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МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ

Compressors for the process industry — Turbo types — Specifications and data sheets for their design and construction

Compresseurs pour l'industrie de procédé — Turbocompresseurs — Spécifications et feuilles de données pour la conception et la construction

Reference number
ISO 8011 : 1988 (E)

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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 8011 was prepared by Technical Committee ISO/TC 118, *Compressors, pneumatic tools and pneumatic machines*.

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

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Contents

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Compressors for the process industry — Turbo types — Specifications and data sheets for their design and construction

0 Introduction

This International Standard contains two annexes in addition to the main text.

Annex A, which contains instructions subject to agreements in the contract, is given for information and guidance only and is not an integral part of this International Standard.

Annex B, which contains the data sheets, is an integral part of this International Standard.

1 Scope

This International Standard specifies the technical requirements for the design and construction of turbo- and related types of compressors used in the process industry. It also details the documentation requirements.

2 Field of application

This International Standard applies to radial and axial flow turbo-compressors. It covers the minimum requirements for such compressors handling air or gas, and which have a specific compression work of more than 25 000 J/kg. It is recommended that this International Standard be used for other turbo-compressors if the standards set by this International Standard are required for the particular application.

This International Standard also covers certain requirements for compressor drivers, drive equipment, lubrication and sealing liquid systems, controls, instrumentation and auxiliary equipment.

The compressors to which this International Standard applies are not normally used for critical process applications in refineries.

3 References

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

ISO 898-1, *Mechanical properties of fasteners — Part 1: Bolts, screws and studs.*

ISO 1000, *SI units and recommendations for the use of their multiples and of certain other units.*

ISO 1219, *Fluid power systems and components — Graphic symbols.*

ISO 3511, *Process measurement control functions and instrumentation — Symbolic representation —*

Part 1: Basic requirements.

Part 2: Extension of basic requirements.

Part 3: Detailed symbols for instrument interconnection diagrams.

ISO 3989-1, *Acoustics — Measurement of airborne noise emitted by compressor units including prime movers — Part 1: Engineering method for determination of sound power levels.* [1)]

ISO 5389, *Turbocompressors — Performance test code.* [1)]

IEC Publication 79, *Electrical apparatus for explosive gas atmospheres.*

IEC Publication 85, *Thermal evaluation and classification of electrical insulation.*

VDI 2056, Verein Deutscher Ingenieure: Beurteilungsmaßstäbe für mechanische Schwingungen von Maschinen, VDI Richtlinie 2056, VDI GmbH Düsseldorf (D) 1964.

4 Unit system

SI units (Système international d'unités) are used throughout this International Standard (see ISO 1000).

However, in addition to SI units, this International Standard also uses some non-SI units accepted by ISO 1000. These units are as follows:

—	for pressure:	bar	(1 bar = 10^5 Pa)
—	for volume:	litre	(1 litre = 10^{-3} m^3)
—	for time:	minute	(1 min = 60 s)
—	for time:	hour	(1 h = $3{,}6 \times 10^3$ s)
—	for rotational speed:	r/min	(1 r/min = $\frac{2\pi}{60}$ rad/s)

1) At present at the stage of draft.

5 Definitions

Illustrations of various definitions are shown in figures 1 to 3.

5.1 General

5.1.1 oil-free, dry, compressor: A compressor where the medium being compressed is isolated from the lubricant system. The rotors, synchronized by timing gears, do not touch each other or the casing and therefore require no lubricant in the compression chamber. The air or gas is not contaminated by the lubricant nor any other liquid while passing through the compressor.

5.1.2 oil-free, liquid-injected, compressor: A compressor where the medium being compressed is isolated from the lubricant system but where a liquid is continuously injected into the compression chamber for the purpose of oil-free lubrication, cooling and sealing. Any separation of the liquid from the air or gas is carried out after the gas-liquid mixture leaves the compressor.

5.1.3 oil-flooded compressor: A compressor where oil is continuously injected into the compression chamber. Any separation of the oil from the air or gas is carried out after the gas-oil mixture leaves the compression chamber. Synchronizing gears may not be required.

5.1.4 standard inlet and discharge points: The points at the inlet and discharge flanges of the compressor.

NOTE — When the SUPPLIER provides piping or other parts between the points of demarcation, a separate agreement should be made to define the inlet and discharge points.

5.1.5 arrangement sketch: A sketch to clarify, by the use of reference letters, the relative arrangement of the main components (e.g. compressor casings, process stages, intercoolers, gears and couplings).

5.2 Pressures

5.2.1 effective (gauge) pressure: The pressure measured with reference to atmospheric pressure.

5.2.2 absolute pressure: The pressure measured with reference to absolute zero, i.e. with reference to an absolute vacuum. It equals the algebraic sum of the atmospheric pressure and the effective pressure (static pressure or total pressure).

5.2.3 static pressure: The pressure measured in a fluid under such conditions that the fluid velocity has no effect on the measurement.

5.2.4 total pressure: The sum of the static and dynamic pressures.

It designates the fluid condition at which the flow energy of the fluid is converted into pressure without any losses in a stationary body of fluid. In a stationary gas, the static pressure and the total pressure are numerically equal.

5.2.5 inlet pressure: The total mean absolute pressure at the standard inlet point.

NOTE — The total absolute pressure may be replaced by the static absolute pressure provided that the gas velocity and density are sufficiently low.

5.2.6 discharge pressure: The total mean absolute pressure at the standard discharge point.

NOTE — The total absolute pressure may be replaced by the static absolute pressure provided that the gas velocity and density are sufficiently low.

5.2.7 rated discharge pressure: The highest discharge pressure required to meet the conditions specified by the USER for the intended service.

5.2.8 design pressure: The maximum pressure which the component is designed to withstand safely.

5.2.9 maximum allowable working pressure: The maximum operating pressure which the SUPPLIER's design permits when handling the specified gas at any service conditions specified for the compressor or any part to which the term is referred, such as an individual stage.

5.2.10 relief valve set pressure: The opening pressure on the inlet side of a relief valve.

NOTE — For a differential-type valve the set pressure is the pressure difference across the valve when opening commences. The downstream pressure is termed the back pressure.

5.3 Temperatures

5.3.1 inlet temperature: The temperature at the standard inlet point of the compressor.

5.3.2 discharge temperature: The temperature at the standard discharge point of the compressor.

5.3.3 rated discharge temperature: The highest predicted operating temperature.

5.3.4 maximum allowable working temperature: The maximum gas temperature which the SUPPLIER or USER permits in the compressor, when handling the specified gas at any service conditions specified.

5.3.5 design temperature: The extreme temperature level(s) which the compressor is designed to withstand safely.

NOTE — This covers gas, coolant and ambient temperatures.

5.3.6 casing design temperature range: The range of temperatures to which the compressor casing may be continuously subjected at the casing design pressure.

5.4 Flow rate

5.4.1 actual volume rate of flow of a compressor (deprecated: "actual capacity"): The actual volume rate of flow of gas compressed and delivered at the standard discharge point referred to conditions of total temperature, total pressure and composition (e.g. humidity) prevailing at the standard inlet point.

5.4.2 standard volume rate of flow (deprecated: "standard capacity"): The actual volume rate of flow of compressed gas as delivered at the standard discharge point, but referred to standard conditions (for temperature and pressure).

5.4.3 inlet mass rate of flow: The mass flow of gas or gas mixture induced by the compressor at the standard inlet point(s).

5.4.4 discharge mass rate of flow: The mass flow of gas mixture delivered by the compressor at its standard discharge point(s).

5.4.5 surge limit: The flow limit below which stable operation of the compressor is not possible.

5.5 Power

5.5.1 theoretical required power: In a compressor without losses, the power which is theoretically required to compress a gas according to the chosen reference process, from a given inlet pressure to a given discharge pressure.

5.5.2 driver coupling power: The maximum power required at the driver shaft, including losses in external transmissions such as gears or belt drives when such transmissions form part of the SUPPLIER's scope of delivery.

5.5.3 shaft input power: The power required at the compressor shaft, excluding losses in external transmissions.

5.5.4 rated driver power: The maximum power continuously available from the motor.

5.6 Specific energy requirement

5.6.1 actual specific energy requirement: The shaft input power per unit of compressor actual volume rate of flow.

5.7 Speed

5.7.1 compressor speed: The rotational speed of the impeller.

5.7.2 rated compressor speed: The compressor speed necessary to meet the specified service conditions.

5.7.3 minimum allowable compressor speed: The lowest compressor speed at which the compressor may be continuously operated.

5.7.4 maximum allowable compressor speed: The highest compressor speed at which the compressor may be continuously operated.

5.7.5 100 % speed n_{100}: The speed necessary for operation at all the specified operating points.

5.7.6 trip speed n_t: The speed at which the prime mover is automatically tripped out.

5.7.7 input drive shaft speed: The rotational speed at the coupling linking the driver and its gearbox to the compressor and its integrated gearbox, if any.

5.8 Operating point

5.8.1 specified operating point: Any point at which the operation of the compressor is specified in the data sheets.

5.8.2 normal operating point: The point at which the usual operation of the compressor is expected.

5.8.3 rating point: The operating point, specified by the USER, at which the performance test data must comply with the specified data.

5.9 Plates (see figure 2)

5.9.1 baseplate: A plate or structure supporting one piece of machinery, e.g. compressor, gear or driver.

5.9.2 common baseplate: A plate or structure supporting more than one piece of machinery, e.g. compressor, gear or driver.

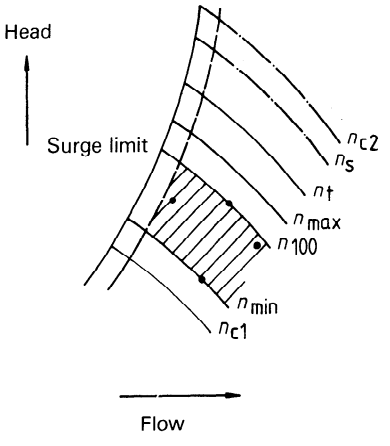
5.9.3 soleplate: A plate or structure supporting one or more baseplates.

5.9.4 mounting pad: A plate under an individual support point of a machine.

6 Gas properties

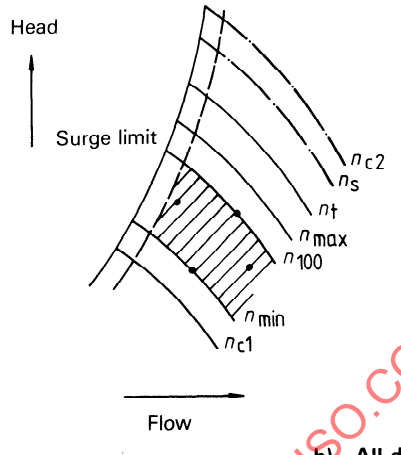
For the computation of gas properties, the advice given in ISO 5389 shall be followed.

The USER shall indicate to the SUPPLIER in data sheet 202 whether the gas is to be considered as toxic, flammable or corrosive and whether it contains solid impurities.



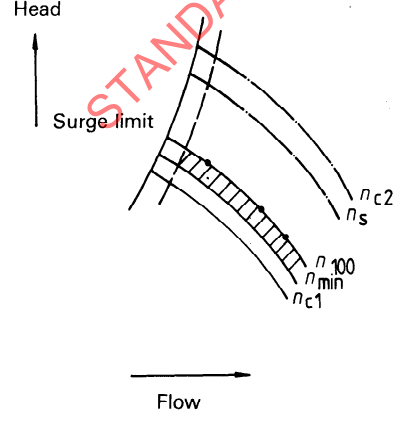
upper critical speed, $n_{c2} \geqslant 1{,}26\ n_{100}$
impeller overspeed test, $n_s = 1{,}18\ n_{100}$
trip speed, $n_t = 1{,}125\ n_{100}$
maximum continuous operating speed, $n_{max} = 1{,}05\ n_{100}$
100 % speed, n_{100}
minimum continuous operating speed, n_{min}
lower critical speed, $n_{c1} \leqslant 0{,}85\ n_{min}$
specified operating point, ●
normal operating range, ////
surge flow plus 5 %, — — —

a) Single-shaft turbine or expander drive



upper critical speed, $n_{c2} \geqslant 1{,}26\ n_{100}$
impeller overspeed test, $n_s = 1{,}21\ n_{100}$
trip speed, $n_t = 1{,}105\ n_{100}$
maximum continuous operating speed, $n_{max} = 1{,}05\ n_{100}$
100 % speed, n_{100}
minimum continuous operating speed, n_{min}
lower critical speed, $n_{c1} \leqslant 0{,}85\ n_{min}$
specified operating range, ●
normal operating range, ////
surge flow plus 5 %, — — —

b) All drives involving a split-shaft gas turbine



upper critical speed, $n_{c2} \geqslant 1{,}2\ n_{100}$
impeller overspeed test, $n_s = 1{,}12\ n_{100}$
100 % speed (synchronous speed-slip), n_{100}
minimum continuous operating speed, n_{min} ($= n_{100}$ for fixed-speed motors)
lower critical speed, $n_{c1} \leqslant 0{,}85\ n_{min}$
specified operating point, ●
normal operating range (variable-speed motors), ////
surge flow plus 5 %, — — —

c) Electric motor drive

Figure 1 — Illustration of various definitions in terms of a) a single-shaft turbine or expander drive, b) all drives involving a split-shaft gas turbine and c) an electric motor drive

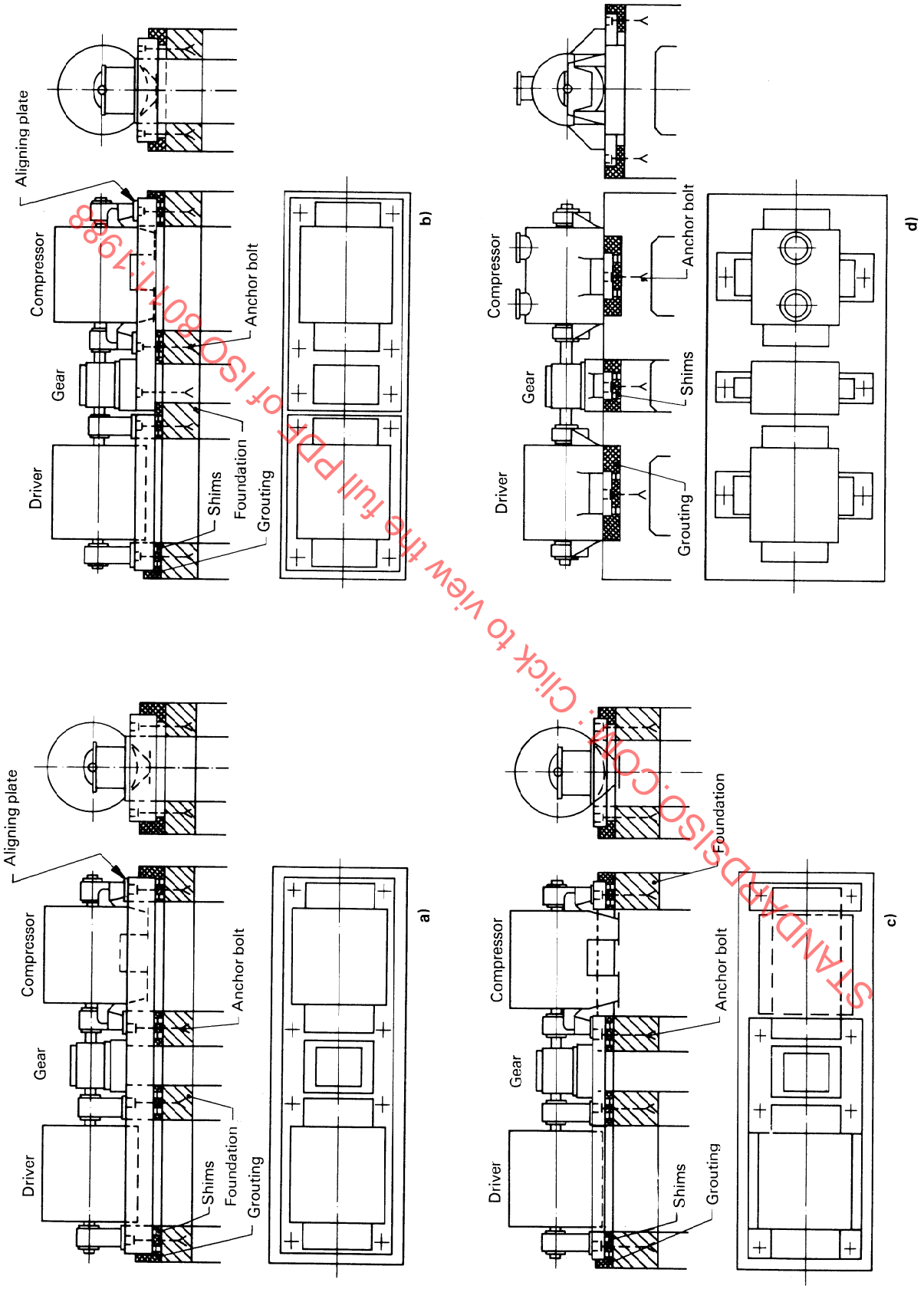
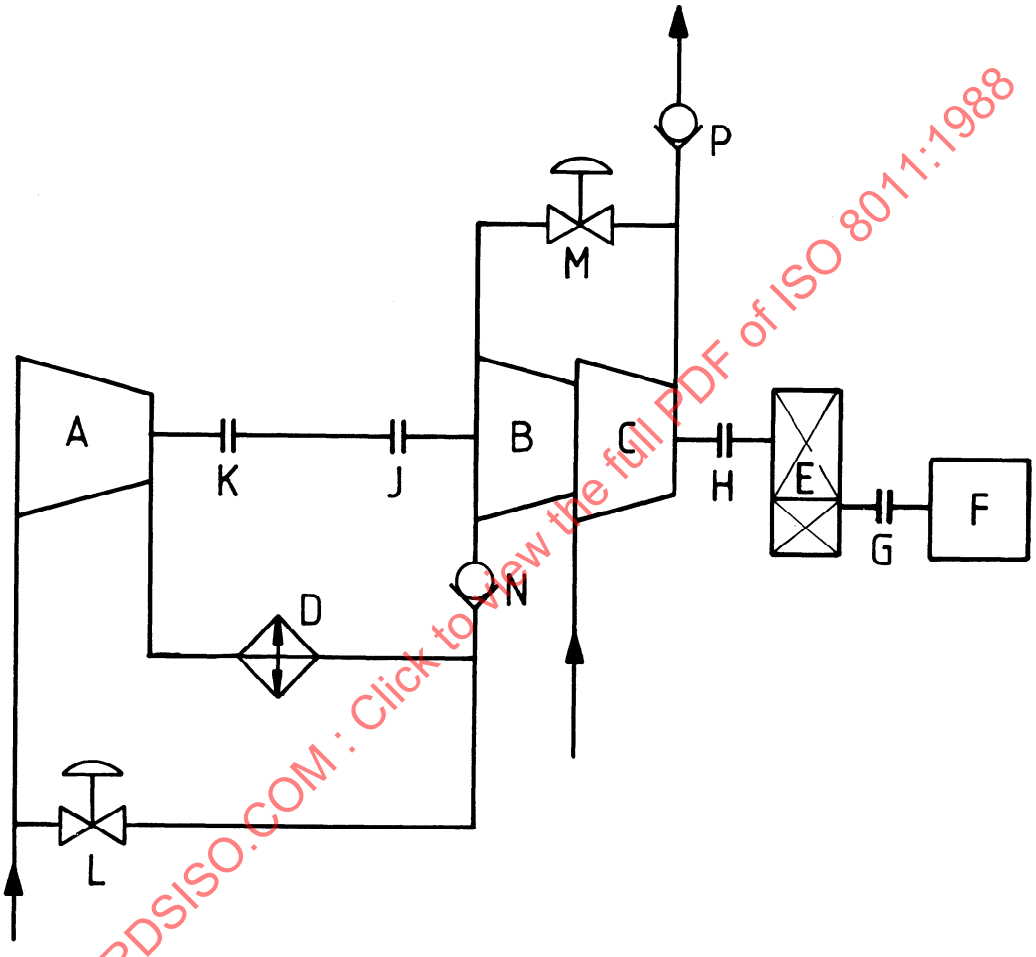


Figure 2 — Illustration of definitions of a) a common baseplate, b) a separate baseplate for driver and compressor, c) soleplates and d) mounting pads

Re-vision	Info.	COMPRESSOR DATA SHEET No. 210		
		ARRANGEMENT SKETCH		Page of
		USER:	**PROJECT:**	**SUPPLIER:**
		Ref. No.	Ref. No.	Ref. No.



A, B, C	stage cylinders
D	intercooler
E	gearbox
F	driver
G, H, J, K	couplings
L, M	pressure control valves
N, P	non-return valves

Figure 3 — An example of an arrangement sketch

USER to mark X in Info. column where data required in SUPPLIER's proposal

Revision No.	Original	1	2	3	4	5	6	7	8	9
Name										
Date										

7 Basic requirements

7.1 General

7.1.1 In the case of conflict between this International Standard and the enquiry or order, the information included in the order shall govern. The completed data sheets form part of the order.

7.1.2 Any documentation pertaining to the enquiry, proposal or order is of a proprietary nature and shall not be divulged to a third party except as may be necessary for the execution of the proposal or the contract.

7.1.3 The approval of documents (drawings) does not constitute permission to deviate from the order requirements unless specifically agreed upon in writing. Any such approval does not release the respective party from his contractual responsibilities.

7.1.4 The responsibilities with respect to the drive train coordination shall be defined prior to the contract.

7.1.5 For budget proposals, the short-form data sheets may be used.

7.2 The enquiry

7.2.1 The USER shall complete the data sheets to the extent possible and specify not only all process requirements, flow rate control and any known abnormal conditions but also, where this International Standard provides a choice or requires that a decision be made, all other items necessary for the SUPPLIER to make out his proposal.

7.2.2 The USER shall indicate the relevant design and safety codes and the exceptions to, or deviations from, those codes which he wishes the SUPPLIER to comply with.

7.2.3 The USER shall indicate in the data sheets the major spare parts he wishes to be included in the proposal.

7.3 The proposal

7.3.1 The SUPPLIER shall include the data sheets in his proposal, completed as applicable and as indicated by the USER, amplifying these as necessary to describe clearly the nature of his supply.

Unless otherwise specified in the enquiry, the SUPPLIER shall quote only for the instrumentation listed as mandatory in 12.6 and shall supply equipment to his own standard.

Items not listed in the enquiry, but which are considered to be desirable by the SUPPLIER, shall be indicated in his proposal.

7.3.2 The proposal shall state the delivery time as being from the date of receipt of an order, on the basis that the information necessary to proceed with manufacture is received by the SUPPLIER in due time (see A.4.1).

7.3.3 The SUPPLIER shall describe the compressor flow rate control system and shall state the limits of his supply.

7.3.4 The proposal shall include either a specific statement that all equipment is in strict accordance with the USER's specifications or a specific list of deviations therefrom. Deviations may include alternative designs equivalent to those specified.

7.4 Ratings

7.4.1 Performance rating

7.4.1.1 Constant-speed compressors

The flow rate shall be within $^{+5\ \%}_{0\ \%}$ of the rated flow specified in the data sheets.

NOTE — Larger tolerances may be required for machines with a low flow rate or which handle certain gases (e.g. helium).

The specific energy requirement shall not exceed the rated value by more than 4 % at the rating point specified in the data sheets. Losses in external transmissions, such as gears, shall be stated in the data sheets.

