.

4.1.21 Spare parts

Spare parts for the compressor and all furnished auxiliaries shall meet all the criteria of this International Standard.

4.1.22 Regulations

● The purchaser and the vendor shall agree on the measures to be taken for compliance with governmental regulations, ordinances or rules that are applicable to the equipment.

4.2 Package

4.2.1 Lubrication — General

4.2.1.1 Unless otherwise specified, bearings and bearing housings shall be arranged for hydrocarbon oil lubrication.

4.2.1.2 A pressurized oil system shall be furnished to supply oil at a suitable pressure or pressures, as applicable, to the following:

a) the bearings of the integrally geared compressor;

b) the spray nozzles for the gear teeth;

c) the bearings of the driver, if specified.

4.2.1.3 If 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 on the data sheets (see annex A) by the purchaser on the basis of mutual agreement with all vendors supplying equipment served by the common oil system.

Unless otherwise specified, pressurized oil systems shall conform to the requirement of ISO 10438.

4.2.2 Pressure lubrication systems

4.2.2.1 The pressure lubrication system shall consist of main and standby positive displacement oil pumps, a supply-and-return system, oil cooler twin full-flow filters and instruments (see Figure 1). The filter assembly shall include a continuous-flow two-way switch valve(s). The requirements of 4.2.2.2 to 4.2.2.10 shall apply.

Unless otherwise specified, oil-containing pressure components shall be steel.

4.2.2.2 The main oil pump shall be driven in accordance with the data sheets (see annex A). The standby pump shall be separately driven and automatically controlled. Both pumps shall be full capacity. The required pump shaft power shall not exceed the driver nameplate rating, with the pump delivering lubricating oil at the relief valve set pressure and with the oil at the maximum viscosity expected at the vendor's minimum allowable oil temperature. This temperature shall be stated in the vendor's proposal. Oil pumps shall be sized so that they can each deliver the required capacity when pumping lubricating oil at the highest temperature and corresponding minimum viscosity.

4.2.2.3 Individual external relief valves shall be provided for each positive displacement pump. These valves shall function only to protect the pumps from over pressure. Relief valves for all operating equipment shall meet the limiting relief valve requirements defined in API RP 520, Parts I and II, or local regulation. Relief valves shall be set to operate at not more than the maximum allowable working pressure, but not less than 110 % of the rated pressure or the rated pressure plus 170 kPa (25 psi), whichever is the greater. The vendor shall determine the sizes and set pressures of all relief valves related to the equipment.

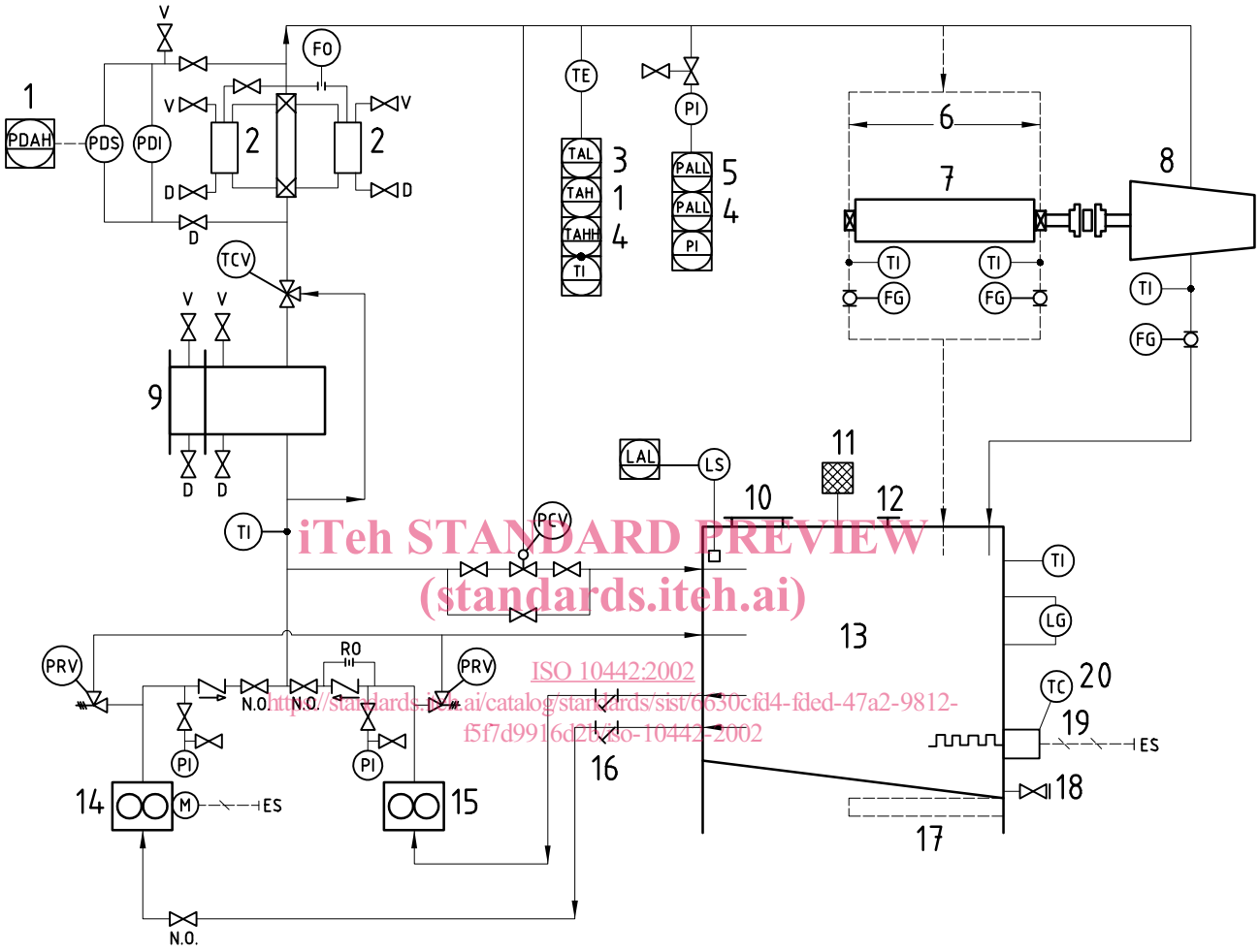
4.2.2.4 A separate, direct-acting back-pressure control valve with manual bypass shall be provided and sized to maintain system pressure even when both pumps are operating.