7.4.1.2 Variable-speed compressors

The specific energy requirement shall not exceed the rated value by more than 4 % at the rating point specified in the data sheets.

Where changes in specified speeds beyond n_{max} are required to meet the rating point, the operating speed range of the compressor shall be adjusted as agreed between the SUPPLIER and the USER, provided that the mechanical integrity of the machine remains unaffected.

7.4.2 Tests

Test procedures shall be in accordance with ISO 5389 (see A.1.3.6).

7.5 Noise limitations

7.5.1 The limitations, if any, on airborne noise emission levels of the compressor and its accessories shall be indicated by the USER at the time of enquiry. It shall be the USER's responsibility to consider any noise specifications that may be applicable at the plant site when stating his requirements to the SUPPLIER. The latter shall not be liable for any cost incurred owing to incomplete USER's requirements.

7.5.2 The maximum permissible A-weighted sound power level in decibels re 10^{-12} W for the relevant octave bands of the noise output of the compressor and its accessories shall be stated by the USER in his enquiry.

The SUPPLIER shall state in his proposal the expected A-weighted sound power level, in decibels, of the main components in his supply.

7.5.3 The methods of measurement and interpretation shall be as stated in ISO 3989-1.

The responsibility for carrying out noise tests on site shall be agreed between the USER and the SUPPLIER and shall be stated in the data sheets.

NOTE — The sound pressure level in a compressor room depends on the sound power emission from the machines installed and the acoustic properties of the room. It is therefore not possible for the SUPPLIER to predict the final sound pressure levels which will be present on site.

7.5.4 The SUPPLIER shall quote separately for any noise-abating treatment, other than that normally built into the equipment, necessary to comply with the noise limitations imposed.

7.5.5 If silencers to comply with these limitations are supplied by the USER, the SUPPLIER shall indicate the respective noise levels at his limits of supply.

7.5.6 Silencers and valves shall be located relative to each other in the piping system in such a way as to avoid any undesirable mutual influence during any operating condition of the compressor. This shall be by mutual agreement between the SUPPLIER and the USER.

7.5.7 Any special noise measurements (e.g. in pipes) shall be performed as agreed between the USER and the SUPPLIER.

8 Compressor

8.1 General

8.1.1 Compressors and auxiliary equipment shall be designed for continuous operation at all specified operating points for at least 3 years, taking into consideration the start-up, shut-down and momentary surge conditions.

It is recognized that this is a design criterion and that continuous operation for this period of time involves factors that are beyond the SUPPLIER's control.

8.1.2 The number and arrangement of the machine casings, including the driver and auxiliaries, shall be agreed upon between the USER and the SUPPLIER of the equipment.

8.1.3 The layout and structural detail of the compressor unit, including the auxiliaries, shall be planned so that sufficient space is available for operating and maintenance purposes.

8.1.4 The SUPPLIER shall specify and supply with the compressor all the special tools and equipment required to assemble the components. Special equipment required for barrel-type compressors shall be included. The main parts, such as casing components and bearing housings, shall be provided with centring spigots, alignment dowels etc. so that precise alignment within a machine is ensured on reassembly using the original parts.

To facilitate assembly and dismantling, lifting rings, eye bolts, jacking screws or similar devices and guide pins shall be provided. Where jacking screws are provided, precautions shall be taken to avoid damage to sealing surfaces. Tapped holes for eye bolts shall have the thread form clearly identified by adjacent stamping etc., to avoid the possibility of fitting incorrect eye bolts.

8.1.5 The control equipment, bearing arrangements, shaft seals and oil system shall be designed such that the penetration of moisture, dust and foreign bodies is minimized whilst the compressor and auxiliary equipment are both in service and at rest.

8.1.6 The compressor and auxiliary equipment shall be suitable for the local and climatic site conditions as specified by the USER on data sheet 203.

It shall be possible to drain, at rest, all parts of the casings and pipes where water can collect.

All parts and systems that could malfunction or be damaged by specified low temperature conditions shall be properly protected from so doing.

The SUPPLIER shall indicate any protection necessary, such as heat tracing or insulation, to be supplied by the USER.

Lubricating oil and control oil at the correct temperature shall be available at the points of consumption at start-up.

8.1.7 All welded connections (structural welds) on casings, pressure-containing castings and pipes, and repair welds shall be undertaken in accordance with the following conditions:

a) the materials shall be suitable for welding and the filler metals shall be compatible with the parent metal;

b) the welding process shall be selected according to the material properties, workpiece thickness and stress on the welded connection;

c) for welds requiring inspection authority approval, welders shall be suitably qualified by an agreed authorizing body (see also 8.2.3);

d) unless otherwise specified, all welds (including repairs) shall be carried out at the SUPPLIER's discretion and in accordance with his own practice.

8.1.8 The USER shall indicate in the data sheets those components where his approval is required prior to repairs being undertaken by the SUPPLIER.

8.2 Casing

8.2.1 The SUPPLIER shall state in the proposal whether the compressor has a horizontally or vertically split casing.

8.2.2 The casing and the casing nozzles shall be designed for the casing design pressure, taking into consideration the hydrostatic test pressure; the casing may be subdivided into chambers for design calculations and testing. (For interstage diaphragms see 8.7.)

For casings not made from corrosion-resistant materials, a suitable corrosion allowance shall be added to the wall thickness.

8.2.3 Structural welds that connect casing parts shall be stress relieved. (For pipes welded to the casings see 8.5.)

8.2.4 Cast iron casing repairs by welding, brazing or cramping are permitted if agreed between the SUPPLIER and the USER. Minor defects in cast iron casings may be repaired with screwed plugs.

Repair welding of steel casings is permitted if the execution and post-weld treatment are properly conducted (see also 8.1.7 and 8.1.8).

8.2.5 Unless otherwise agreed between the SUPPLIER and the USER, the casing material shall be selected in accordance with the following considerations.

a) Steel shall be used if

1) the casing design pressure is above 64 bar;

2) the maximum calculated operating temperature in the casing is above 260 °C.

b) For temperatures below −40 °C, special grade high impact strength materials shall be used, as agreed between the SUPPLIER and the USER.

c) For corrosive, toxic or flammable gases, the USER shall state in the enquiry any special requirements concerning the casing materials and design.

d) For pressures up to 64 bar nodular cast iron may be used.

e) For pressures up to 32 bar grey cast iron may be used.

8.2.6 Cast iron casing joints shall be of the flat-faced or double-raised-face type.

The use of sealing compounds is permissible.

8.3 External forces and moments

The SUPPLIER shall specify the casing nozzle displacements due to thermal movements of the compressor, and the permissible forces and moments on the casing nozzles to which the USER has to connect. These forces and moments shall not affect the safe operability of the compressor under any specified operating condition, including standstill (misalignment, internal clearances, stresses in casings and flanges etc.). Sole responsibility for the layout of the piping systems and their calculation on the basis of the nozzle displacement and permissible forces and moments shall be taken by the furnisher of the piping system who shall ensure that the permissible values are not exceeded. The result of the piping calculations shall be transmitted to the SUPPLIER. This does not affect the aforementioned responsibility of the piping furnisher.

8.4 Bolted connections

8.4.1 All threads shall be metric in accordance with ISO 262 unless otherwise agreed.

8.4.2 Threaded holes for bolts shall be kept to a minimum. Studs are to be preferred to cap bolts. Threaded holes shall not penetrate into pressure areas and the remaining base metal shall be thick enough to prevent any possibility of leakage; this thickness shall in any case be at least half the nominal bolt diameter.

8.4.3 The casing bolt materials shall be selected according to the casing design temperature range. At temperatures between −20 and +300 °C bolts of grade 4.6 shall be used for cast iron and of grade 5.6 for cast steel in accordance with ISO 898. For higher and lower temperatures, and for corrosive media, materials for bolts and nuts shall be selected according to the standards in the SUPPLIER's country, or equivalent.

8.5 Casing apertures for pipe connections

8.5.1 Inlet and discharge pipes shall be flanged and the connections shall be oriented as specified in the order. Unless otherwise specified, the SUPPLIER's standard design shall be used.

8.5.2 For the auxiliary piping connections on the casing, glands and bearing housings, flanged connections shall have a minimum inner diameter of 20 mm. If, for reasons of space, piping connections cannot be made as flanged connections, intermediate pieces of seamless steel tubing, inserted between the casing and the flanged connection, of the same nominal diameter as specified for the flanged connection, are permitted.

The intermediate pieces may be screwed into the casing wall. For oil, and toxic, corrosive or flammable gases, these screwed connections shall be brazed to cast iron casings or welded to steel casings. Threadless welding of intermediate pieces larger than 50 mm is also permissible provided that such welds are stress relieved. Screwed connections with gaskets are permitted for non-flammable and non-toxic gases and liquids (see figure 4). The USER shall specify in the data sheets which of these procedures is not acceptable in certain instances.

These conditions are applicable to the following auxiliary connections:

a) vent openings;

b) drain openings on casings and seals;

c) sealing gas connections and gas balancing pipes;

d) sealing fluid connections;

e) connections for liquid-injection equipment;

f) lubricating oil connections;

g) cooling water connections.

These conditions shall not apply to pipes, both ends of which are welded or brazed to the casing, forming an integral part of it (e.g. balance lines).

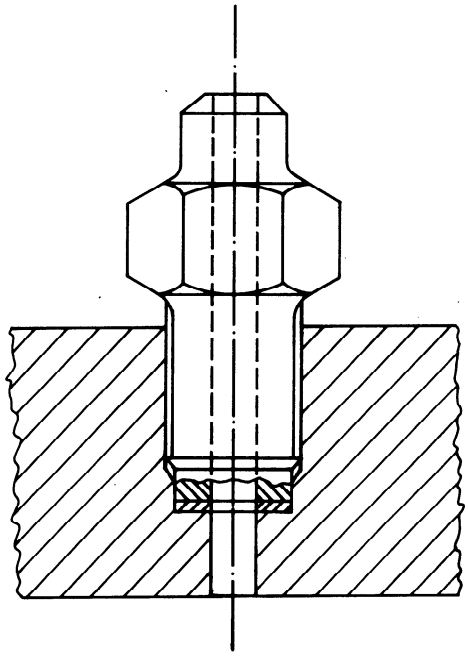


Figure 4 — A screwed connection to casing for non-flammable and non-toxic gases and liquids

8.5.3 Unless otherwise agreed, connections for control oil and pressure measuring lines may be made on the casing and on glands with a minimum inner diameter of 12 mm. For toxic, corrosive and flammable media, flanged connections shall be used.

Thermometer wells shall be used for the installation of thermometers in spaces containing gas. Their use is recommended in all other instances.

8.5.4 All flanges to which connections are made by the USER, or another furnisher commissioned by him, shall be executed in accordance with the standards specified by the USER in the enquiry. Alternatively the mating flanges shall be provided by the SUPPLIER.

All flanges to which auxiliary pipes supplied by the SUPPLIER are connected may be executed in accordance with the SUPPLIER's own standard.

8.5.5 Unless otherwise agreed, the construction of the flange sealing surfaces shall be of the standard design specified by the respective flange standard.

8.5.6 Threaded openings to which no pipe is connected shall be sealed with cylindrical steel plugs (welded, brazed or screwed). Screwed plugs shall be seal welded or brazed or shall have a metallic flat face seal. In the case of corrosion-resistant casings, corrosion-resistant plugs shall be used.

8.6 Rotor

8.6.1 Shafts

The shafts or tie-rods, if any, shall be made of forged steel or equivalent. Protective shaft sleeves are permitted.

If the couplings are supplied by a third party, agreement shall be reached between the SUPPLIER and the coupling furnisher to ensure proper matching of the shaft end with the coupling bore.

8.6.2 Impellers for centrifugal compressors

Impellers of the open or closed design may be used. The impellers shall be firmly fitted to the shaft or to each other and centred so that they cannot alter the rotor balance up to the trip speed at the maximum operating temperature. Shrink fits without keys are permitted.

8.6.3 Rotors for axial flow compressors

The rotor may be designed as a one-piece unit, as a shaft with shrunk-on discs, as a combination of both types, or as an assembled or welded drum or disc rotor. The conditions given in 8.6.2 shall apply to the securing of the rotor parts.

8.6.4 Blades of axial flow compressors

The design shall be such as to avoid any undesirable blade resonances over the specified operating speed range, taking account of the necessary starting procedure and any other likely transient condition.

8.6.5 Rotor materials

In selecting rotor materials the SUPPLIER and the USER shall agree on all factors affecting material properties (e.g. the presence of H_2S).

8.7 Diaphragms, diffusers, guide vane carriers and attached coolers

Interstage diaphragms shall be suitable for all specified operating conditions including start-up, shut-down and momentary surge. Where diaphragms separate chambers with external flow connections, the USER shall specify the maximum differential pressure that may occur during operation or shut-down of the compressor. Unless otherwise specified, diaphragms, diffusers and guide vane carriers may be made of cast iron. Diffuser passages and return channels shall be free from any obstructions (e.g. casting irregularities). Coolers connected directly to the compressor casing may have cast or welded casings.

The design pressure shall be used for the gas side. The design of the cooling water side shall be in accordance with 10.2.2.

8.8 Labyrinth seals

8.8.1 Internal seals between fixed and rotating parts shall be equipped with labyrinths. The labyrinth tips may be mounted on the fixed or on the rotating parts. They shall be designed such that they may be replaced easily. With fixed tips, protective sleeves on the shaft are permitted.

8.8.2 In selecting labyrinth materials the SUPPLIER and the USER shall agree on all factors concerning the gas composition and operating conditions.

8.9 Thrust balance piston and balancing line

8.9.1 For single-inlet, multi-stage radial flow and axial flow compressors, a thrust balance piston with balancing line is desirable to limit axial thrust bearing loading.

8.9.2 For double-inlet compressors, or compressors in which the flow is guided in opposite axial directions by individual stages or groups of stages, a thrust balance piston may be omitted or an intermediate seal between two compression stages can take over the function of the thrust balance piston. A balancing line is then unnecessary.

8.9.3 The thrust balance piston shall be designed as a labyrinth seal in accordance with 8.8.

8.9.4 The balance line shall be sized, as a minimum, to handle a balance piston labyrinth gas leakage corresponding to twice the design clearance, without exceeding the load rating of the thrust bearing.

8.10 Bearings and bearing housings

8.10.1 Except for compressors with overhung impellers, the bearings shall be replaceable without removing the upper casing half of a horizontally split machine or the end cover of a vertically split unit.

The bearing housings may be cast integral with the compressor casing or connected to the compressor casing as separate components. Care shall be taken to ensure reliable and repeatable centring of the bearing housings.

8.10.2 The radial bearings shall be designed as journal bearings in accordance with the SUPPLIER's standards. Bearings shall be designed to maintain oil film stability at any operating condition up to and including the trip speed.

8.10.3 The thrust bearing shall be of the double-acting type. For the main load direction, the bearing should preferably be a tilting pad unit. The thrust bearing shall be sized to take additional external loads transmitted through the coupling. If gear-type couplings are used, a minimum friction coefficient of 0,15 shall be used to calculate the axial thrust transmitted. The SUPPLIER shall obtain the necessary data from driver, gear and coupling furnishers to enable him to size the thrust bearing. The thrust collar may be integral with the shaft or replaceable; if of the latter type, it shall be fitted to the shaft without clearance. If start-up under axial load is required, the thrust bearing shall be suitably designed.

The compressor shall be equipped with an appropriate sensing device to detect either a change in the thrust load or an axial displacement of the shaft.

8.10.4 Bearing housings shall be designed in such a way that vibration-measuring instruments may be fitted. In addition, provision should be made for at least one non-contact vibration probe on or near each line bearing. If two probes are used, they should be circumferentially spaced between 80° and 100° apart.

8.10.5 Forced-feed lubrication shall be provided for all compressor bearings. Care shall be taken to ensure minimum foaming and generous lubricant return line cross-sections. If the gas being handled can affect the properties of the lubricant or the bearing materials, special precautions are necessary. The USER shall inform the SUPPLIER thereof.

8.11 Shaft seals

8.11.1 The type of seal shall be agreed between the SUPPLIER and the USER. The USER shall inform the SUPPLIER of all adverse conditions under which the seal has to operate.

8.11.2 Dangerous and hazardous gases shall not be allowed to escape into the surrounding atmosphere during normal operation; they shall be reliably and safely discharged from the compressor.

8.11.3 Depending on the requirements to be met by the seal during operation or at rest, the use of the following types of seal is acceptable:

a) labyrinth seals;

b) segmental ring seals;

c) mechanical contact seals;

d) floating ring seals;

e) self-acting gas seals.

The seals should be fitted so that they are easily accessible and replaceable.

8.12 Critical speeds

8.12.1 Lateral critical speeds

Lateral critical speeds shall be calculated with due allowance for external factors, such as the type of coupling, and the bearing and bearing support properties, and shall lie within the ranges defined in table 1.

Table 1 — Lateral critical speeds

Drive	Electric motor	Turbine or expander
Stiff shaft design	$n_c \geqslant 1{,}2\ n_{100}$	$n_c \geqslant 1{,}26\ n_{100}$
Flexible shaft design	$n_{c1} \leqslant 0{,}85\ n_{min}$ $n_{c2} \geqslant 1{,}2\ n_{100}$	$n_{c1} \leqslant 0{,}85\ n_{min}$ $n_{c2} \geqslant 1{,}26\ n_{100}$

See also figure 1.

NOTE — There are applications where the wide operation range of the process can only be covered by deviation from the criteria given in table 1. In such cases other criteria may be applied by agreement between the SUPPLIER and the USER and the SUPPLIER should demonstrate the suitability of the compressor.

8.12.2 Torsional critical speeds

Unless otherwise specified, the SUPPLIER need only carry out a torsional analysis of the system if the compressor is motor or engine driven. If torsional natural frequencies lie in the range of

excitation frequencies, the SUPPLIER shall ensure that no harmful forces occur in the most highly stressed parts.

The furnishers of the motors, couplings and gears shall provide the SUPPLIER with the pertinent data to enable him to complete the torsional analysis.

8.13 Vibration

If specified in the enquiry, compressors shall be subject to the vibration requirements detailed hereafter.

8.13.1 Measuring techniques

The following methods may be used to determine the radial vibration levels of the compressor (as specified in 8.13.2 and 8.13.3):

a) measurement of shaft vibration with non-contact-type pick-ups mounted adjacent to the journal bearings;

b) measurement of bearing housing vibration with contact-type pick-ups fastened to the bearing housings.

8.13.2 Acceptable vibration levels

Vibration acceptance testing shall be carried out during the mechanical running test of the compressor. The limits shall not be exceeded between the minimum and maximum continuous speeds. The mechanical run-out of the shaft diameter, where the vibration is measured with respect to the bearing journal, and the electrical run-out due to non-homogeneity of the shaft material at the point of measurement may be subtracted from the reading to obtain the net shaft vibration.

If non-contact probes are used, measurements shall be taken with two pick-ups at each line bearing circumferentially spaced between 80° and 100°. Whilst it is emphasized that the permissible limit must be agreed between the SUPPLIER and the USER, figure 5 is given to provide a guideline to the order of magnitude of the maximum shaft movement. It must be appreciated, however, that different bearing designs are characterized by different shaft movements; for example, a tilting-pad bearing usually permits less shaft movement than indicated by the guideline, whilst an elliptical bearing can allow more shaft movement in the horizontal plane. Such factors shall be considered when setting permissible shaft movements for a specific machine.

If contact-type pick-ups are used, they shall permit measurement in two perpendicular planes, and the test procedure and acceptance criteria as stated in guideline VDI 2056 [1] apply. The applicable vibration frequency (abscissa in charts of VDI 2056) shall correspond to the 100 % shaft speed. As a guide to the order of magnitude of the permissible maximum bearing housing vibration, the line separating the "good" from the "permissible" regions shall be used.

It is normal practice to follow the SUPPLIER's standard procedure for the interpretation of the measured levels. Vibration monitoring instrumentation, if provided (see 8.13.3), shall be in operation during this test, whenever possible.

8.13.3 Vibration monitoring

If required by the USER, vibration monitoring during normal operation of the compressor shall be undertaken using method a) or b) (specified in 8.13.1), as specified in the contract, using one pick-up per compressor. The pick-up which should preferably be used is that which gave the greatest readings during the mechanical running test.

8.13.4 Alarm and trip levels

Since the variation rather than the absolute magnitude of the vibration levels is indicative of possible machine deterioration, the alarm and trip levels of the monitoring system, if provided, shall be set with respect to the values actually measured and logged during the vibration acceptance test and not with respect to the maximum acceptable levels given in figure 5. The trip level shall be specified by the SUPPLIER.

8.13.5 Vibration signature

It is recommended that the vibration signature of the compressor be established by frequency analysis with the machine running at its normal operating point. The signature so obtained can be used for initial and future diagnosis of machine trouble.

8.14 Balance

Rotor assembly and balancing shall be carried out in such a way that the rotor is virtually free from inner couples and that the vibration criteria of 8.13.2 are met. Balancing shall be carried out in at least two reference planes.

Couplings and their spacers shall be dynamically balanced independently of the rotor. Whilst balancing the complete rotor, no corrections shall be applied to the coupling halves.

Balancing shall not be achieved by welding.

8.15 Baseplate or soleplate

8.15.1 A common baseplate, soleplates or mounting pads, that may be rigidly connected to the foundation, shall be provided for the compressor or for the compressor and gear unit. Foundations shall be executed in accordance with the relevant specifications.

8.15.2 The soleplates or baseplates shall have machined surfaces for satisfactory seating of the parts of the plant mounted on them. In addition, aligning plates, machined on both sides or made of multiple layers, are permissible between the machine and the baseplate or soleplate.

1) Verein Deutscher Ingenieure: Beurteilungsmaßstäbe für mechanische Schwingungen von Maschinen, *VDI Richtlinie 2056*, VDI GmbH Düsseldorf (D) 1964.

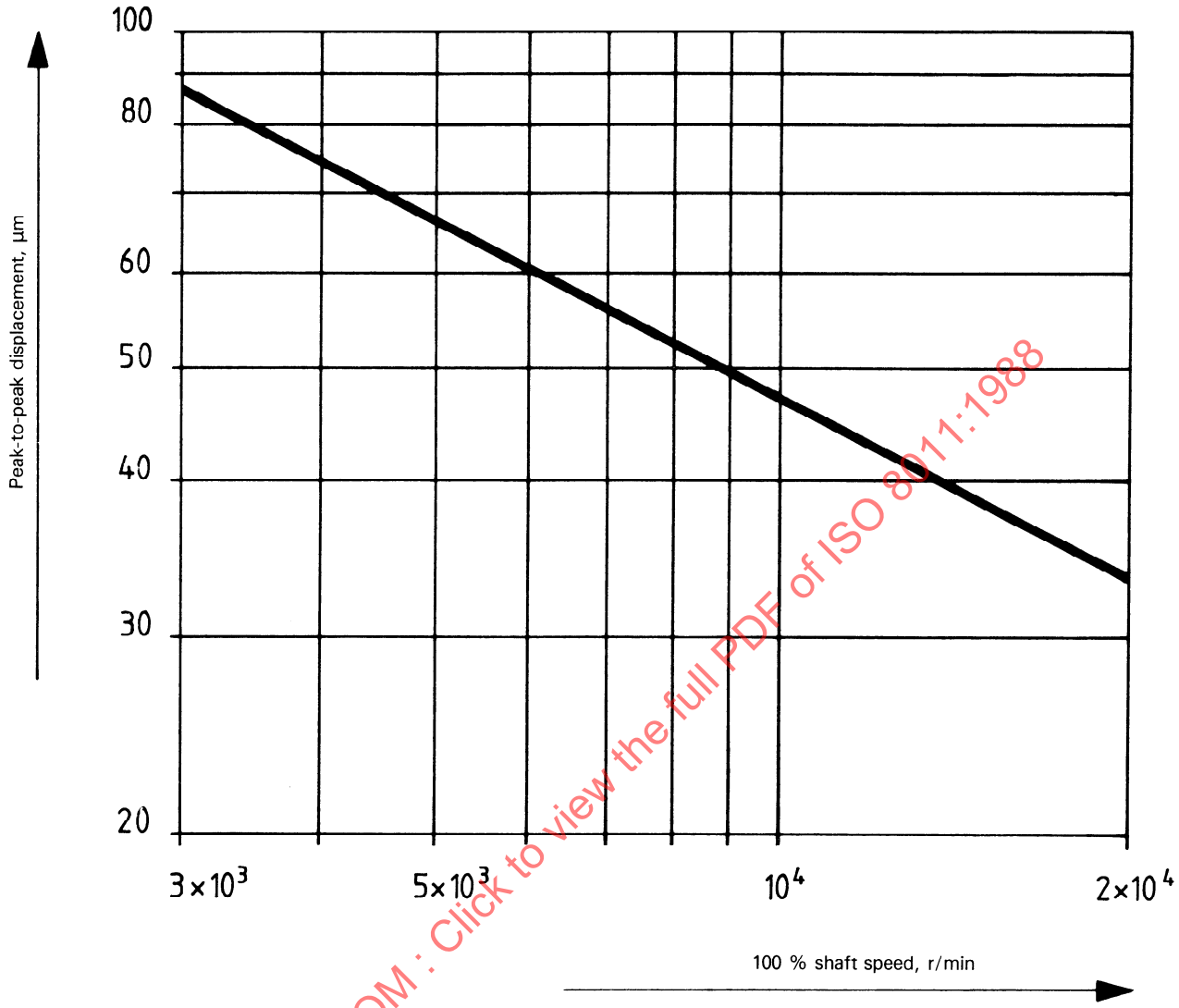


Figure 5 — Guideline to the order of magnitude of the permissible maximum shaft movement

8.15.3 Jacking screws or shims for adjustment of the vertical position of baseplates or soleplates on the foundation shall be supplied.

8.15.4 If necessary, openings for grouting shall be provided in the baseplates or soleplates with a diameter of not less than 100 mm. They shall be arranged so that oil cannot collect above exposed grouting.

8.16 Injection devices

8.16.1 If the compressor is to be equipped with injection devices, this shall be stated in the order so that the necessary bosses can be provided on the compressor casing.

8.16.2 For the injection of liquid, nozzles shall be provided and fitted in such a way that a uniform fine distribution of the liquid in the gas stream is obtained.

8.16.3 A compressor equipped with an injection system shall be provided with adequate drainage facilities.

8.16.4 Unless otherwise agreed, the supply shall comprise

a) built-in injection nozzles with preceding isolating and setting valves;

b) drainage pipes with isolating valves; the pipes end in the region of the baseplate or soleplate.

8.16.5 To avoid damage to the compressor, the SUPPLIER shall provide complete instructions on the operation of the injection system as well as on the maximum permissible amount of injection liquid.

8.17 Rating plates and rotation arrows

8.17.1 The direction of rotation shall be agreed with the furnisher(s) of the driver and gear unit. Either rotation arrows shall be cast on the casings of the compressor and gear unit or the direction of rotation shall be marked by arrows made of corrosion-resistant material on the compressor and gear unit.

8.17.2 The compressor shall be identified by a rating plate made of corrosion-resistant material. The rating plate shall give at least the following data:

a) manufacturer's name;

b) manufacturer's serial number;

c) manufacturer's model number;

d) year of manufacture;

e) inlet volume rate of flow, in cubic metres per second;

f) maximum allowable working temperature, in degrees Celsius;

g) maximum continuous speed, in revolutions per minute;

h) prohibited speed ranges, in revolutions per minute;

i) casing design effective pressure, in bars.

The USER shall inform the SUPPLIER of any local regulations requiring additional data to be inserted on the rating plate.

9 Drivers and drive equipment

9.1 Drivers

9.1.1 General

The type of driver shall be specified by the USER. It shall be sized taking into account the power losses in gear units and/or fluid coupling. The breakaway and starting torque of the driver shall exceed the compressor torque/speed requirements.

Changes in power and speed due to foreseeable changes in the gas properties and conditions of service of the gas being handled by the compressor shall be specified to the manufacturer of the driver by the SUPPLIER, as stated by the USER in the data sheets.

For oil supply see 11.1.3.

For noise see 7.5.

9.1.2 Steam turbine

Unless otherwise agreed, the steam turbine serving as the main drive unit shall be designed to meet the following conditions.

a) It shall be capable of producing continuously a rated driver power which is at least 110 % of the necessary power at each specified operating point and at the corresponding speeds as indicated in data sheet 201. Unless otherwise specified, this condition shall be met under the specified normal inlet and exhaust steam conditions.

b) At certain specified operating points, which shall be indicated by the USER in the enquiry, the turbine shall be capable of producing continuously 100 % of the necessary power under the minimum continuous operating steam inlet and the maximum continuous operating exhaust conditions.

c) The turbine shall be suitable for continuous operation at all speeds between the minimum and maximum continuous operating speeds of the compressor.

9.1.3 Motor

The motor shall be capable of producing continuously a rated driver power which is at least 115 % of the calculated power at each specified operating point and at the corresponding speeds as indicated in the data sheets.

Area classification and other design characteristics shall be as specified in the data sheets.

To enable the SUPPLIER to conduct torsional analyses, the motor manufacturer shall provide the SUPPLIER with the pertinent dynamic characteristics of the motor (see 8.12.2).

9.1.4 Gas turbine

Gas turbine drivers shall be sized by mutual agreement between the SUPPLIER and the USER.

9.1.5 Expansion turbine

If the expansion turbine is the sole driver of the compressor, its design with regard to power and speed shall be as specified for the steam turbine (see 9.1.2).

9.1.6 Other cases

In all other cases, the sizing and operation of the drivers shall be agreed between the SUPPLIER and the USER.

9.2 Gears

9.2.1 Parallel shaft gears and pinions shall be of the helical or double-helical type. Spur-type gears may be used in epicyclic gear drive systems. The tooth shape shall be the responsibility of the manufacturer.

9.2.2 Although there are no universally accepted calculation and design procedures available for gears, table 2 should be used as a guide when selecting a gear unit. Future International Standards will provide a basis for these calculations.

9.2.3 The gear unit shall be capable of continuous operation at the maximum continuous speed of the compressor for a minimum of 100 000 h at no less than the rated gear torque multiplied by the appropriate application factor in table 2. The rated gear torque (in newton metres) is greater than or equal to the highest torque resulting from the gear input power (in kilowatts) and the gear input speed (in revolutions per minute) combinations at any specified operating point (see 9.1.2 and 9.1.3) and shall be computed in accordance with the following formula:

$$\text{rated gear torque} \geqslant \frac{30\,000}{\pi} \times \frac{\text{gear input power}}{\text{gear input speed}}$$

The gear input power is normally equal to the rated driver power. For gears (e.g. between casings) not transmitting the full driver power, the gear input power shall be calculated on an equivalent basis.

9.2.4 The application factors given in table 2 are recommended values.

Table 2 — Application factors

Type of drive	Application factor
Steam or gas turbine; turbo-expander	1 to 1,2
Electric motor with a starting torque ratio as indicated in data sheet 404, but not greater than 2	1 to 1,2
Synchronous motor with an oscillating torque (peak value) during start-up and other transients (for torsional analysis, see 8.1.2.2) of less than five times the rated gear torque (see 9.2.3)	1,2 to 1,5
Reciprocating engine with a continuous torque fluctuation of less than five times the rated gear torque (see 9.2.3)	1,3 to 1,6
All other cases	To be agreed with gear manufacturer

9.2.5 Thrust bearings, if provided, shall be sized to absorb the axial thrust transmitted by friction in the couplings as well as any axial gearing forces. For the sizing of thrust bearings, see 8.10.3.

9.2.6 The rotating parts of the gear shall be dynamically balanced in accordance with the requirements of 8.14.

9.2.7 Lateral critical speeds of the low-speed shaft shall not be within ± 15 % of the high-speed shaft speed, and vice versa, at any specified operating point.

9.2.8 The lubricating oil quality shall be agreed with the gear unit manufacturer.

9.2.9 The directions of rotation of all shafts shall be clearly shown by directional arrows, either cast-on or made of corrosion-resistant material, on the gear casing.

9.2.10 For noise see 7.5.

9.3 Couplings

9.3.1 Solid or flexible couplings may be used between the compressor, the gear unit and the driver. For coupling speeds over 2 000 r/min, the metallic parts of the couplings shall be made of steel. Cast iron shall not be used in couplings.

9.3.2 The coupling shall be designed to be capable of continuous operation for a minimum of 100 000 h at no less than the rated coupling torque multiplied by the appropriate application factor given in table 2. The rated coupling torque shall be computed on an equivalent basis to the rated gear torque (see 9.2.3).

9.3.3 Couplings shall be designed to allow uncoupled operation of the drive shaft.

9.3.4 In the design of gear-type couplings with continuous lubricating oil spray, care shall be taken to avoid sludge build-up in the coupling. The lubricating oil filtration rating shall be agreed with the coupling manufacturer.

9.3.5 Coupling spacers shall be removable for access to both coupling halves, bearings and external shaft seals without dismantling the compressor, gear or motor.

9.3.6 Prior to the contract, the SUPPLIER and the USER shall reach agreement regarding who is to supply the couplings between the driver and the compressor and who is responsible for the balancing and assembly work on the couplings (see also 8.14).

9.3.7 Coupling bolts shall be selected by mass to permit interchange without altering the balance.

9.3.8 Non-integral coupling halves shall be mounted by cylindrical or conical shrink-fits. Shaft keys are permitted. If two shaft keys are used they shall always be installed in diametrically opposed locations for reasons of balance and ease of replacement.

9.3.9 Each coupling shall be guarded in such a way that it can be readily inspected and dismantled. This also applies to the couplings of auxiliary drives. If a coupling has lubricating oil inlet and outlet pipes, these pipes shall meet the specifications for auxiliary pipes (see 10.7).

9.3.10 It shall be stated in data sheet 401 whether limited end-float couplings are required or not.

10 Auxiliary equipment

10.1 General

10.1.1 All auxiliaries which come within the scope of pressure vessel codes (including gas coolers, silencers, separators and traps) shall be designed, manufactured, inspected and tested in accordance with any recognized code stated by the SUPPLIER in data sheet 207, unless the USER specifically invokes a particular code at the time of enquiry.

10.1.2 Where carbon steel surfaces in gas coolers, silencers, separators, traps or other auxiliaries are exposed to water or other corrosive media, then a minimum corrosion allowance of 3 mm shall be incorporated on all such surfaces. This requirement does not apply to cooler tubes. Alternative methods of protection shall be agreed between the SUPPLIER and the USER.

10.1.3 Design pressures of auxiliaries as referred to in this International Standard shall follow the definition of the casing design pressure (5.2.8) unless otherwise specified.

10.1.4 Design temperatures of auxiliaries as referred to in this International Standard shall follow the definition of the compressor casing design temperature range (see 5.3.6), using the upper value unless otherwise specified.

10.1.5 Threaded openings to which no pipe is connected shall be sealed with cylindrical steel plugs (welded, brazed or screwed). Screwed plugs shall be seal welded or brazed or shall have a metallic flat face seal. In the case of corrosion-resistant casings, corrosion-resistant plugs shall be used.

10.2 Gas coolers

10.2.1 Shell-and-tube or air-blast coolers may be used. Shell-and-tube-type coolers shall have removable tube bundles and channel covers.

10.2.2 The cooling water side of gas coolers shall be designed for the water pressure specified by the USER, but for an effective pressure of at least 4,5 bar and for vacuum.

NOTE — In special applications (e.g. where chlorine is used) it may be desirable to keep the water pressure below the gas pressure.

10.2.3 Where intercoolers are an integral part of the compressor casing, they shall be subject to the criteria of 8.2 (see also 8.7).

10.2.4 The fouling factors for both water and gas sides should be agreed between the SUPPLIER and the USER. If not agreed, the fouling factors given in table 3 shall be used for the water side.

Table 3 — Fouling factors

Water	Fouling factor $m^2 \cdot K/W$
Closed circuit (treated)	$0{,}85 \times 10^{-4}$
Normal cooling tower	$1{,}7 \times 10^{-4}$
Brackish	$3{,}4 \times 10^{-4}$

10.2.5 A minimum water velocity through the tubes of 1 m/s shall be maintained. The maximum velocity shall be determined according to the properties of the tube material and the construction.

10.2.6 All coolers shall be thermally rated for the most severe operating conditions (e.g. of cooling water, temperature, gas density and flow rate), as indicated in data sheets 201, 202, 205 and 502.

10.2.7 All piping connections to coolers shall be to the standard specified by the USER. In the absence of any specification, they shall conform to the requirements of 10.5, 10.6 and 10.7 as a minimum.

10.2.8 The maximum allowable cooling water temperature rise and pressure drop shall be as stated in data sheet 205.

10.3 Silencers

10.3.1 Intake, discharge and blow-off silencers, when required, shall be to the SUPPLIER's preferred standard, unless otherwise specified by the USER.

10.3.2 Account shall be taken of the most severe operating conditions (e.g. compressor surge, maximum flow, pressure, temperature and corrosion) in the design of the silencers.

10.3.3 All piping connections to silencers shall be to the standard specified by the USER. In the absence of any specification, they shall conform to the requirements of 10.5, 10.6 and 10.7, as a minimum.

10.4 Separators and traps

10.4.1 Liquid separators shall be provided in suction lines and downstream of coolers if specified by the USER or deemed to be necessary by the SUPPLIER. The USER shall furnish any pertinent information to the SUPPLIER.

10.4.2 Where separators are an integral part of the compressor casing, they shall be subject to the criteria of 8.2.

10.4.3 Unless otherwise specified by the USER, each separator shall be fitted with a drain trap, complete with isolating and blow-down valves. Provision shall be made in the drain line for flow detection.

10.4.4 Separators with a manual drainage facility only shall have a hold-up tank volume to permit continuous full-duty utilization without drainage for two attendance intervals, as stated in the data sheets. Where the SUPPLIER considers this to be inappropriate, he shall advise the USER accordingly.

10.5 Pipework (general)

10.5.1 The dimensions of piping shall be in accordance with applicable International Standards or equivalent. Non-preferred pipe sizes as indicated in national standards shall be avoided.

10.5.2 The scope of supply of pipework shall be defined on data sheet 501A.

10.5.3 Terminal-point isolating valves shall not form part of the SUPPLIER's standard supply.

10.5.4 Mating flanges for terminal connections shall be supplied by the SUPPLIER

a) when specified by the USER;

b) when the standard of the terminal flange does not comply with a recognized national standard or the standard specified by the USER.

10.5.5 The SUPPLIER shall supply all the jointing and bolting as necessary for the connections within his supply, including terminal connections where he supplies the mating flange.

10.5.6 Valved and blanked or plugged low-point drain connections shall be provided by the piping furnisher. Water pipework systems shall also be fitted with high-point vent valves by the pipework installer.

10.5.7 The SUPPLIER shall define precisely the location, size and type of his terminal connections.

10.5.8 Bite-type (i.e. cutting ring) fittings shall not be used except for instrument air lines.

10.5.9 Screwed connections sealed by brazing or welding shall not be coated beforehand with thread lubricant or sealing compound. The seal welds shall comprise at least two passes and shall cover all exposed threads.

10.5.10 All pipes shall be routed to ensure adequate elasticity. They shall have a minimum of fittings but consistent with ease of maintenance of equipment and, where necessary, of cleaning of the piping.

10.5.11 Piping runs which may be used by personnel for support during maintenance or other operations shall be suitably robust or well supported, or shall be protected by guards supplied by the piping installer.

10.5.12 All pipework and auxiliaries of the SUPPLIER's supply which is integral to a unit shall be supported at the SUPPLIER's discretion and by the SUPPLIER in such a way that the possibility of damage due to vibration, thermal expansion and the mass of the pipework and auxiliaries is minimized.

10.5.13 Where the SUPPLIER supplies piping external to the unit (i.e. where the piping cannot be supported from the unit or its foundation) but does not supply the supports, he shall advise the USER of suggested support arrangements intended to minimize the effects of thermal changes, the pipe and fittings' mass, pulsation and mechanically induced vibrations and the imposition of strain on the machine connections.

10.5.14 The use of flexible joints to allow for thermal expansion and to reduce stresses in the piping system is permitted, subject to the agreement of the USER.

Express attention is drawn to the fact that the manufacturer of such joints should be consulted with regard to the necessary procedures to be adopted for the installation and support of these items.

10.5.15 Piping shall be free of loose rust, slag, welding beads and other foreign matter.

10.6 Process gas pipework

10.6.1 The process gas pipework shall be in accordance with a relevant recognized national specification of the SUPPLIER's choice, unless the USER specifically invokes another specification at the time of enquiry. Such a specification shall be supplemented by 10.6 of this International Standard; however, where the requirements of the specification and this International Standard are in conflict, the specification shall govern.

10.6.2 The process gas pipework shall have a minimum inner diameter of 20 mm.

10.6.3 Process gas piping shall have flanged or welded connections unless there is express agreement between the SUPPLIER and the USER that screwed connections may be used for piping of up to 50 mm inner diameter.

10.6.4 The SUPPLIER and the USER shall agree on the nature of the tests applied by the SUPPLIER to pipework fabrications of his supply.

10.6.5 The USER's own piping installation shall not impose loads on the SUPPLIER's equipment except as specified in 8.3.

10.6.6 Isolating valves on purge and vent connections, where the process gas is explosive or otherwise hazardous, shall be protected against accidental operation.

10.7 Auxiliary pipework

10.7.1 The auxiliary systems are as follows:

a) lubricating and control oil;

b) sealing liquid;

c) sealing gas and gas equalization;

d) cooling water;

e) discharge, drainage and venting;

f) instrument, impulse and sensing lines.

The associated fittings, control devices and measuring devices shall also be subject to the requirements of 10.5.

10.7.2 Except where the gas demands special materials, seamless carbon steel pipe shall be used for gas and lubricant lines. Coolant lines may be made of seam-welded pipe. It is recommended that stainless steel piping be used between the lubrication and seal liquid filters and the machines.

10.7.3 Fittings and valves in auxiliary systems shall be made of steel. The use of grey or nodular cast iron or other materials such as bronze or Monel is subject to agreement between the SUPPLIER and the USER.

10.7.4 The valve trim shall be made of a corrosion-resistant material.

10.7.5 Copper or plastic pipe is only permissible for measuring and impulse lines, with agreement of the USER.

10.7.6 A nominal effective pressure of 10 bar shall be taken as the minimum pressure rating for all connections.

10.7.7 Oil return lines shall be generously dimensioned and arranged so that a satisfactory flow rate is obtained (allowing for possible foaming). Pipes running "horizontally" should have a slope of at least 40 mm per linear metre towards the oil reservoir (i.e. 1 in 25).

10.7.8 Drain lines, other than from instruments or controls, shall be of 20 mm inner diameter as a minimum. The USER shall arrange his drainage system to dispose safely of any process gas which accidentally gains access to the drainage system.

10.7.9 All auxiliary piping supplied by the SUPPLIER which is within the perimeter of the baseplate or part of an auxiliary unit (e.g. oil console or control panel) shall be completely connected with associated control and measuring devices etc. Such piping shall have flanged terminal connections. Interconnecting pipes within the SUPPLIER's scope of supply may be fabricated on site.

10.7.10 The pipe systems should preferably be made by bending and welding. Welded fittings and flanges shall be of butt weld, socket weld or slip-on types. Threaded connections are permissible for sizes up to 50 mm inner diameter and a nominal pressure of 10 bar, but they should be limited to a minimum and shall be seal-welded for corrosive, toxic or flammable gases or liquids, with the exception of connections to instruments.

10.7.11 Auxiliary oil pipes, made of carbon steel, shall be pickled and passivated after fabrication.

11 Lubrication and seal liquid systems

11.1 General

11.1.1 The lubrication and seal liquid system(s) shall be completely furnished by the SUPPLIER unless otherwise agreed. For seal systems using liquids other than lubricant, the following requirements shall apply, as applicable. The lubrication, seal oil and control oil systems may be combined. They shall be designed to supply lubricant at suitable conditions to the following components, as applicable:

a) the bearings of compressors, gears and drivers;

b) the seals of compressors;

c) the couplings;

d) the control and trip systems of compressors and drivers.

11.1.2 The SUPPLIER shall specify the lubricant quality to be used in the lubrication, seal oil and control oil systems for the equipment listed in 11.1.1. Wherever possible, only one grade of lubricant shall be utilized for all equipment.

The USER may use lubricant from these systems for his own needs if this is approved by the SUPPLIER.

11.1.3 The manufacturer of the equipment furnished with lubricant from the lubrication and seal oil system shall indicate to the furnisher of the system his requirement as follows:

a) the lubricant flow rate (minimum, normal and maximum);

b) the lubricant pressure (minimum, normal and maximum);

c) the lubricant characteristics;

d) the heat to be dissipated;

e) the degree of filtration;

f) the lubricant temperature.

Unless otherwise agreed, it shall be the SUPPLIER's responsibility to coordinate the lubricant requirements of the various units.

11.1.4 The filters and coolers shall be furnished with valved drains and valved vents to permit draining, cleaning and filling while the compressor is in operation. Valves shall have a minimum bore of 12 mm.

11.1.5 Pressure vessels shall be supplied in accordance with 10.1.

11.2 Lubricant reservoirs

11.2.1 Lubricant reservoirs shall preferably be separate from the compressor. Reservoirs shall be internally descaled. The use of a rust preventative other than paint is recommended. Reservoirs with top-mounted equipment shall have sufficient rigidity to prevent sagging and vibration.

11.2.2 All cover openings in the top surface shall be sealed using gaskets and raised at least 25 mm above the surface to avoid the entry of solids and water.

11.2.3 Openings encompassing a minimum diameter of 500 mm shall be provided in the reservoir for inspection and cleaning of the interior. The reservoir shall have a sloping bottom and the drain shall be located at the lowest point to ensure complete drainage. Care shall be taken to avoid re-entrainment of gas bubbles and contaminant from the lubricant returns, e.g. by means of baffles.

11.2.4 A suitable, locally mounted and protected continuously indicating lubricant level gauge, marked with the maximum filling, maximum operating and minimum operating levels shall be supplied. A filler opening with a strainer shall be provided. The reservoir shall be suitably vented and care shall be taken to avoid the ingress of contaminant.

11.2.5 The lubricant reservoir shall be sized in accordance with the following requirements.

a) For degassing and contaminant settling-out: the total reservoir lubricant volume below the minimum operating level shall provide a retention time of 8 min. This time is calculated on the basis of the time required for the total lubricant return to flow from machinery to the reservoir at the normal operating point of the compressor.

b) For safety in the event of breakage or leakage: the reservoir lubricant volume between the minimum operating level and the level at which the pump commences to cavitate shall be sufficient for operation for 5 min. This time is calculated on the basis of the time necessary for the total lubricant return to flow from machinery to the reservoir at the normal operating point of the compressor.

c) Special applications: the sizing of the reservoir shall be agreed between the SUPPLIER and the USER.

Degassing shall be taken into account in the design and relative dimensioning of the reservoir.