- **4.2.2.5** An oil cooler shall be provided to maintain the oil supply temperature at or below 50 °C (120 °F). A removable-bundle design is required for coolers with more than 0,50 m^2 of surface, unless otherwise specified. Removable-bundle coolers shall be in accordance with TEMA Class C, unless otherwise specified and shall be constructed with a removable channel cover. 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. Coolers shall be equipped with vent and drain connections on their oil and water sides. Internal oil coolers are not permitted. Each cooler may require to be equipped with an automatic oil-side bypass for regulation of the oil temperature.

- **4.2.2.6** Full-flow filters with replaceable elements and filtration of 10 µm (400 micro-inch) nominal or finer shall be supplied. The filters shall be located downstream of the coolers. The filter cases and heads shall be suitable for operation at a pressure of not less than the relief valve setting. Filters that have covers with a mass of more than 16 kg (35 lb) shall have cover lifters (see 4.1.22). Filters shall not be equipped with a relief valve or an automatic bypass. Filter cartridge materials shall be corrosion-resistant. Metal-mesh or sintered-metal filter elements are not permissible. Stacked filter cartridge designs are not permitted. The pressure drop for clean filter elements shall not exceed 15 % of the total allowable dirty pressure drop, or 34 kPa (5 psi) at an operating temperature of 38 °C (100 °F) and normal flow. Cartridges shall have a minimum collapsing differential pressure of 500 kPa (75 psi). The filters shall be equipped with a vent and clean-and-dirty drain connections.

If a specific filter element is desired, the purchaser shall specify the make and model number of the element.

NOTE Particle size implies the diameter of a spherical bead: thus, a 10 µm (400 micro-inch) particle is a sphere with a diameter of 10 µm. Within the element recommended maximum pressure drop, 10 µm (400 micro-inch) nominal implies that the efficiency of the filter on particles that are 10 µm or larger in diameter will be no less than 90 % for the life of the element. Absolute particle ratings are different. An absolute filter rating implies that no particle of the rating size or larger will pass; for example, a filter rating may be 10 µm (400 micro-inch) nominal and 15 µm (600 micro-inch) absolute.



A common suction line may be used, but shall then be sized for the capability of two pumps.

Key

1 Alarm
2 Filter
3 Interlock
4 Shutdown
5 Alarm/pump start
6 Optional
7 Driver
8 Compressor
9 Oil cooler
10 Manhole
11 Mist eliminator
12 Fill connection
13 Oil reservoir, stainless steel
14 Auxiliary pump, motor driven
15 Main oil pump, motor driven
16 See the above provisions for suction lines
17 Steam coil, optional
18 Drain valve
19 Electric heater
20 On/off

Figure 1 — Sketch of minimum requirements for pressure lubrication system