11.2.6 A heating device, when provided, shall have sufficient power to heat the lubricant in the reservoir from the specified minimum site temperature to the SUPPLIER's minimum required temperature in 12 h. Special severe climatic site conditions (wind etc.) shall be taken into consideration. The heating device shall have a low watt density (maximum, 20 kW/m^2).

If steam heating is employed, the operating lubricant shall not be in direct contact with the steam pipe.

The maximum steam temperature shall be chosen to prevent the heat from carbonizing the lubricant.

Electric immersion heaters shall be thermostatically controlled and their heat density shall not cause deterioration of the lubricant. They shall be switched off automatically if the lubricant level becomes less than 50 mm above these elements.

11.2.7 When specified by the USER, the reservoir shall include a suction and return connection for a lubricant purifier. The filler opening and drain connection may be used for this purpose.

11.2.8 If specified by the USER, lubricant reservoirs shall be so designed that heat insulation may be easily added later without the necessity of relocating instruments etc.

11.3 Pumps and drivers

11.3.1 Each lubricant system shall include at least one main lubricant pump and one standby pump.

11.3.2 The drivers of both pumps and the overall lubrication system shall be sized for continuous parallel operation of both pumps.

11.3.3 The main lubricant pump may be separately driven or shaft driven.

11.3.4 If shaft-driven main lubricant pumps run backwards, they shall not fail and shall maintain an adequate lubricant supply to prevent damage to the machine.

11.3.5 Couplings between pumps and drivers shall be made of lubricant-resistant materials.

11.3.6 The nominal flow rate of the lubricating oil pump shall be at least 115 % of the lubricant flow required by the system at the normal operating point of the compressor.

The nominal flow rate of the seal oil pump shall be at least 120 % of the total seal oil flow under the most severe conditions, or 0,6 litre/s greater than the rated flow, whichever is the greater.

11.3.7 An elevated tank or other suitable means shall be provided for lubrication and seal oil supply during emergency run-down if specified by the USER or deemed necessary by the SUPPLIER.

Elevated seal oil tanks shall be equipped with suitable means of isolating seal liquid from the gas, if required.

11.3.8 A separate suitably sized and powered lubricant pump to cool the turbine bearings after shut-down shall be provided if required by the SUPPLIER or the USER.

In the case of a separately driven main lubricating oil pump, or if no emergency overhead tank is supplied, a separate suitably sized and powered emergency lubricating oil pump may be required to supply lubricating oil during run-down.

A single pump may be used to serve both purposes.

11.3.9 The standby lubricant pump shall be primed (unless of a self-priming design) and ready for operation at all times.

11.3.10 The main and standby lubricant pumps shall be designed to be driven from independent power supplies.

11.3.11 The main and standby lubricant pumps shall have identical flow rate and discharge pressure ratings.

11.3.12 The standby lubricant pump shall be controlled automatically to start up to provide lubricant and to maintain operation upon reduction in pressure below a safe level. An accumulator or elevated tank shall be furnished to maintain lubricant pressure whilst the standby pump is coming up to pressure, if the standby pump is steam turbine driven, or if agreed between the SUPPLIER and the USER. To facilitate the checking of the proper functioning of the standby lubricant pump during normal operation, the pressure switch shall be equipped with an isolating valve and bleed orifice as illustrated in figure 6.

11.3.13 Positive-displacement pumps shall be provided with a full flow rate, externally mounted, relief valve and return line piped to the lubricant reservoir. The relief valve shall be set at a minimum pressure of 110 % of the maximum operating pressure, with due regard given to the variable-speed pump drive, pressure control valve characteristics etc.

11.3.14 The check valve in the discharge line of shaft-driven pumps shall have suitable means for priming.

11.3.15 Pressure regulating devices shall operate without chattering or hunting. Pressure regulating valves shall be sized to maintain the normal lubricant pressures between the following operating limits:

a) the maximum lubricant demand with one pump running;

b) the minimum lubricant demand with two pumps running.

11.3.16 For lubricant pumps external to the reservoir and with flooded suction, valves in the suction lines shall be installed as close as possible to the pump suction port and shall be locked open during normal operation. It shall be possible to clean suction strainers, if supplied, during normal operation of the compressor.

11.4 Filters

11.4.1 Full-flow twin filters shall be furnished. The filters shall be equipped with interlocked continuous-flow transfer valves. The filter pressure drop with clean elements shall not exceed 0,35 bar at the normal operating temperature. Bypass relief valves shall not be used unless specifically agreed between the SUPPLIER and the USER for special operations.

11.4.2 Seal liquid filters shall retain 90 % of all particles with a dimension larger than 10 µm and 99,5 % of all particles with a dimension larger than 15 µm.

Lubricating oil filters shall retain 95 % of all particles with a dimension larger than 25 µm and 99,5 % of all particles with a dimension larger than 30 µm.

If supplied, filters for gear-type couplings shall have a filtration rating as agreed between the SUPPLIER and the coupling furnisher.

11.4.3 Filter cases and heads shall be suitable for operation at not less than the pump relief valve setting. Filter elements shall have a minimum collapsing differential pressure of 3 bar.

11.4.4 Filters shall be located downstream of the coolers.

11.4.5 The filter materials shall conform to the specifications of 10.7.3. Filter elements shall be made of corrosion-resistant material.

11.5 Coolers

11.5.1 Shell-and-tube or air-blast coolers may be used. If specified by the USER, twin coolers shall be provided. Coolers shall be provided with interlocking continuous-flow transfer valves. Each cooler shall be sized to dissipate 120 % of the total heat generated at the maximum continuous operating speed of the compressor and with the maximum coolant inlet temperature. Water, when present, shall flow through the tubes.

The lubricant-side operating pressure should be higher than the water-side pressure.

11.5.2 Shell-and-tube-type coolers shall have removable tube bundles and channel covers.

11.5.3 Coolers shall be suitable for lubricant system operation at a pressure not less than the relief valve setting for the pumps.

11.5.4 Unless otherwise agreed, the coolers shall be made of steel or cast iron for shell coolers, steel, cast iron (sea water) or bronze for channels and covers, steel or copper alloy for tube sheets, and steel or copper alloy for tubes.

Steel tubes shall be corrosion protected, if required by the USER.

The materials of seal liquid coolers shall be compatible with the process gas to be sealed, if the liquid is contaminated.

11.5.5 Tubes shall have an inside diameter of not less than 12 mm, with a minimum wall thickness of 1,5 mm for brass tubes and 2 mm for steel tubes.

11.5.6 The fouling factor for the water side should be agreed between the SUPPLIER and the USER. If not agreed, the factors given in table 3 (see 10.2.4) shall be used for the water side.

11.5.7 The velocity of the cooling water in the tubes shall not be less than 1 m/s during normal operating conditions, and adequate lubricant temperatures to bearings and seals shall be maintained.

11.6 Overhead tanks

11.6.1 An overhead tank shall be provided if specified by the USER.

11.6.2 The purpose of the overhead tank is to function as an emergency lubricant run-down tank, to ensure safe coast-down of the compressor.

The overhead tank shall be sized to maintain sufficient lubricant flow to the equipment for not less than 2 min after shut-down, in the event of failure of all lubricant pumps.

11.6.3 The overhead tank shall be provided with

a) a bottom nozzle, which shall extend 25 mm inside the vessel in order to retain foreign matter;

b) an opening of 150 mm inner diameter for access and inspection;

c) a vent connection, valved drain connection and overflow connection, all of at least 20 mm inner diameter.

11.6.4 The bottom of the overhead tank shall be located at a height sufficient to meet the minimum coast-down pressure requirements, taking into account all items of equipment to be supplied with lubricant. The top of the tank shall not be located higher than the height that would produce the trip pressure.

11.6.5 A heating device shall be provided if specified by the USER.

11.7 Seal liquid drain traps

11.7.1 One drain trap per seal shall be provided unless otherwise specified by the USER. Consideration shall be given to the on-line maintenance of traps.

11.7.2 Drain traps may be manual for non-toxic gas services having seal pressures of less than 10 bar and maximum seal leakages of 40 litres per day per seal (seals in a deteriorated condition).

11.7.3 Automatic traps shall be used for all other conditions up to 60 bar. They may be mechanical float-type traps.

At pressures greater than 60 bar, a level controller and a separate control valve shall be used.

11.7.4 Traps shall be furnished with reflex-type glass gauges. The inlet piping shall enter the seal traps above the lubricant level. Drain lines shall be separate to allow the monitoring of leakage from individual seals.

11.7.5 When specified, seal trap vents shall be equipped with mist eliminators to separate most of the residual lubricant before the vent gas is recycled to the compressor suction or vented to other disposal outlets.

11.8 Accumulators

11.8.1 An accumulator shall be furnished, if necessary or specified by the USER, to maintain lubricant pressure whilst the standby pump is coming up to pressure.

11.8.2 The accumulator design shall be such that precharged gas cannot be delivered with the lubricant to the equipment.

11.8.3 Bladder-type accumulators should be considered for certain process requirements.

11.8.4 A manual pre-charge valve and a pressure gauge for checking the pre-charge pressure in the accumulator shall be provided.

11.8.5 The non-bladder type of accumulator shall be equipped with an armoured reflex-type glass gauge to show the lubricant level during all normal running conditions of the equipment.

The normal lubricant level shall be clearly marked on the gauge glass, indicating the corresponding normal lubricant pressure thereto.

11.8.6 A valved vent may be supplied if specified.

11.9 Schematics

The schematic diagram shown in figure 6 represents the basic minimum requirements for a lubricating system . Figures 7 to 24 represent developments of this basic system and may be used to suit specific requirements. Take-off points for the control lubricant are shown in certain diagrams; their details should be agreed with the USER.

Table 4 gives a summary of figures 6 to 24, showing the subject and pump drive, and the accumulator and emergency overhead tank requirements.

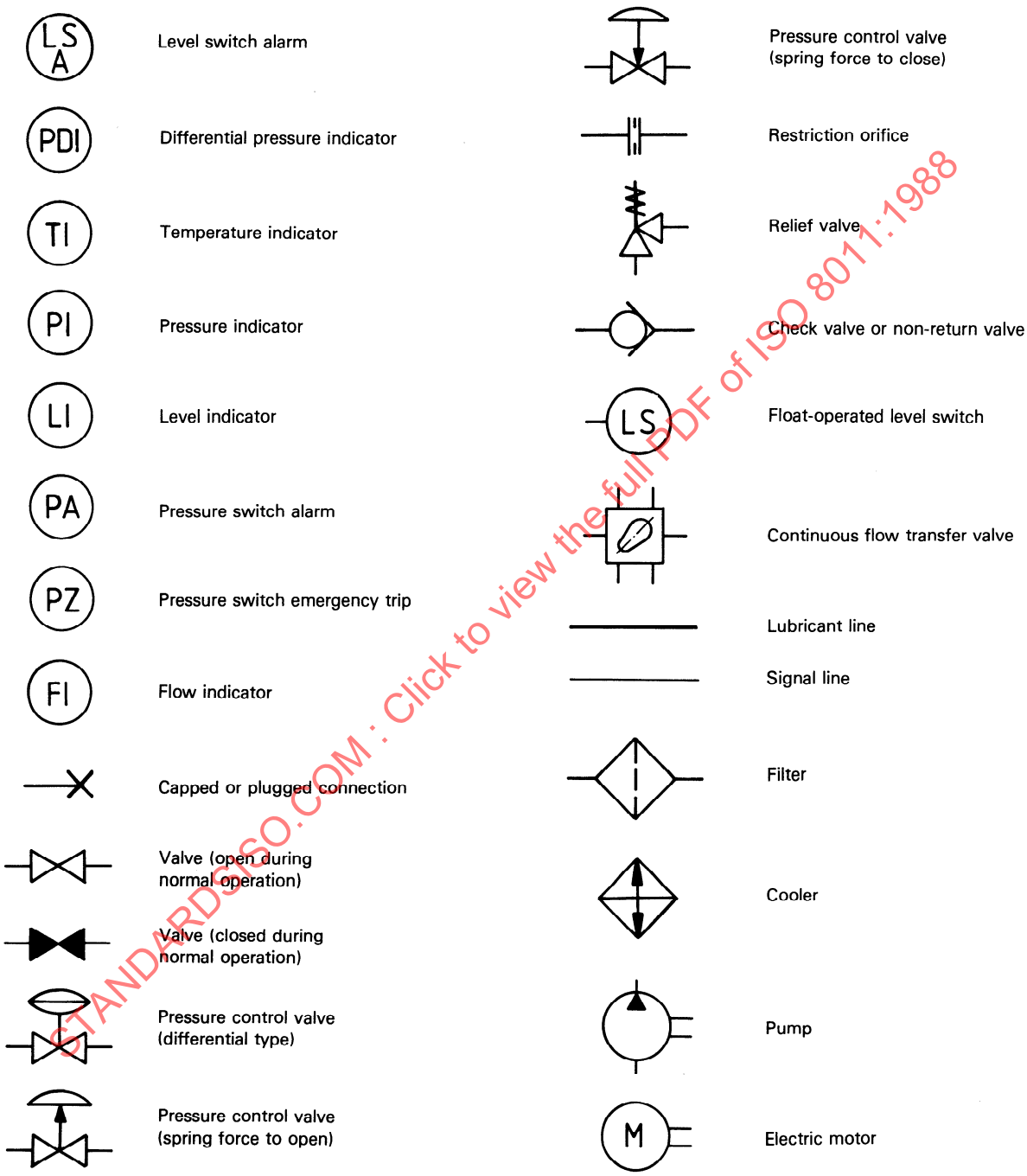
Table 4 — Summary of figures 6 to 24

Subject	Figure	Pump drive		Accumulator [1]	Emergency overhead tank [1]
		Main	Auxiliary		
Lubrication system only	6	Shaft	Electric motor	(x)	(x)
	7	Shaft	Steam turbine	x	(x)
	8	Steam turbine/ electric motor	Electric motor	(x)	(x)
	9	Electric motor	Steam turbine	x	(x)
Combined lubrication and seal liquid system with differential pressure control	10	Shaft	Electric motor	(x)	(x)
	11	Shaft	Steam turbine	x	(x)
	12	Steam turbine/ electric motor	Electric motor	(x)	(x)
	13	Electric motor	Steam turbine	x	(x)
Combined lubrication and seal liquid system with level control	14	Shaft	Electric motor	(x)	(x)
	15	Shaft	Steam turbine	x	(x)
	16	Steam turbine/ electric motor	Electric motor	(x)	(x)
	17	Electric motor	Steam turbine	x	(x)
Seal liquid system with differential pressure control	18	Electric motor	Steam turbine	x	(x)
	19	Electric motor/ steam turbine	Electric motor	(x)	(x)
Seal liquid system with level control	20	Electric motor	Steam turbine	o	o
	21	Electric motor/ steam turbine	Electric motor	o	o
Compressor with labyrinth shaft seals	22				
Compressor with liquid seals, separate system	23				
Compressor with liquid seals, combined lubrication and seal liquid system	24				

1) (x), if specified; x, mandatory; o, not required.

Key to figures 6 to 24

The use of symbols in figures 6 to 24 is according to ISO 3511-1, ISO 3511-2, ISO 3511-3 and ISO 1219.



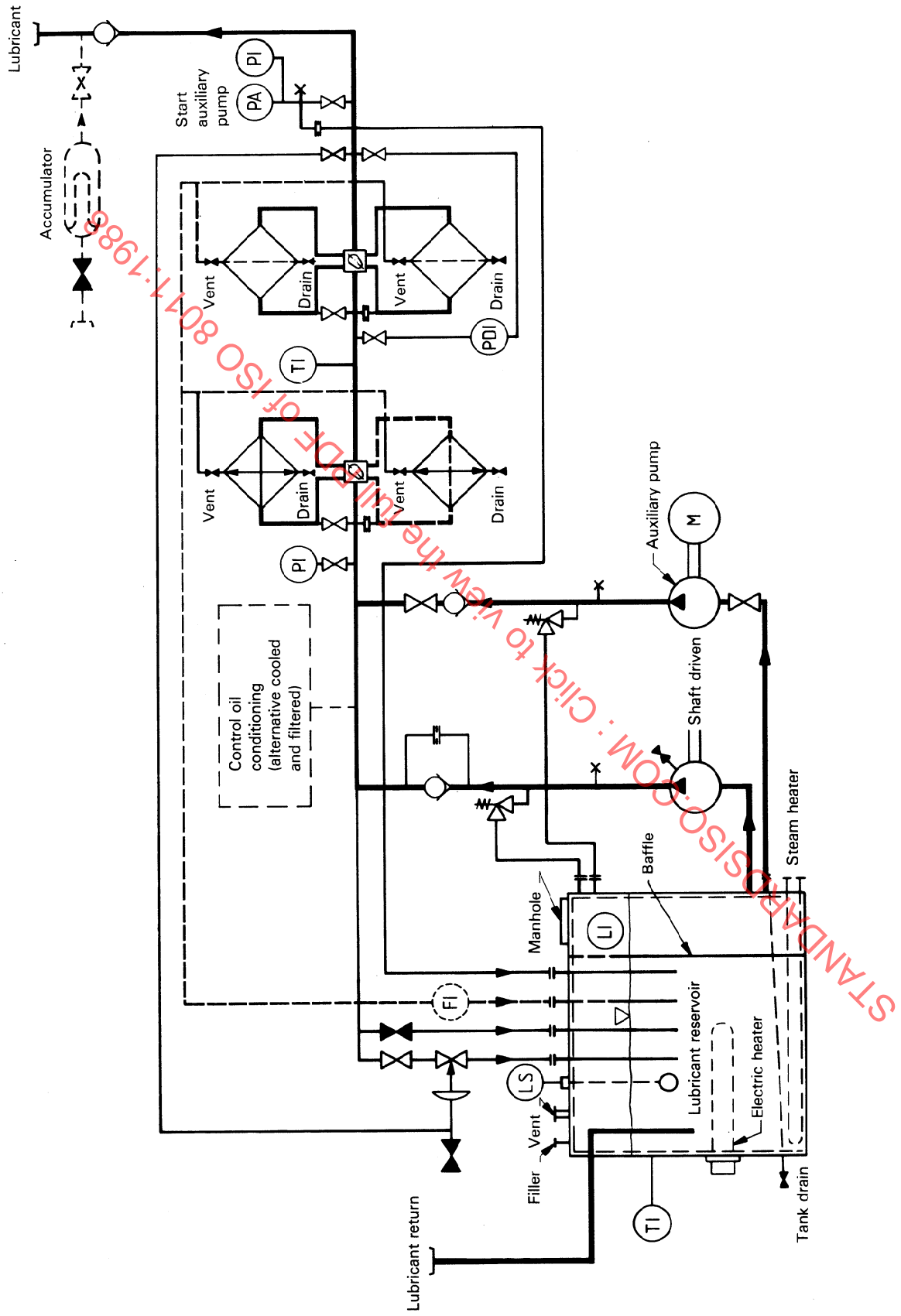


Figure 6 — Piping and instrumentation diagram (lubrication system only; shaft; electric motor)

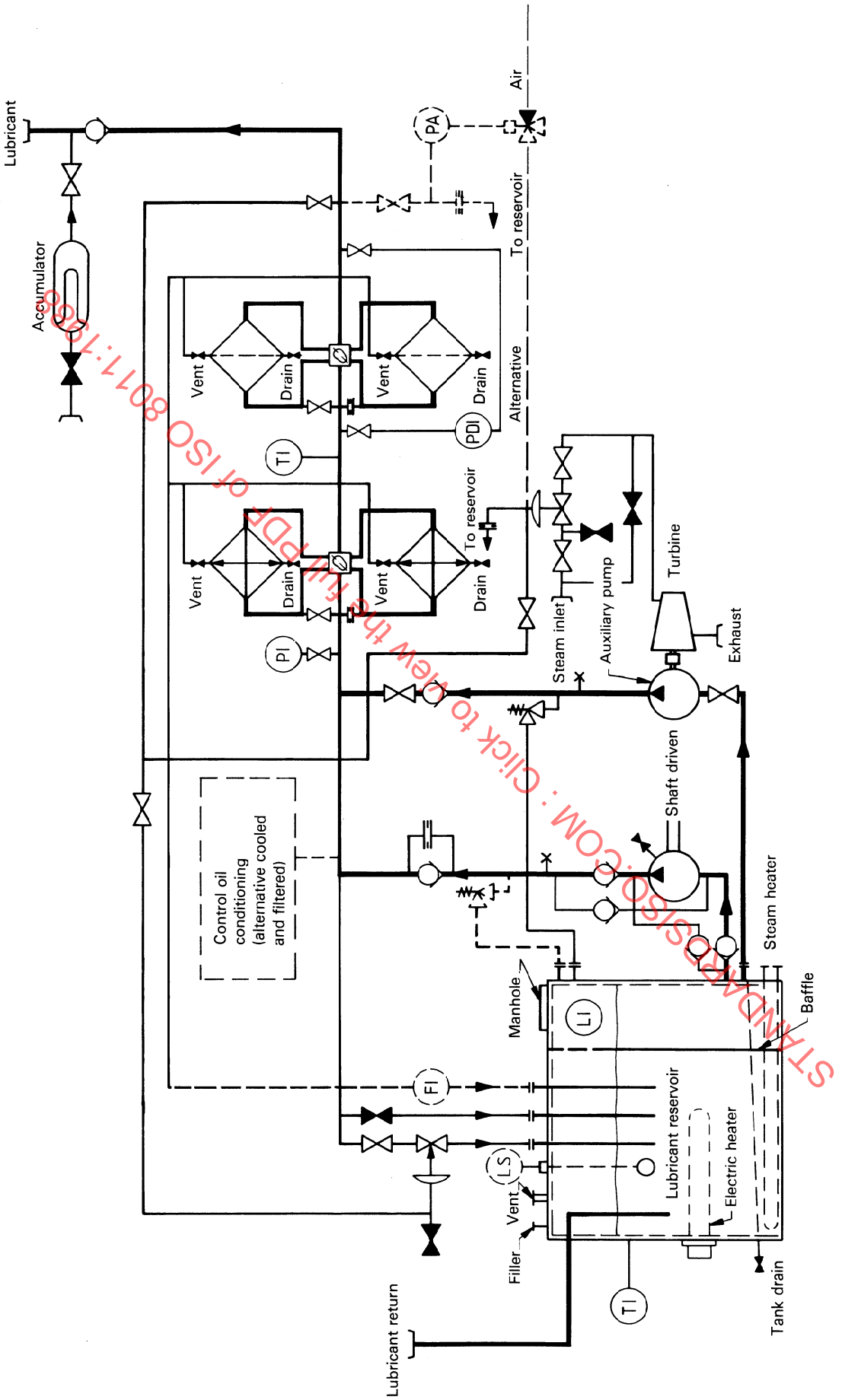


Figure 7 — Piping and instrumentation diagram (lubrication system only; shaft; steam turbine)

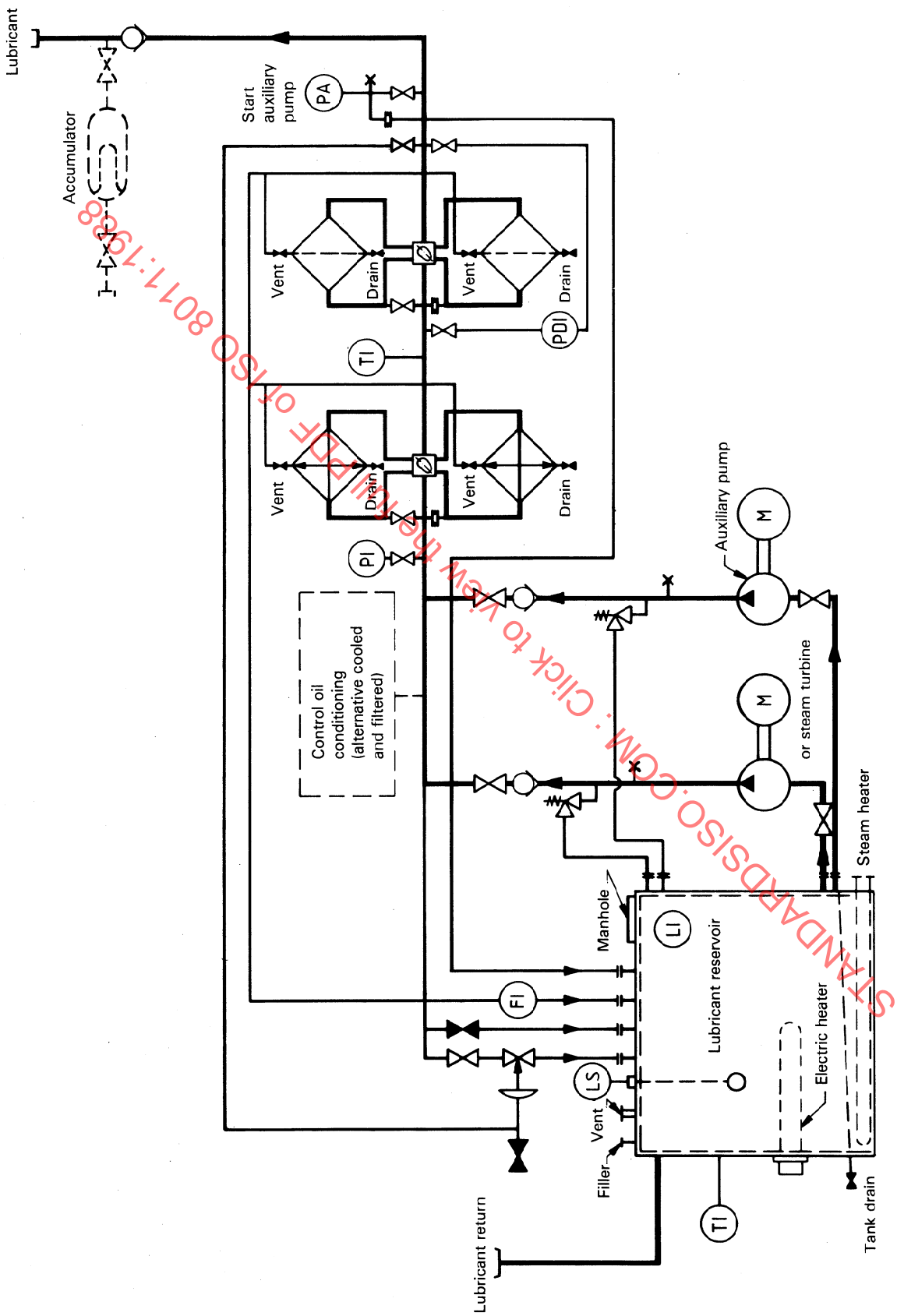


Figure 8 — Piping and instrumentation diagram (lubrication system only; steam turbine/electric motor; electric motor)

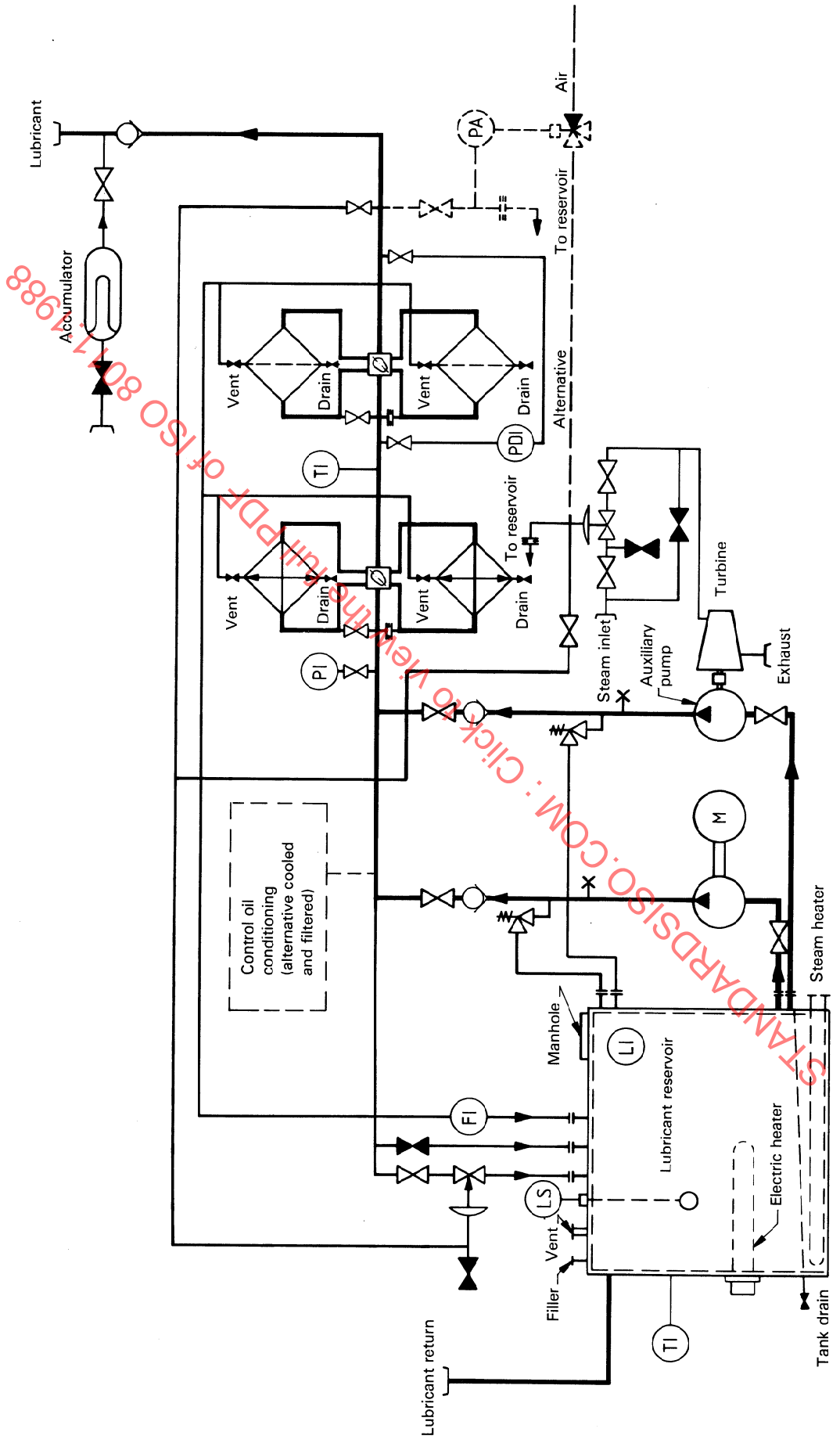


Figure 9 — Piping and instrumentation diagram (lubrication system only; electric motor; steam turbine)

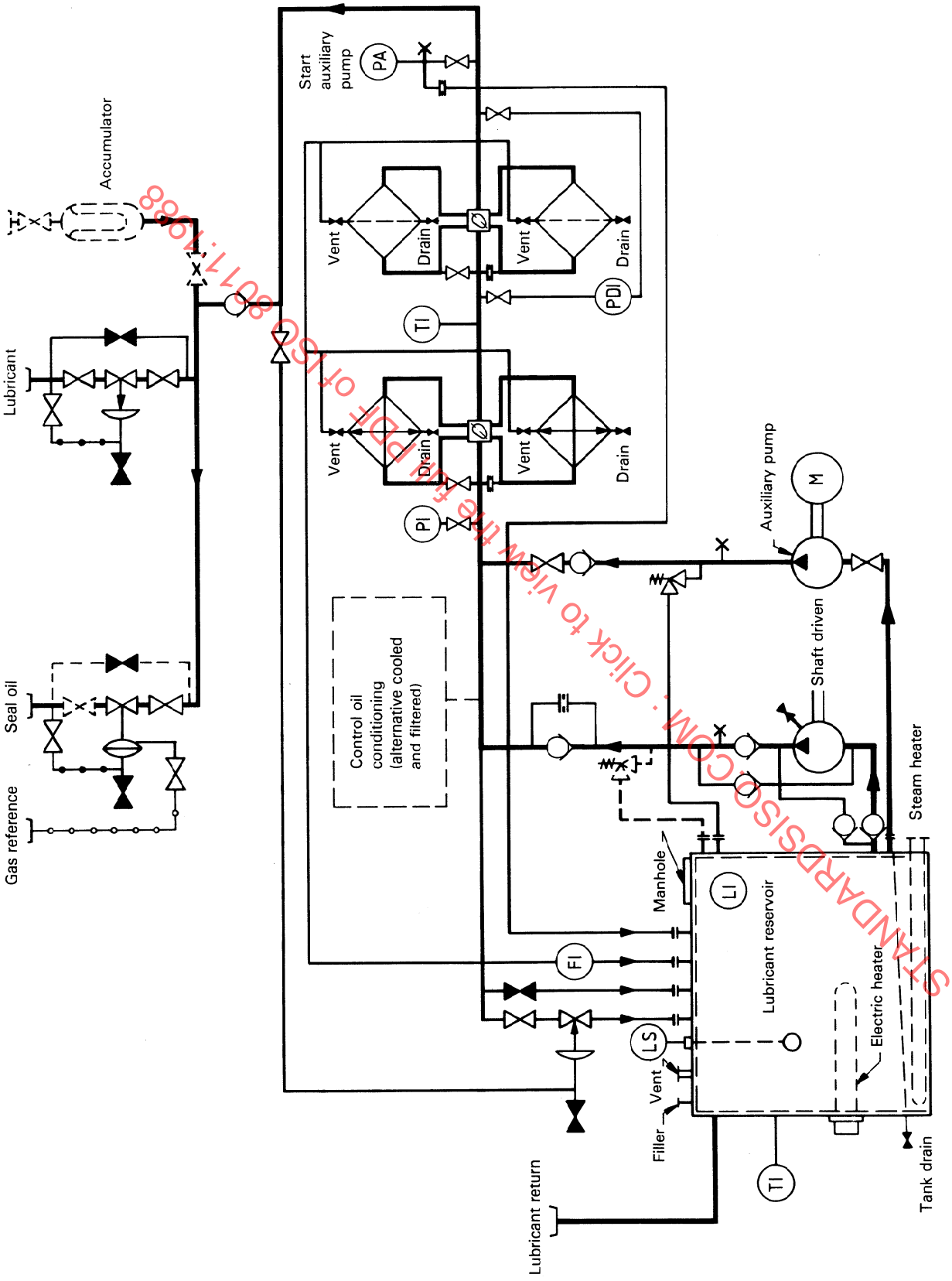


Figure 10 — Piping and instrumentation diagram (combined lubrication and seal liquid system with differential pressure control; shaft; electric motor)

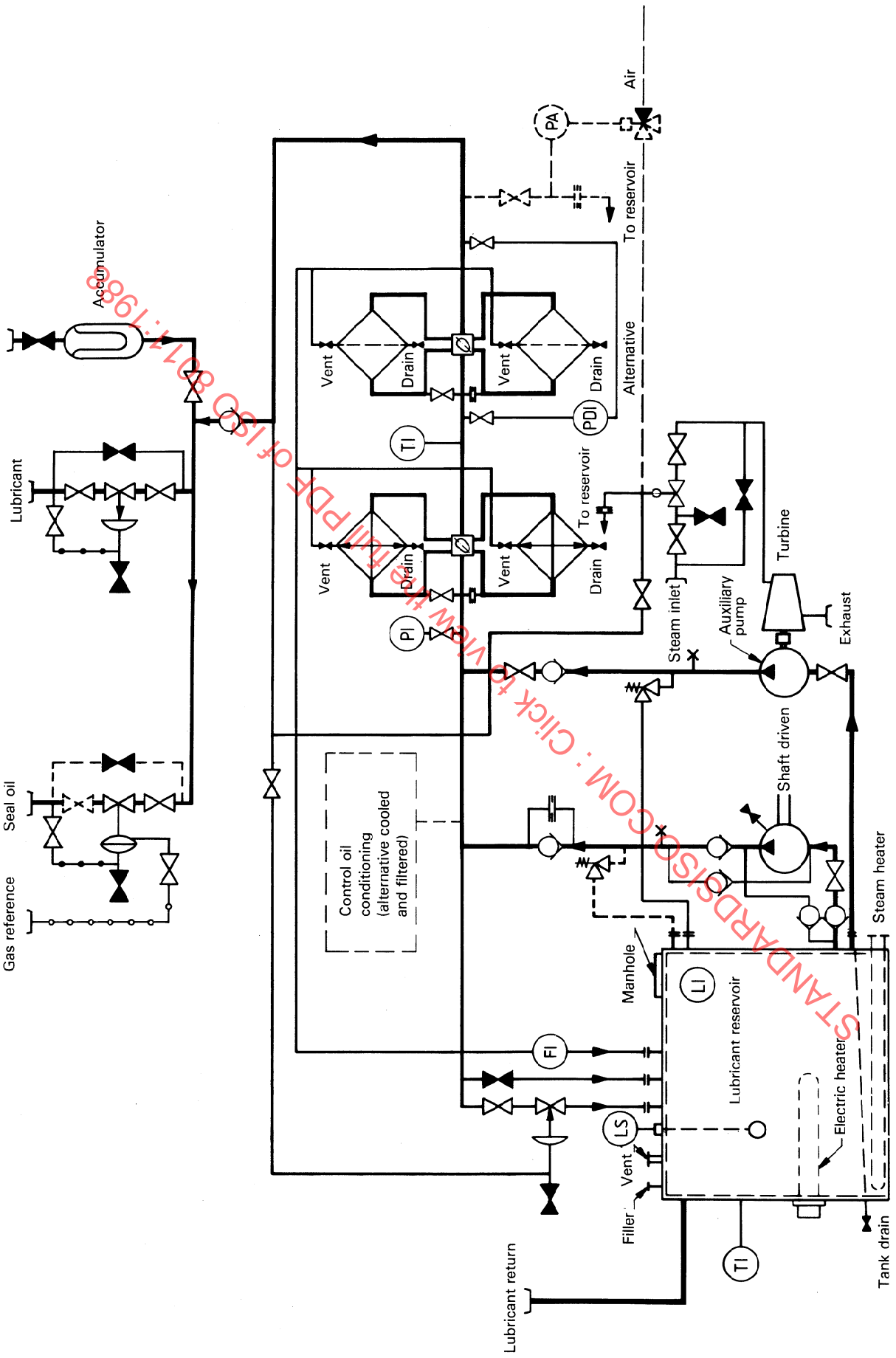


Figure 11 — Piping and instrumentation diagram (combined lubrication and seal liquid system with differential pressure control; shaft; steam turbine)

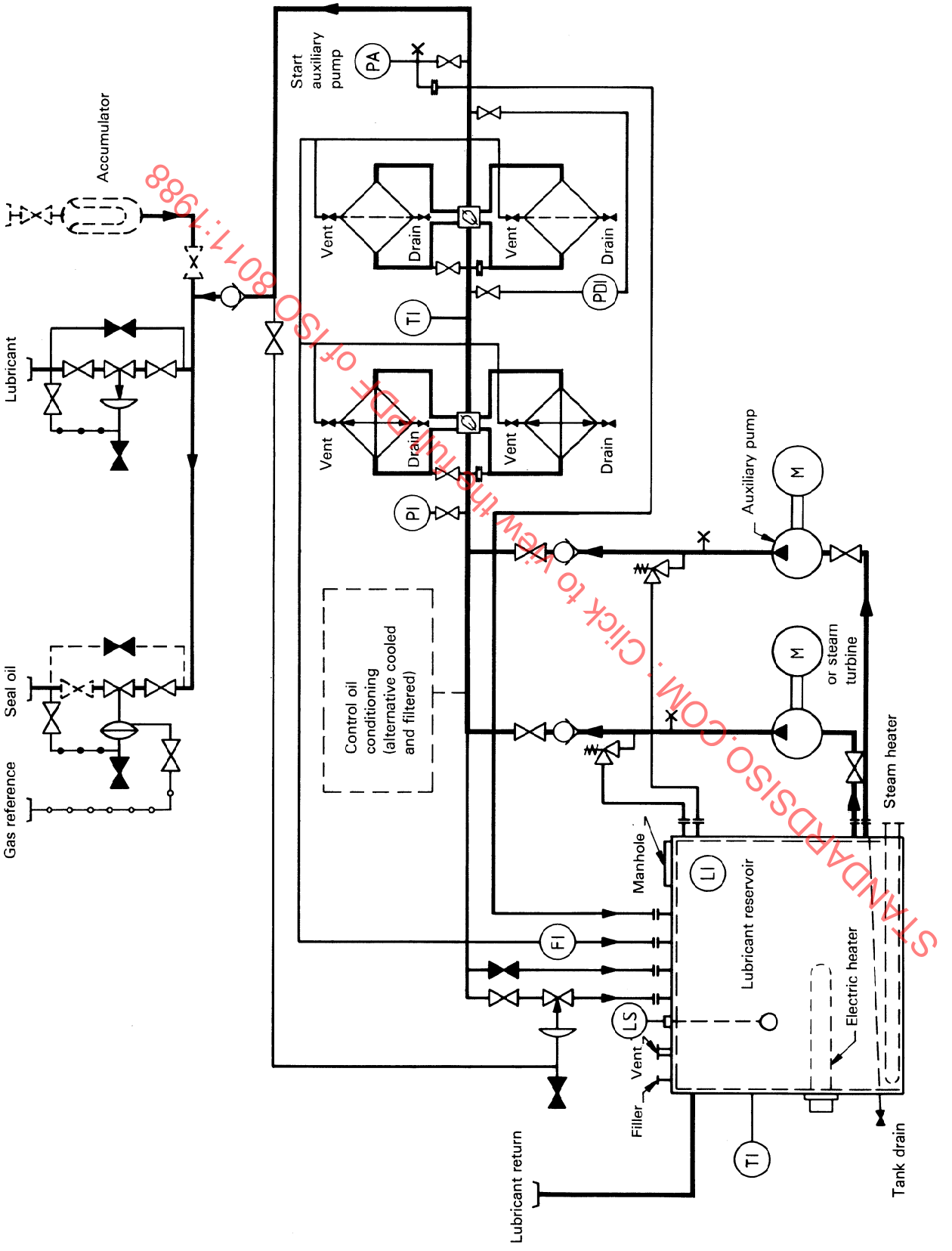


Figure 12 — Piping and instrumentation diagram (combined lubrication and seal liquid system with differential pressure control; steam turbine/electric motor; electric motor)

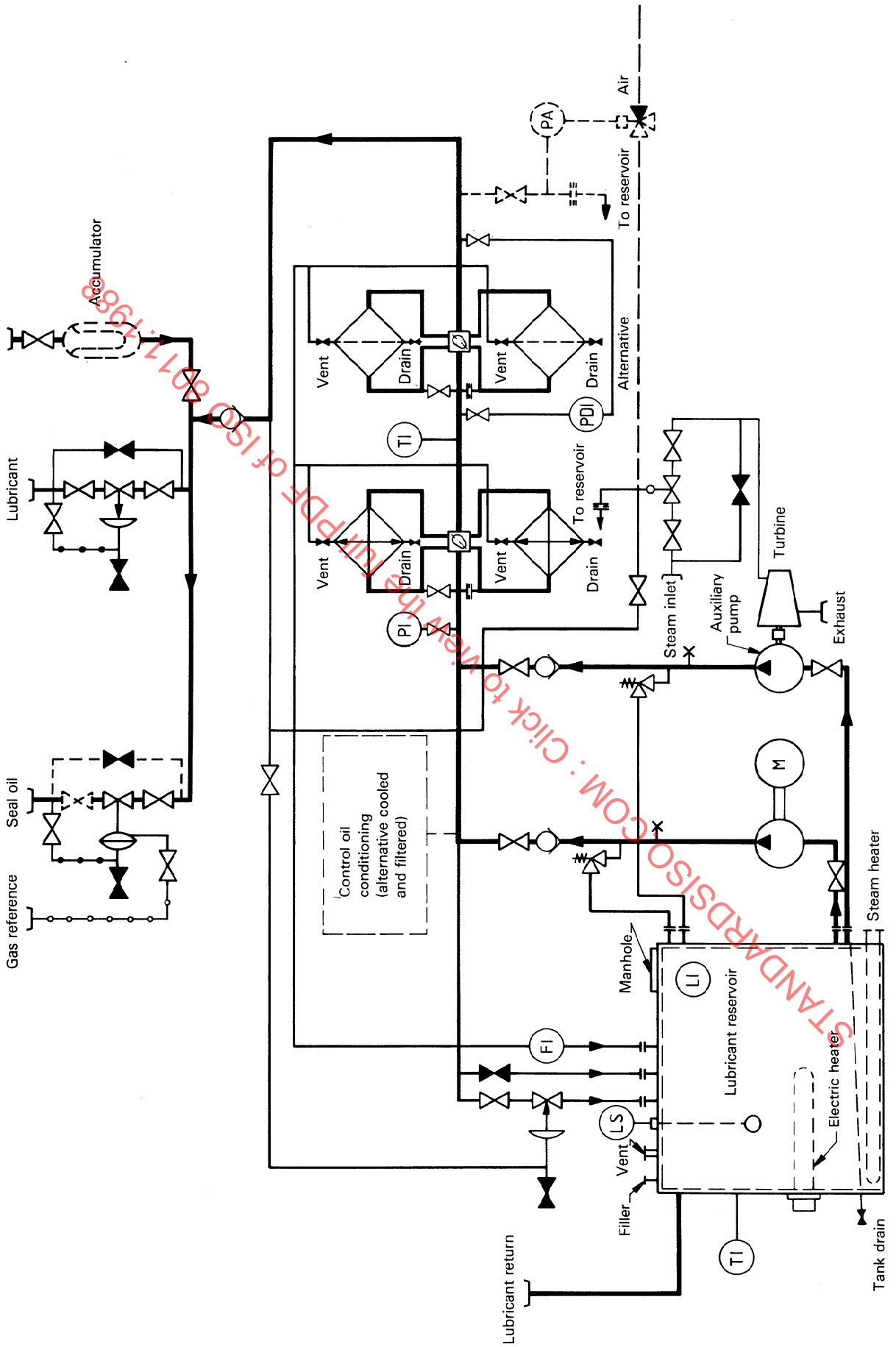


Figure 13 — Piping and instrumentation diagram (combined lubrication and seal liquid system with differential pressure control; electric motor; steam turbine)

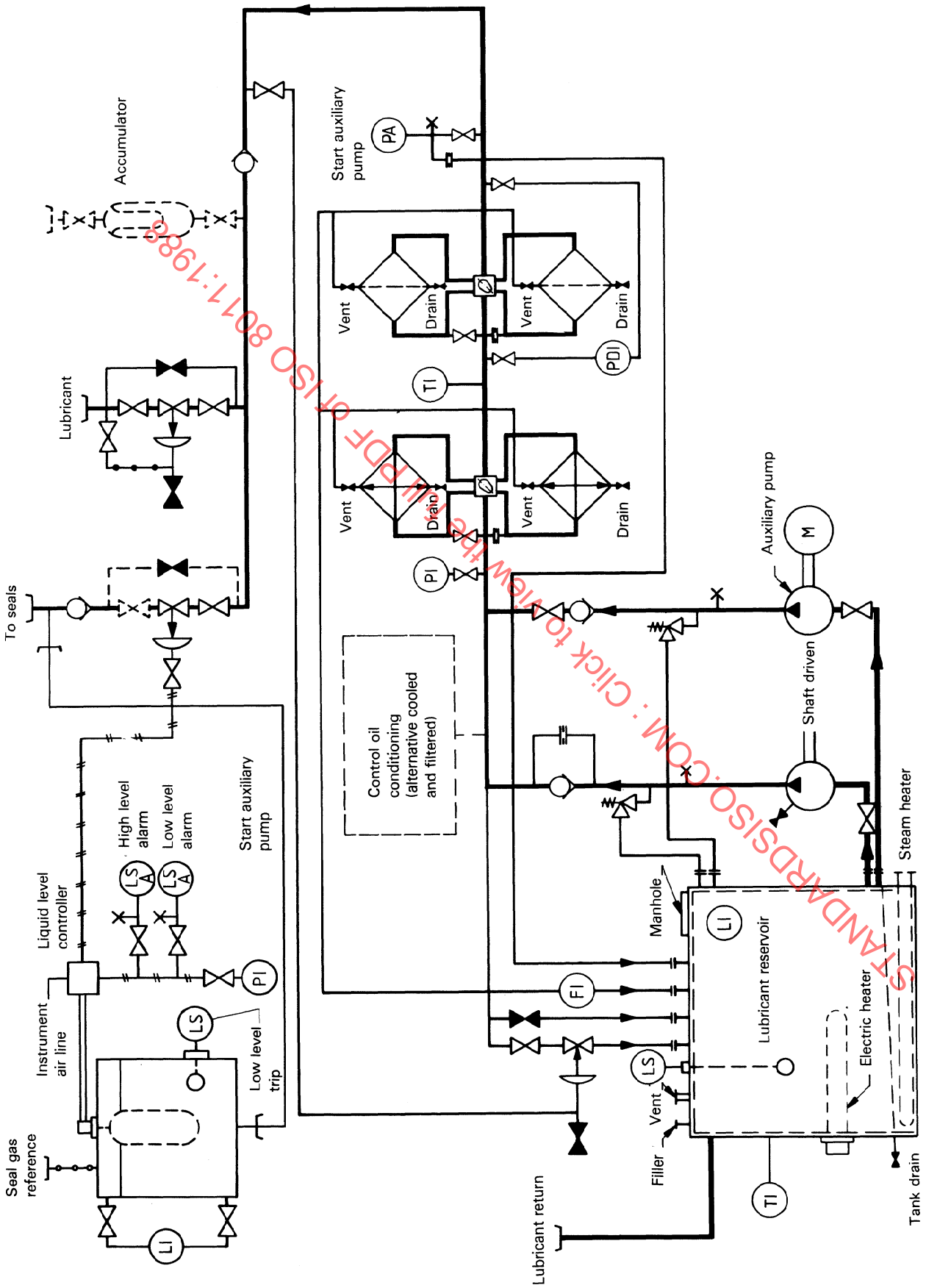


Figure 14 — Piping and instrumentation diagram (combined lubrication and seal liquid system with level control; shaft; electric motor)

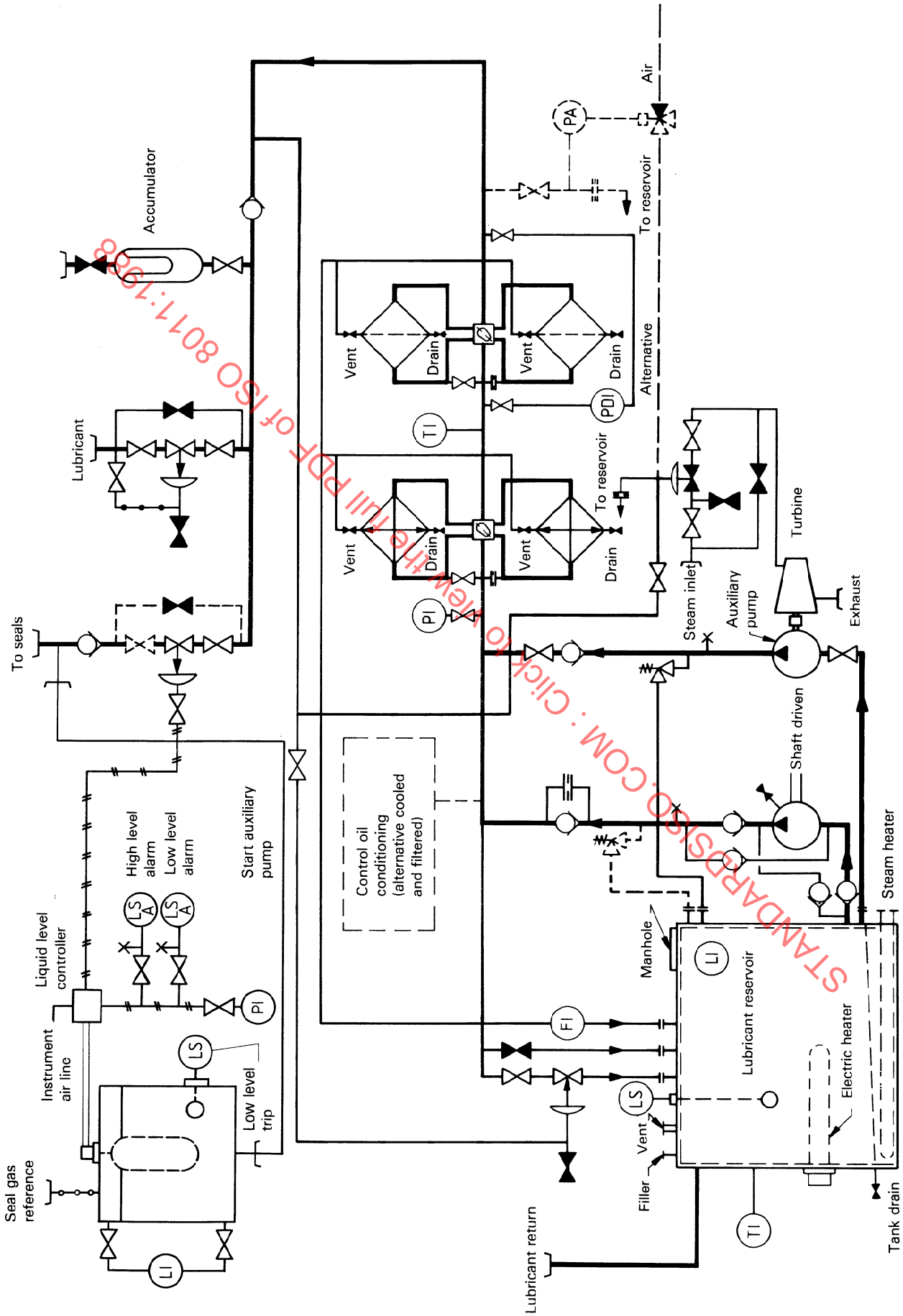


Figure 15 — Piping and instrumentation diagram (combined lubrication and seal liquid system with level control; shaft; steam turbine)

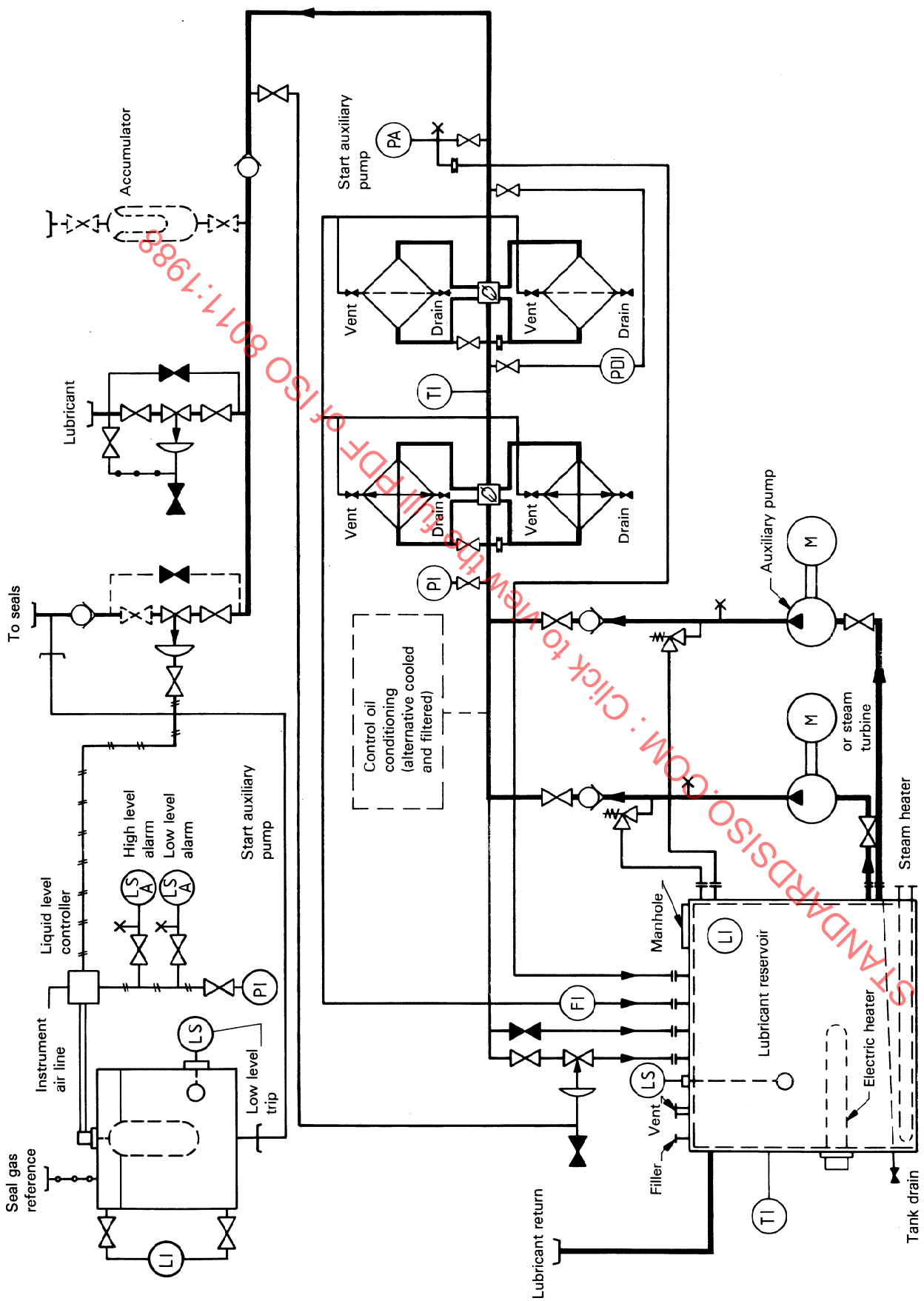


Figure 16 — Piping and instrumentation diagram (combined lubrication and seal liquid system with level control; steam turbine/electric motor; electric motor)

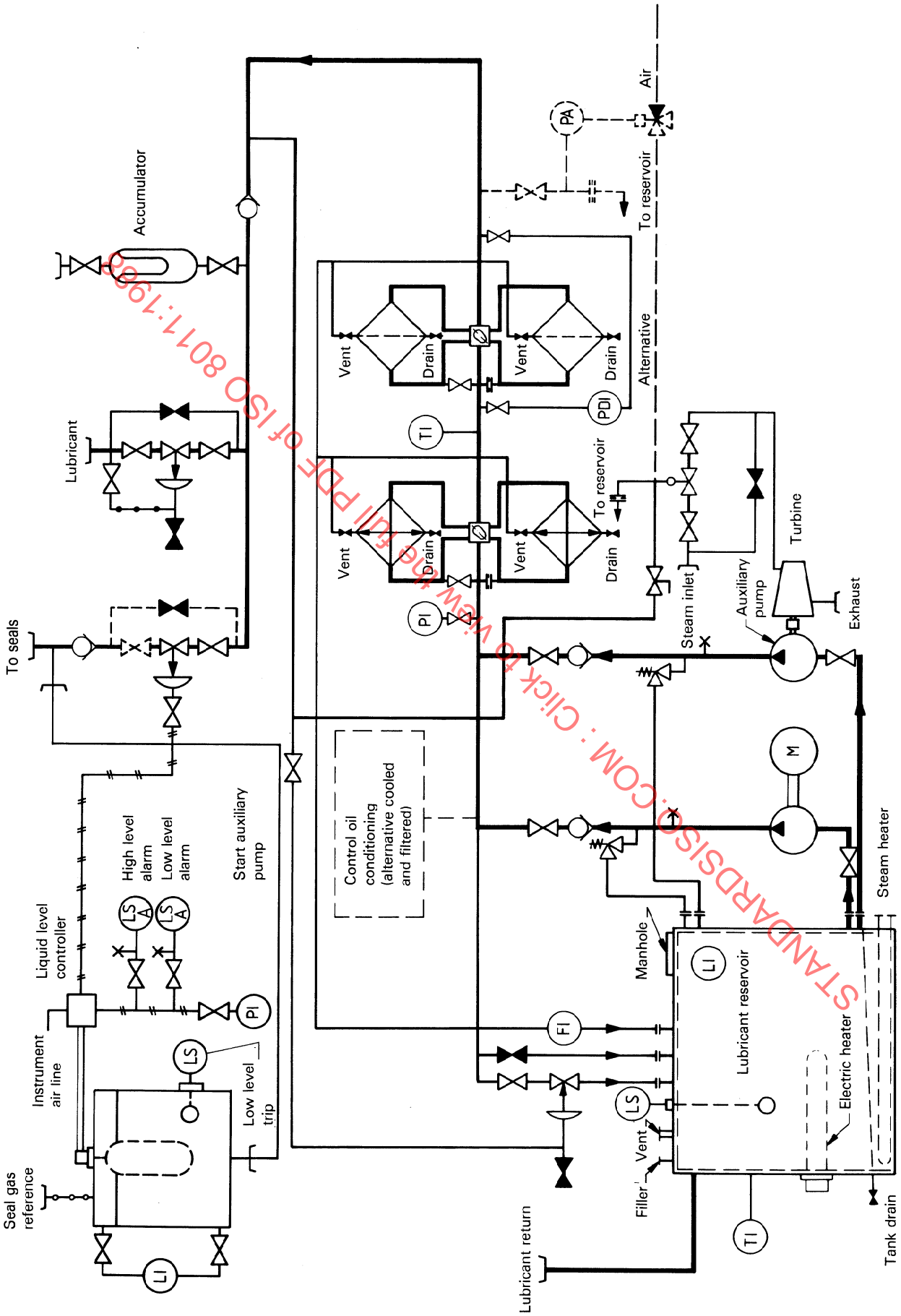


Figure 17 — Piping and instrumentation diagram (combined lubrication and seal liquid system with level control; electric motor; steam turbine)

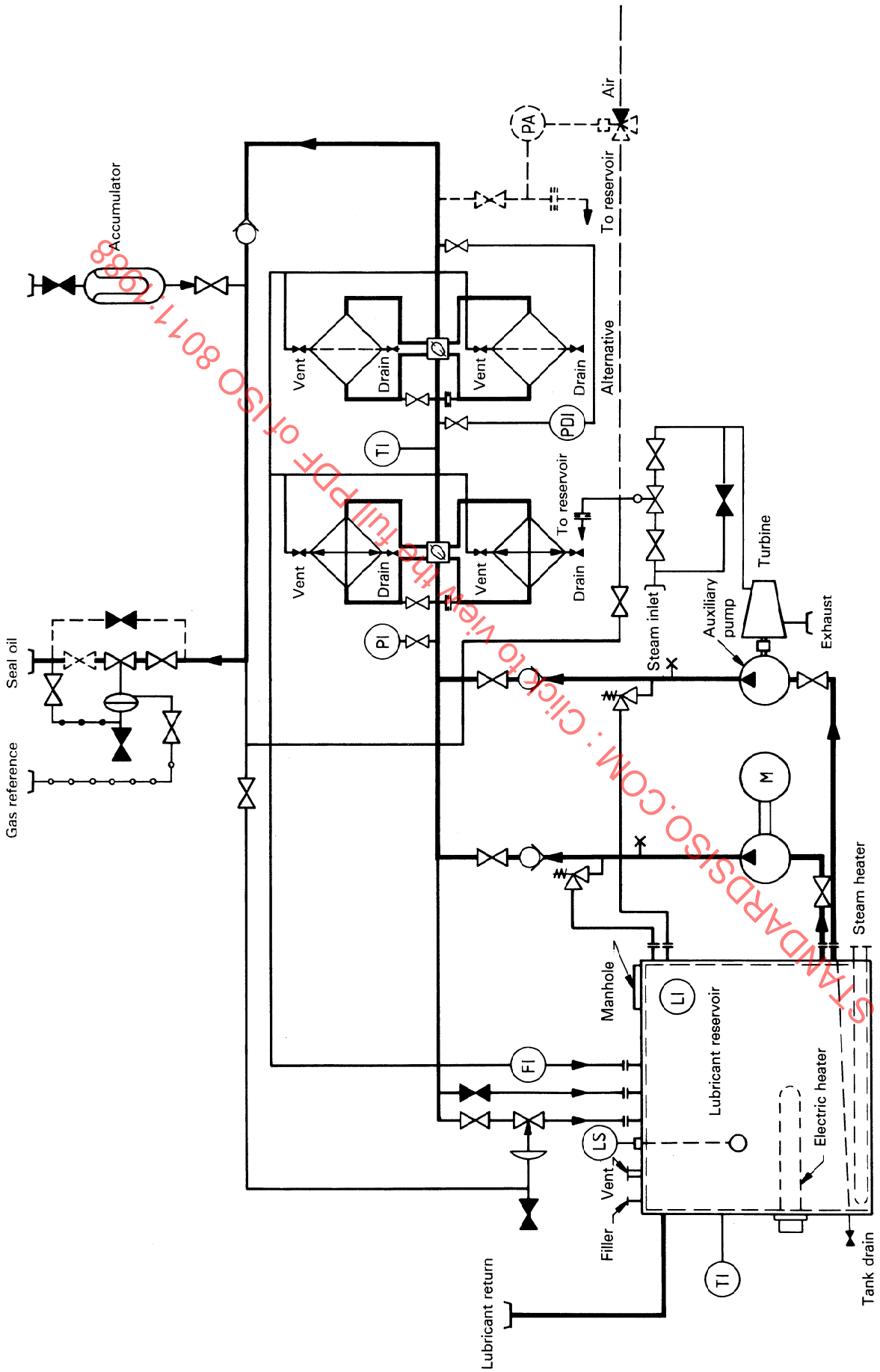


Figure 18 — Piping and instrumentation diagram (seal liquid system with level control; electric motor; steam turbine)

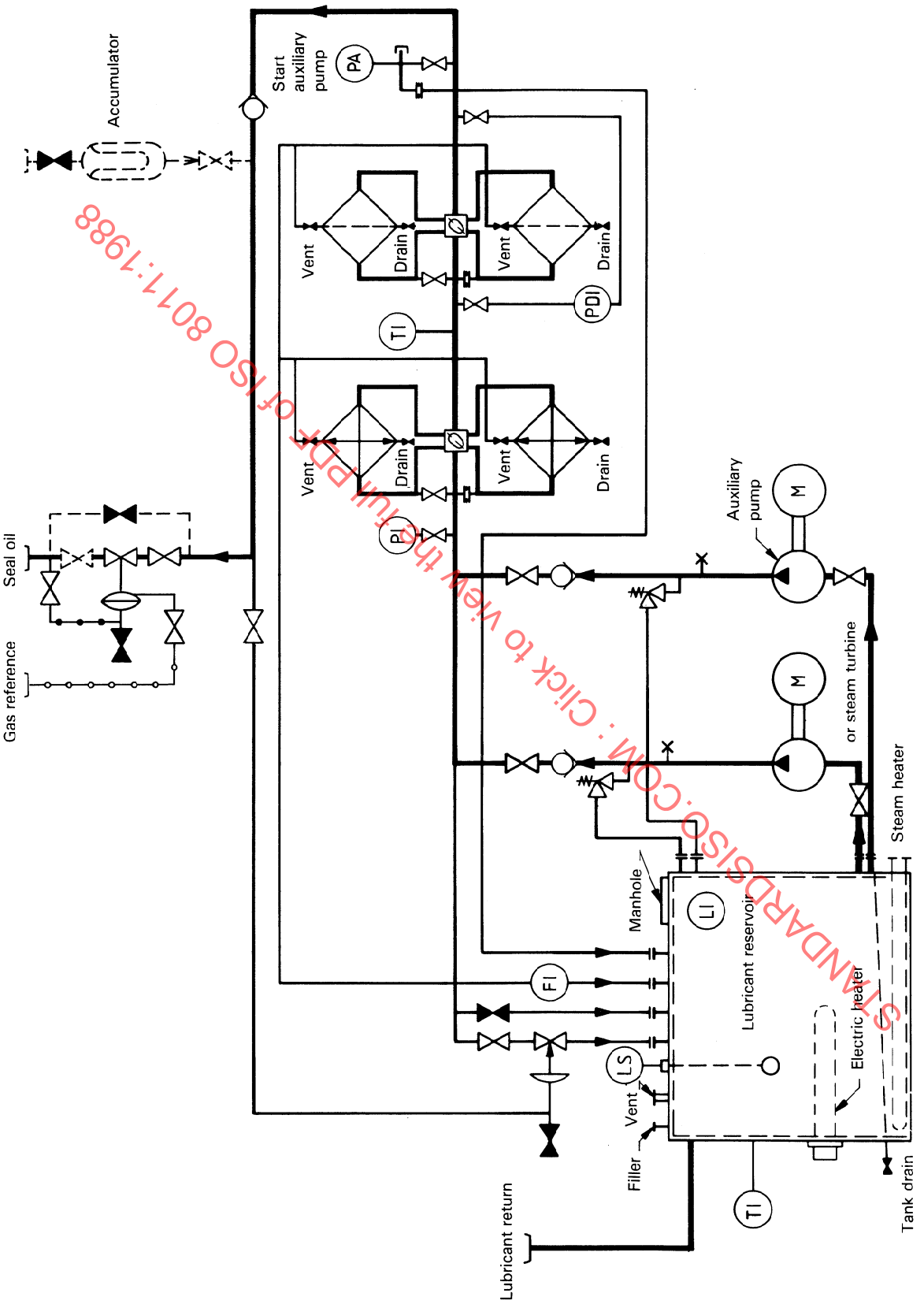


Figure 19 — Piping and instrumentation diagram (seal liquid system with level control; electric motor/steam turbine; electric motor)

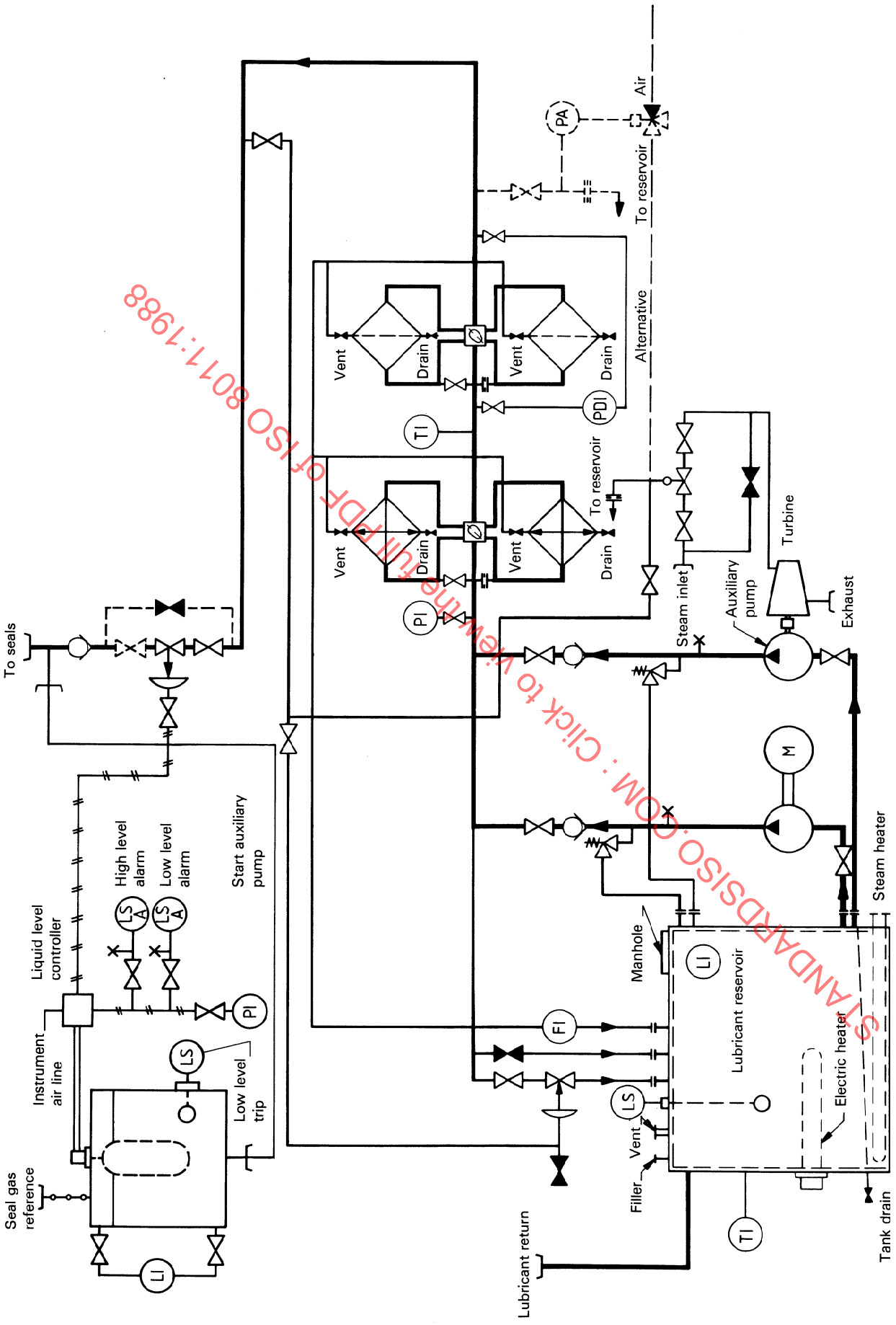


Figure 20 — Piping and instrumentation diagram (seal liquid system with level control; electric motor; steam turbine)

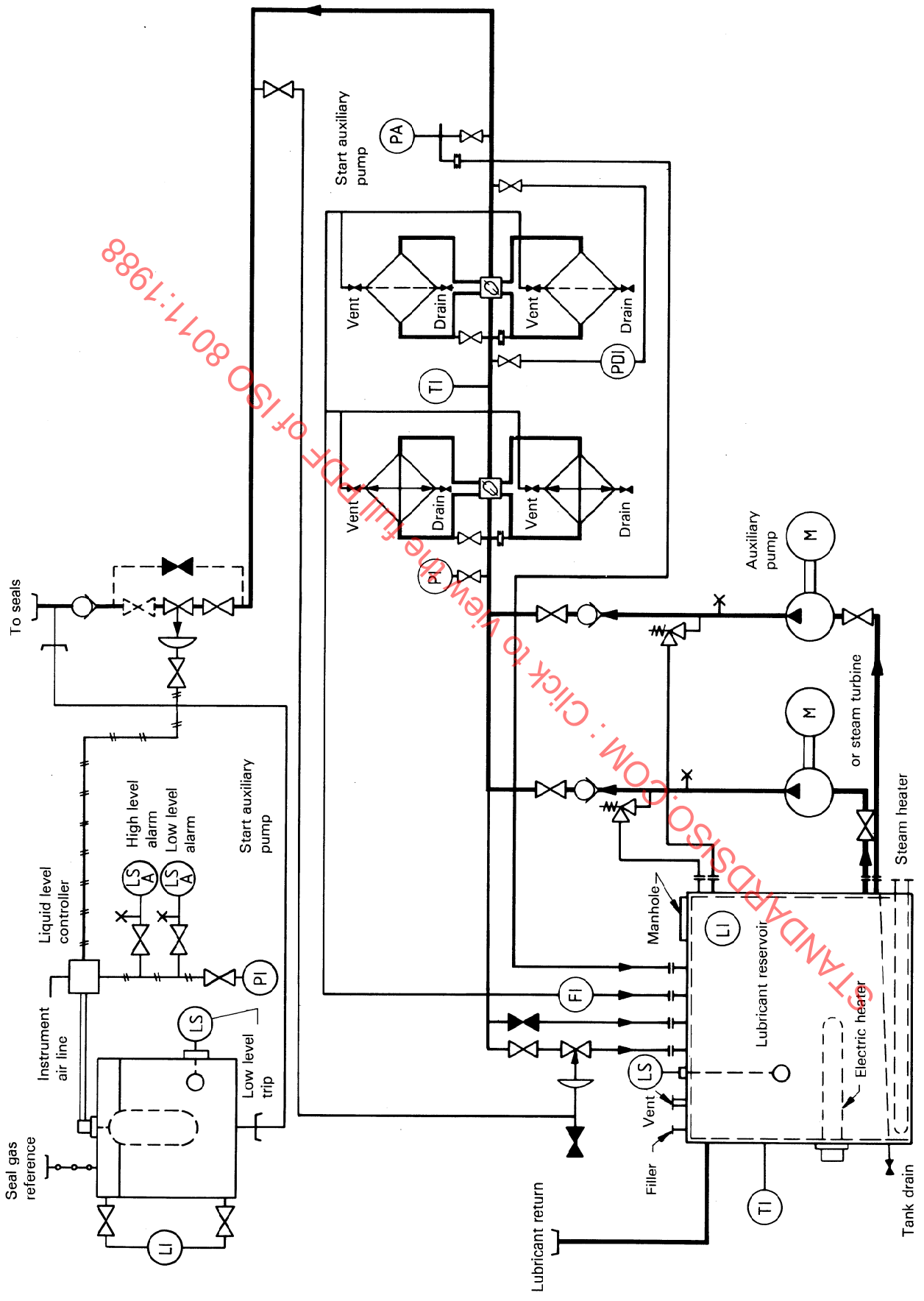


Figure 21 — Piping and instrumentation diagram (seal liquid control system with level control; electric motor/steam turbine; electric motor)

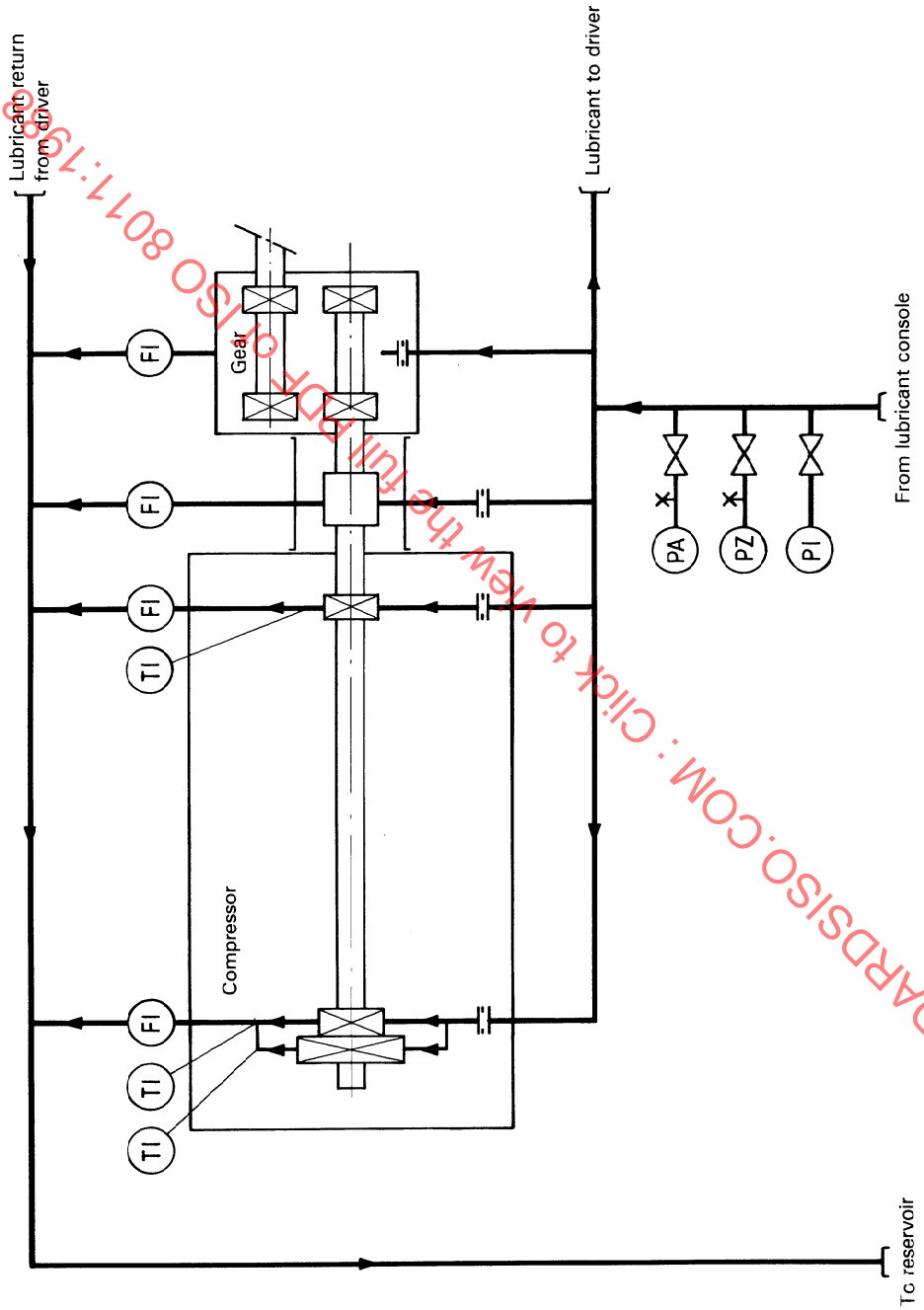


Figure 22 — Piping and instrumentation diagram (compressor with labyrinth shaft seals)

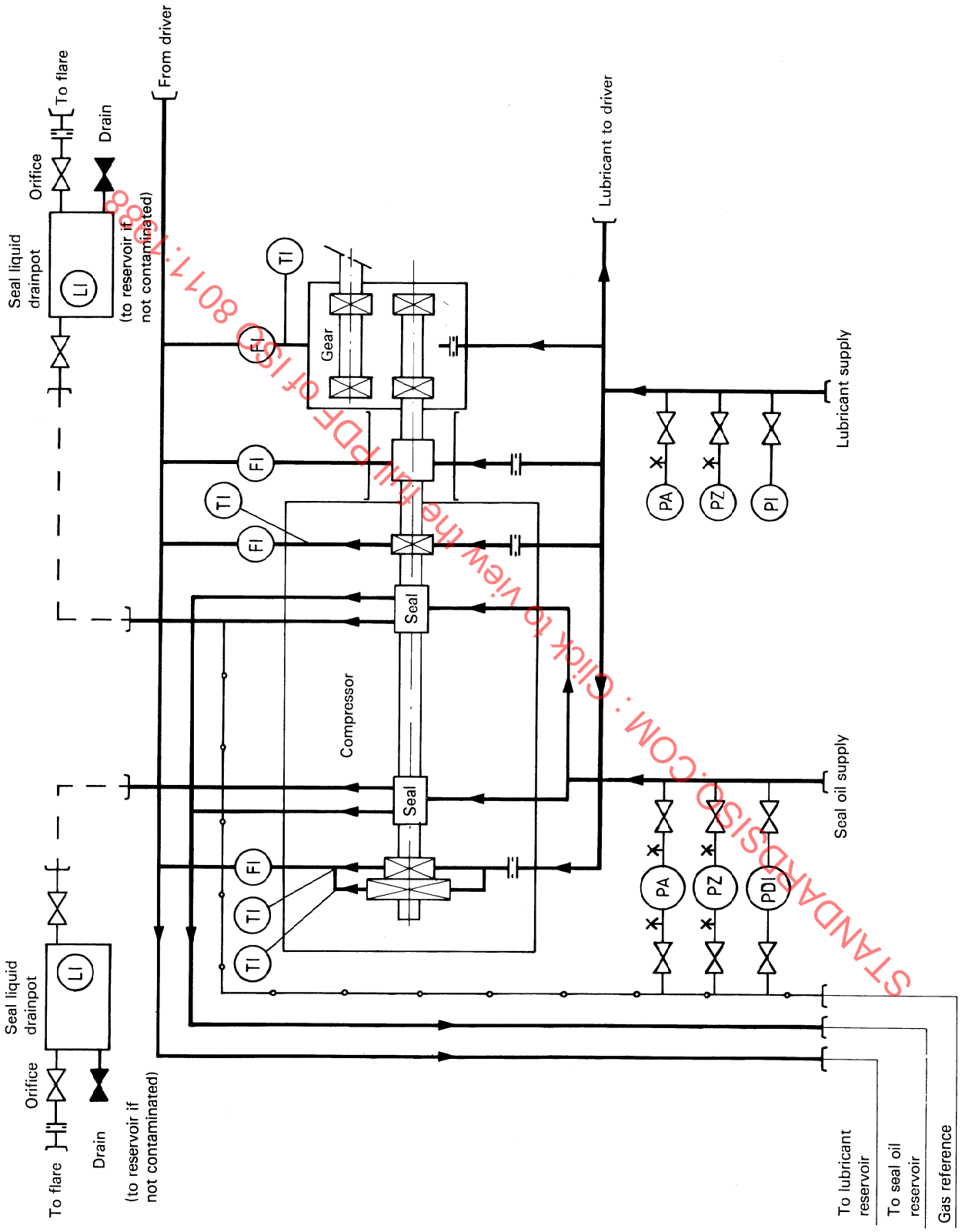


Figure 23 — Piping and instrumentation diagram (compressor with liquid seals, separate system)

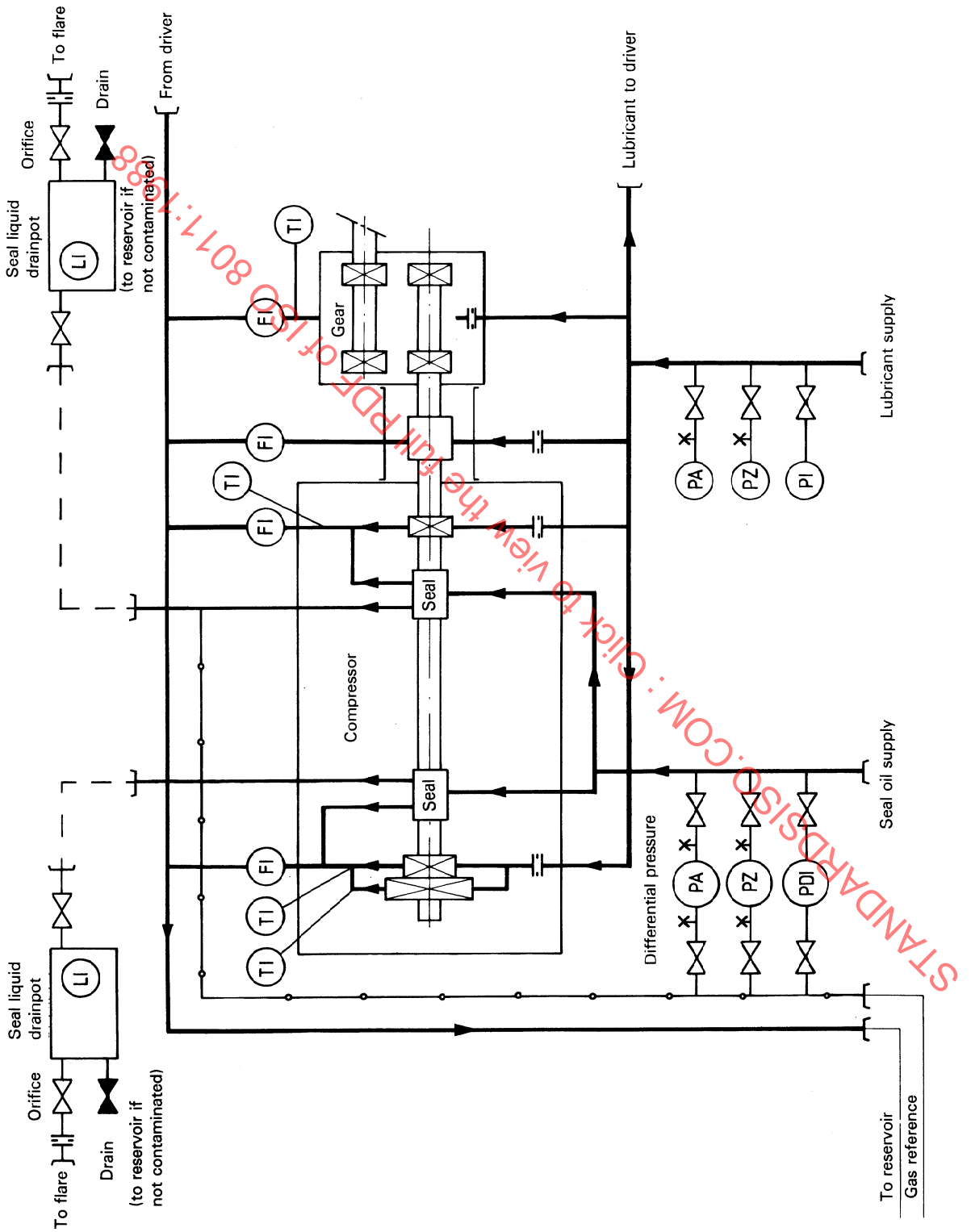


Figure 24 — Piping and instrumentation diagram (compressor with liquid seals, combined lubrication and seal liquid system)

12 Controls and instrumentation

12.1 General

12.1.1 Figure 25 illustrates the definitions and terms relating to the control circuit.

12.1.2 The USER shall specify in data sheet 204 at the time of enquiry any electrical area classification applicable.

12.1.3 If there is a need for increased safety or flexibility of the compressor operation, the USER shall specify at the time of enquiry any additional instrumentation requirements (e.g. two or three selective shut-down operations) in the data sheets.

12.2 Compressor control systems

12.2.1 The USER shall specify at the time of enquiry whether the compressor has to work in parallel or in conjunction with other compressors.

12.2.2 The control system may be pneumatic, hydraulic, electrical, electronic etc., or a combination of these. It may be either manual, or automatic with manual override. The USER shall specify in his enquiry the controlled condition with its possible variation as a function of time, the adjustment range of the command variable, and the preferred type of control system, e.g. manual, or automatic with or without remote setting. The SUPPLIER shall furnish the complete control system from the measuring device with computing element to, and including, the regulating unit with motive element, unless otherwise specified.

12.2.3 For a turbine variable-speed drive, the compressor control system shall furnish the set point signal for the turbine speed governor system. The corresponding set point characteristics shall be furnished by the SUPPLIER with the control system flow sheet.

12.2.4 The SUPPLIER shall be given the opportunity to comment on the location of the inlet throttle valve, the non-return valves and the process flow measuring device.

12.2.5 Controls shall be designed so that the full range of the control signal corresponds to the required operating range of the compressor. The maximum control signal shall correspond to the maximum compressor flow rate or, in the case of a variable-speed drive, to the maximum continuous speed of the compressor, unless otherwise specified. The control system shall be designed to permit manual control with indication of the command variable. Smooth transfer from one mode to the other mode of control shall be possible during normal operation of the compressor.

12.2.6 The approximate piping and apparatus volume between the compressor and the next regulating circuit shall be indicated by the USER.

12.3 Antisurge control

12.3.1 The blow-off limit defines the minimum compressor flow permitted by the antisurge control, which shall be at least 5 % greater than the surge flow.

12.3.2 The antisurge control protects the compressor from surging by means of a blow-off or recirculation valve. The SUPPLIER shall specify the most suitable characteristics of the blow-off limit for the specified operating points.

12.3.3 The SUPPLIER and the USER shall agree about the supply of the flow measuring device.

12.3.4 The blow-off or recycle valve shall be supplied by the SUPPLIER unless otherwise specified in data sheet 702A.

The SUPPLIER shall comment on the details of the proposed installation of the blow-off or recycle valve on associated piping.

12.3.5 The antisurge control shall be automatic and shall be equipped with a quick opening device which shall be actuated by any trip. This device may be omitted by agreement between the SUPPLIER and the USER. A manual control facility shall exist. It shall be impossible to override the automatic antisurge controller when operating the antisurge valve manually.

12.3.6 The USER shall indicate to the SUPPLIER all possible modes of operation that may adversely affect the functioning of the antisurge control.

12.3.7 The USER shall specify in the enquiry whether remote monitoring of the measured signal of the controlled condition is required. Remote monitoring equipment shall be supplied by the USER.

12.4 Instrument panel

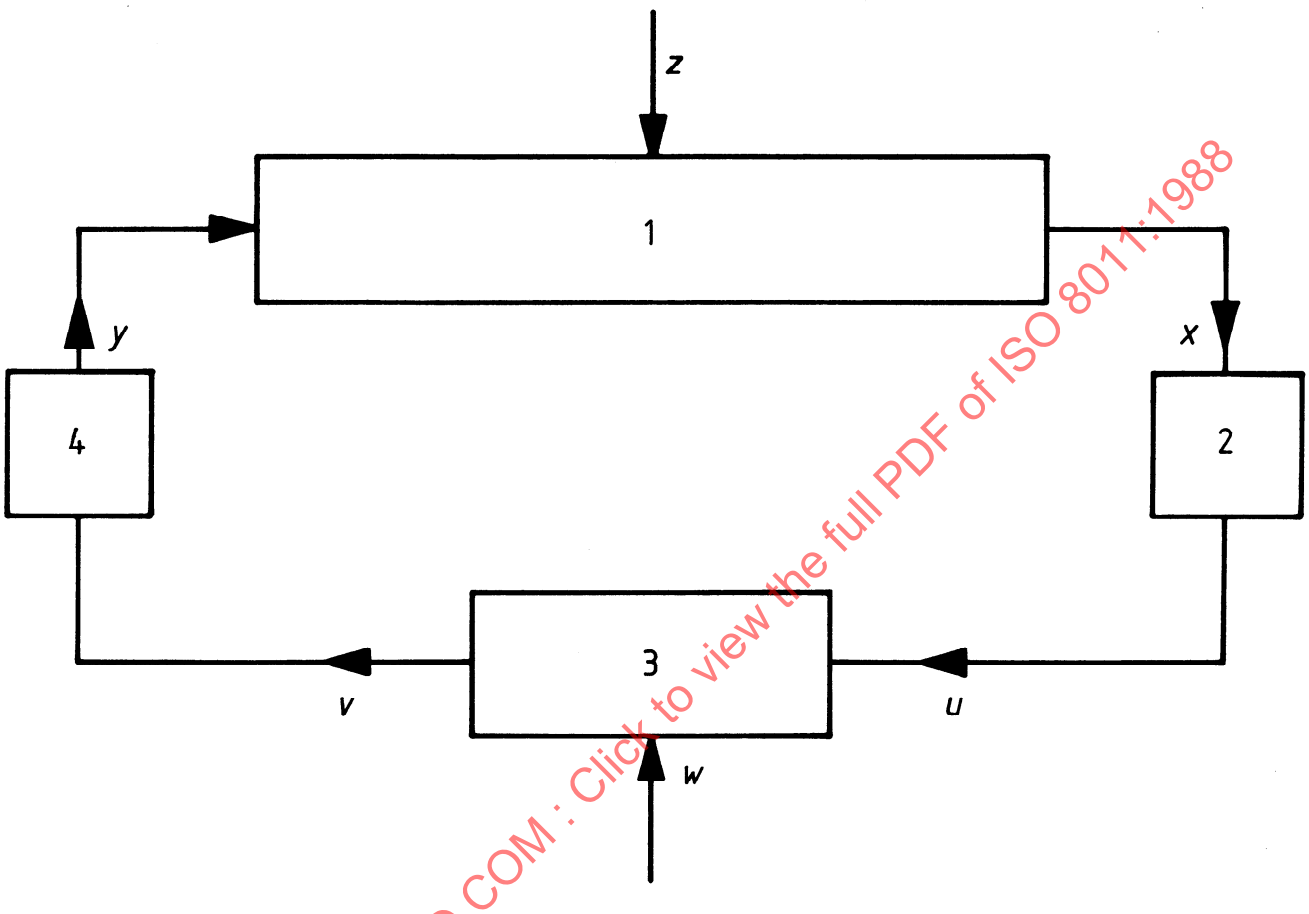
12.4.1 If specified, an instrument panel shall be provided by the SUPPLIER in accordance with the USER's requirements.

The instruments on the panel shall be clearly visible to the operator from the control point. Panels shall be mounted in such a manner that vibrations harmful to the panel equipment are avoided. All instruments and functions shall be labelled.

12.4.2 The USER shall specify in his enquiry whether the SUPPLIER has to include any electrical equipment, such as relays for alarm control and interlock, and wiring to a terminal box, in the supply of the panel.

12.4.3 The USER shall state if the electrical components are to be explosion proof and, if so, the standard with which they shall comply.

The USER shall indicate whether the panel may be pressurized or purged such that the electrical equipment may be of normal design.



1 Controlled member of a plant
2 Measuring device with computing elements
3 Automatic controller
4 Regulating unit with motive element
u Measured signal
v Control signal
w Command variable (set point)
x Controlled condition
y Manipulated variable
z Disturbance variable

Figure 25 — Control circuit

12.4.4 To enable proper layout of the panel, the USER shall specify how and from where the compressor and driver will be operated, and whether the panel is to be of a weather-proof design.

12.4.5 The USER shall indicate any instrumentation of his own which has to be incorporated in a panel supplied by the SUPPLIER.

12.5 Instruments

12.5.1 The USER shall state at the time of enquiry any mandatory requirements with regard to the manufacturers of instruments.

12.5.2 Unless otherwise specified, the instrument connections shall be G 1/4 as a minimum with flat joints.

12.5.3 Pressure indicators shall be suitable for the gas handled and shall have dials of diameter not less than 100 mm unless space is limited. Pressure gauges shall be equipped with a bursting disc and safety glass.

12.5.4 Stick- or dial-type temperature indicators shall be used. Circular dials shall be of diameter not less than 100 mm unless space is limited. Thermowells shall be provided if required for instrument replacement during normal operation of the compressor. In process gas lines, all temperature sensing devices shall be installed in thermowells.

12.5.5 Pressure and temperature switches shall have single-pole double-throw contacts and shall be mounted in such a manner that vibration, harmful to the instruments, is avoided. When specified, switches shall be arranged to permit testing of the control circuit during operation.

12.5.6 Unless otherwise specified by the USER, electrical equipment shall be normally energized during operation.

12.5.7 Unless otherwise specified, remotely reading temperature instruments shall be of the thermocouple type.

12.6 Normal instrumentation

The minimum and recommended requirements for the normal instrumentation are summarized in table 5.

13 Data sheets

The data sheets given in annex B are an integral part of this International Standard and shall form part of

a) the enquiry from the USER;

b) the proposal from the SUPPLIER;

c) the contract.

The space in the data sheets for page . . . of . . . is intended to allow a set of sheets for a given data sheet number to be numbered in series so that any one data sheet may be incorporated more than once if there is insufficient space on a single sheet.

Data sheet number 102A, Table of contents, has a column down the right-hand side where the number of pages of each data sheet which has been included in any given project shall be incorporated.

Items which it is considered must be completed by the USER at the enquiry stage are shown in bold-face type.

Table 5 — Normal instrumentation requirements

Function	Indicator	Alarm [1]	Trip [1]
Gas system			
Inlet pressure of each process stage	(●)	—	—
Discharge pressure of each process stage	●	—	—
Inlet temperature of each process stage	●	—	—
Temperature at each casing outlet	●	(H)	—
Temperature after each cooler	●	(H)	—
Level in liquid separators	(●)	(H)	—
Cooling water system			
Common inlet pressure	●	—	—
Common inlet temperature	●	—	—
Cooler outlet temperatures	●	—	—
Flow	(●)	(L)	—
Lubricating oil system			
Main tank level	●	L	—
Temperature at cooler outlet	●	(H)	—
Filter differential pressure	●	(H)	—
Lubricating oil pressure upstream of cooler	●	—	—
Lubricating oil pressure upstream of bearing orifice	●	L	L
Control oil pressure	●	—	—
Temperature of each compressor journal bearing	●	(H)	—
Temperature of each compressor thrust bearing	●	(H)	—
Temperature of gear drain	●	(H)	—
Sight glasses in oil return lines	●	—	—
Seal liquid system			
Main tank level [2]	●	L	—
Temperature at cooler outlet	●	(H)	—
Filter differential pressure	●	(H)	—
Elevated tank level	●	H, L	L
Pressure differential	●	L	L
Drainpot level	●	—	—
Seal gas system			
Supply pressure	●	L	—
Supply temperature	(●)	—	—
Differential pressure between supply and extraction	●	(L)	—
Shaft position and vibration			
Axial position or axial thrust	●	H	(H)
Radial vibration of shaft or bearing	(●)	H	(H)
Miscellaneous			
Speed (in case of variable-speed drive)	●	—	H

●, H, L, minimum requirements; (●), (H), (L), recommended requirements.

1) H, high; L, low.

2) For electric immersion heaters, see 11.2.6.

Annex A

Instructions subject to agreements in the contract

(This annex does not form an integral part of the standard.)

NOTE — The commercial and contractual requirements concerning claims, covering of expenses and guarantee conditions are normally guided by national laws and practices, or by mutual agreement if the parties concerned happen to belong to different nations.

A.1 Inspection and tests

A.1.1 General

A.1.1.1 During normal working hours and with at least 3 working days notice the SUPPLIER shall allow access to his workshop by the USER's representatives during the period when the manufacture or testing of the equipment is in progress. The SUPPLIER, by agreement with the USER, shall be authorized to limit such access for reasons defined by the SUPPLIER.

The SUPPLIER's proposal shall make clear the proportioning of inspection and testing expenses between the SUPPLIER and the USER.

A.1.1.2 Provided that the contract has stipulated it, the SUPPLIER shall give instructions to his suppliers to allow access as defined in A.1.1.1 to their premises for the purpose of inspection or witnessed testing of subcontracted parts.

A.1.1.3 The USER shall indicate to the SUPPLIER at the time of enquiry all tests required and which tests shall be witnessed by his representatives.

The SUPPLIER shall notify the USER or his representative at least 10 working days in advance of the planned test dates, subject to confirmation at least 3 working days prior to the date of such tests.

An agreement between the USER and the SUPPLIER shall be stated in the contract for cases where the USER's representative is unable to attend a test on the date indicated by the SUPPLIER.

A.1.1.4 Test certificates shall be provided by the SUPPLIER for all tests required by the contract.

A.1.1.5 The USER's representative shall countersign all test certificates provided by the SUPPLIER for witnessed tests. Signature shall not relieve the SUPPLIER of his contractual liability.

A.1.2 Inspection of materials and components

A.1.2.1 Materials and components shall be submitted to the inspections given in table 6.

A.1.2.2 The natural frequencies of finished axial blades shall be determined by using random checks.

A.1.2.3 Impellers shall be subjected to an overspeed test for at least 1 min at the following speeds:

a) 112 % of 100 % speed (n_{100}) for electric-motor-driven compressors;

b) 118 % of 100 % speed (n_{100}) for single-shaft turbine-driven compressors;

c) 121 % of 100 % speed (n_{100}) for split-shaft turbine-driven compressors.

After the overspeed test, impellers shall be examined using magnetic particle or dye-penetrant methods.

A.1.2.4 The finished and assembled casing shall be hydrostatically tested with liquid at not less than 1,3 times the casing design pressure (see 5.2.8). If the casing is subdivided for design and test purposes, every compartment shall be maintained at the appropriate test pressure simultaneously.

If the maximum operating temperature is at a level which affects the mechanical properties of the casing material, the test pressure shall be increased accordingly.

The test pressure shall be maintained for at least 30 min. The test shall be considered to be successful if no leakage occurs.

A.1.2.5 Pressure vessel auxiliaries shall be inspected and tested in accordance with the requirements of 10.1.1.

Table 6 — Inspection of materials and components

Component			Mechanical properties	Chemical analysis	Ultrasonic examination	Spot radiographic examination	Magnetic particle or dye-penetrant examination
Forged rotor elements	Discs for impellers Drums for axial rotors		Yes	Charge analysis	If specified by the USER		
	Rotor shafts Balance pistons						
	Impeller blade material						
	Axial rotor blades		Random check		If specified by the USER		Yes
	Shaft sleeves		If specified by the USER				
Impellers	Impeller welds					If specified by the USER	Yes
	Impeller castings		Yes				
Casings	Steel casings	Cast	Yes	Charge analysis (of each casting if made of several charges)	If specified by the USER		If specified by the USER
		Forged		Charge analysis			
	Steel casing welds					If specified by the USER	Yes
	Nodular iron casings		Yes	Charge analysis (of each casting if made of several charges)			
	Cast iron casings		If specified by the USER				
Cast axial rotor blades			Random				Yes

Mechanical properties shall be determined after final treatment; suitable test pieces shall be produced for this purpose.

Technical details of inspections shall be as agreed between the SUPPLIER and the USER.

A.1.3 Compressor tests

A.1.3.1 General

The tests applicable to turbo-compressors are summarized in table 7.

Table 7 — Turbo-compressor tests

Gas leakage test	Mandatory for toxic gases; mandatory for other gases, if specified in the enquiry by the USER
Porosity test	Mandatory if specified by the USER in the enquiry
Mechanical running test	Mandatory
Functional test	Mandatory if specified by the USER
Performance test	Mandatory if agreed between the SUPPLIER and the USER

A.1.3.2 Gas leakage test

The purpose of the gas leakage test is to confirm the tightness of the casing joints and connections to the degree necessary for the application. This test shall be performed in the SUPPLIER's workshop.

The USER shall indicate in the enquiry whether the gas is to be considered as toxic (see data sheet 202).

Test procedures shall be agreed between the SUPPLIER and the USER.

A.1.3.3 Porosity test

If the casing is made of a cast material, a porosity test may be specified by the USER in the enquiry.

Test procedures shall be agreed between the SUPPLIER and the USER.

A.1.3.4 Mechanical running test

The purpose of this test is to prove the satisfactory mechanical operation of the compressor.

The mechanical running test may be performed in the workshop or on site, as per agreement between the SUPPLIER and the USER.

Turbine-driven compressors shall be accelerated to trip speed and run at maximum continuous speed for a period of 2 h after steady state conditions have been reached.

Motor-driven compressors shall be run at 100 % speed for a period of 2 h after stable lubricant temperature conditions have been reached.

If the mechanical running test is performed in the SUPPLIER's workshop, the SUPPLIER's driver, gear unit and lubricating system may be used. During the mechanical running test, the following details shall be checked:

a) bearing performance;

b) vibration,

1) if, owing to the nature of the particular application, the SUPPLIER and the USER have agreed to subject the compressor to the shaft vibration requirements of 8.13, the vibration shall be determined in accordance with 8.13 and shall not exceed the levels indicated in 8.13.2,

2) the critical speed of flexible-shaft compressors should be checked, if possible, but without adding additional unbalance;

c) hydraulic seal performance (if agreed between the SUPPLIER and the USER);

d) if specified by the USER in the enquiry, spare rotors, if supplied, shall be subjected to a mechanical running test.

After the mechanical running test, the following components shall be inspected:

a) bearings;

b) hydraulic and mechanical seals (if installed during the test);

c) couplings (if the contract couplings are installed for the test).

After the mechanical running test has been completed, the following components may be inspected:

a) labyrinth seals;

b) axial blading.

If any modifications are required to improve the mechanical operation, the initial test is not acceptable and the mechanical running test shall be repeated.

A.1.3.5 Functional test

The purpose of this test is to prove the operability of the compressor and all its systems and components including isolating, venting and purging devices.

It may be undertaken with the specified gas or with any other gas agreed between the SUPPLIER and the USER.

The functional test shall be performed on site; however, packaged units may be tested in the SUPPLIER's workshop. This test shall be carried out subsequent to the successful mechanical running test and completion of the piping installation.

Before the functional test, all protective equipment associated with the machine should be tested at standstill under simulated conditions, as far as this is possible.

The compressor shall be operated in the normal operating range and the following shall be undertaken.

a) The antisurge and other control systems shall be correctly adjusted and set during this period and the results shall be recorded.

b) The flanged joints of all compressor casings, coolers, piping systems etc. shall be thoroughly inspected for leaks.

c) The hydraulic seal performance shall be checked.

d) If specified by the USER, a vibration monitoring system shall be installed and vibration levels recorded.

In this case, 8.13.4 and 8.13.5 shall apply.

If the functional test is carried out on site, the compressor shall be continuously operated for 12 h, unless otherwise specified by the USER in data sheet 803A.

A.1.3.6 Performance test

The purpose of this test is to check whether the compressor is able to comply with the guarantee conditions (see A.1.4). The SUPPLIER and the USER shall agree on which of the following test methods shall be used for the performance test:

a) workshop test in an open loop, with air;

b) workshop test in a closed loop;

c) test to be performed on site.

The performance test procedure shall be in accordance with ISO 5389. Instruments installed for normal operation may be used for this test if agreed between the SUPPLIER and the USER.

The performance test shall be specified by the USER in the enquiry.

A.1.4 Warranties

A.1.4.1 All equipment, components and spare parts shall be guaranteed by the SUPPLIER against defects which, under proper use, appear therein and arise from fault in design, faulty workmanship or defect in materials.

A.1.4.2 The guarantee period starts at the time when the compressor is handed over to the USER for operation and expires 12 months from that date, but not later than 18 months after the compressor is ready for shipment.

A.1.4.3 The guarantee period for spare parts supplied with the compressor shall be as stated in A.1.4.2.

A.2 Preparation for shipment

A.2.1 Preservation

A.2.1.1 All equipment supplied shall be protected by the SUPPLIER against deterioration during transport and storage, as mutually agreed with the USER. For the purpose of establishing appropriate protection, the USER shall specify in the data sheets the modes of transportation anticipated, the final destination and the duration and nature of storage.

When not otherwise specified, the inhibiting oil and packing shall be such as to provide adequate protection against deterioration when the equipment is stored inside a proper storage building for a period of 6 months in a temperate climate.

A.2.1.2 In all cases, machined external surfaces liable to corrosion shall have a protective coating applied by the SUPPLIER.

A.2.1.3 Equipment shall be secured in such a way as to protect it against injurious damage from vibration associated with the modes of transport. A clearly visible warning label shall be affixed to the equipment to indicate any securing devices which must be removed before commissioning.

A.2.1.4 All openings, including auxiliary pipes, shall be covered before dispatch in accordance with the USER's specification. Wooden plugs shall not be used for threaded openings.

A.2.1.5 All internal non-painted surfaces such as compressor and gearbox internals, lubricant pumps, lubricant pipes and gas pipes shall be coated with inhibiting oil before shipment.

Where compressor internals must remain oil-free because of the contract gas to be handled, the USER shall state this so that alternative corrosion protection can be applied. In this case, the compressor shall be fitted with sealed flanges and with desiccant bags placed inside to absorb atmospheric moisture.

A.2.2 Identification

A.2.2.1 All parts of the equipment sent separately shall be suitably marked for identification, as indicated by the USER.

A.2.2.2 All packing cases shall have the USER's contract number clearly marked on the exterior, including the item number of the particular contents.

Documents identifying the contents and the names of the USER and the SUPPLIER shall also be included inside the packing case in the event that the outside markings become obliterated during shipment.

A.2.3 Transportation and handling

A.2.3.1 To ensure that proper provision is made by the SUPPLIER and the USER for transportation of material to site and storage and handling of the material when received at site, the SUPPLIER and the USER shall jointly agree the modes of transportation, the site facilities, including the storage conditions, and the means of handling available for off-loading and positioning of all equipment. The USER shall indicate at the time of enquiry any size and weight limitations.

For transport by sea, the packing shall be lined with waterproof material and desiccant material shall be placed in the packing case.

A.2.3.2 Weights and lifting points shall be clearly indicated on the packing cases.

A.3 Erection and commissioning

A.3.1 Site preparation

A.3.1.1 Where the SUPPLIER is responsible for erection at site, the USER shall notify the SUPPLIER of the date when the site will be ready for erection to commence. The SUPPLIER shall have the right to check before the arrival of the material or the actual commencement of erection, whichever is appropriate, that the foundations and facilities required for erection are available and in good order.

The USER shall carry out the transport of the SUPPLIER's supply up to the foundation or the corresponding hoisting device unless otherwise agreed between the USER and the SUPPLIER.

This does not relieve the USER of his responsibility to provide a foundation of adequate quality.

A.3.1.2 The USER shall make available all site services and facilities to allow the SUPPLIER to erect properly, test and commission the SUPPLIER's supply as agreed with the SUPPLIER.

A.3.1.3 The USER shall notify the SUPPLIER at the time of the contract of any regulations concerning the conditions of work at the site. The USER shall inform the SUPPLIER of his official responsible for safety matters. The responsibility for meeting the local safety regulations lies with the USER.

A.3.1.4 The USER shall ensure that the SUPPLIER's personnel will find adequate accommodation, boarding and health care for the duration of erection and commissioning.

A.3.2 Erection on site

A.3.2.1 The erector in charge of the compressor unit, who shall be defined in the erection contract, is responsible for the proper handling, installation, assembly and cleaning of the compressor and its auxiliaries, as well as for proper connections at the terminal points.

A.3.2.2 The pressure testing of the erected pipework system shall be the responsibility of the USER or the SUPPLIER, whichever party carried out the erection. The compressor shall be isolated from the pipework during any such test.

A.3.2.3 If a long period of standby or shut-down is anticipated, the USER shall consult the SUPPLIER regarding the appropriate protection.

A.3.2.4 Special attention shall be devoted to the flushing of seal liquid lines for compressors with contact or liquid ring seals.

A.3.2.5 Any construction work shall be carried out by the USER. Activities performed by the USER which contractually are to the account of the SUPPLIER shall be ratified by the SUPPLIER's representative.

A.3.2.6 Unless otherwise agreed between the USER and the SUPPLIER, electrical installation work shall be carried out by the USER.

A.3.2.7 Electric welding of external components shall be carried out with the compressor unit electrically insulated from the components.

A.3.3 Training of staff and commissioning

A.3.3.1 It is recommended that the USER's staff who will operate the equipment are present during commissioning for training purposes.

The handing-over procedure shall comprise the commissioning of the SUPPLIER's supply demonstrating satisfactory completion and proper function, and acceptance by the USER.

A.3.3.2 The USER is responsible for ensuring that process gas conditions and utilities are according to those specified in the contract.

A.3.3.3 Any additional requirement for commissioning shall be agreed between the USER and the SUPPLIER.

A.3.3.4 When the USER carries out both erection and commissioning, he shall be responsible for any irregularity which may occur.

A.3.3.5 If an approval of any part of the SUPPLIER's supply by the national authority competent for the site is required, it shall be to the USER's account and he shall specify the necessary documents in the enquiry.

A.3.3.6 The USER shall notify the SUPPLIER of the date when the plant is ready for commissioning, giving sufficient time for all travel arrangements.

A.3.3.7 The USER shall take care that no damage to the SUPPLIER's supply can occur owing to foreign matter in upstream pipework, e.g. water or dirt.

A.3.3.8 When process start-up is delayed for reasons outside the SUPPLIER's control, the USER shall be responsible for the proper protection of the compressor unit with auxiliaries, according to the SUPPLIER's recommendations.

A.4 Documentation

A.4.1 General

The USER and SUPPLIER shall agree on the documents to be provided as a part of the scope of supply. These documents are listed and should be marked with an X on data sheet 1101.

A.4.1.1 At the time of enquiry the USER shall provide the SUPPLIER with all the information necessary to prepare a proposal, using the data sheets in this International Standard.

A.4.1.2 Together with his proposal, the SUPPLIER shall provide the USER with the data sheets complete with all the information necessary to evaluate properly the proposal.

A.4.1.3 At the time of contract, the data sheets shall be updated by agreement and shall form part of the contract.

A.4.1.4 After award of the contract, the SUPPLIER shall provide the USER with the documentation consisting of the drawings and data required for the installation, operation and maintenance study of the machinery supplied and the identification of the spare parts.

Likewise the USER shall send to the SUPPLIER the documentation required for the set design.

At the time of the contract signature, agreement shall be reached between the SUPPLIER and the USER, establishing for each document its applicability and dates of submission. Data sheet 1101 shall be completed with the agreed decisions.

A.4.1.5 Only documents specific to the contract need bear the USER's and the SUPPLIER's contract reference numbers.

A.4.1.6 The language of documentation shall be as agreed between the USER and the SUPPLIER and shall be indicated on data sheet 1101.

A.4.1.7 Requests for changes or modifications to any document or drawing shall be in the contract language. All requests for changes to drawings shall be legible (typed or block letters).

A.4.1.8 The SUPPLIER may combine drawings and data specified in accordance with his normal practice.

A.4.1.9 If certified drawings will not be available within the time specified by the USER, the SUPPLIER shall provide typical preliminary drawings, to assist the USER.

A.4.1.10 For the proposal, the SUPPLIER shall estimate the delivery time on the basis that approval of drawings will be given within 4 working weeks of their submission to the USER.

A.4.1.11 Approval of the SUPPLIER's drawings by the USER shall be made, after receipt by the USER, on the basis of the agreed schedule to maintain the final delivery date.

A.4.1.12 After the drawings have been approved, the SUPPLIER shall furnish certified copies of these as specified in data sheet 1101C.

A.4.1.13 Modifications to approved or final drawings require the USER's consent and shall be identifiable.

A.4.2 Remarks and comments on documents listed in data sheet 1101

A.4.2.1 **Preliminary documents** shall contain sufficient information to allow preliminary discussions between the SUPPLIER and the USER.

A.4.2.2 The **documents for approval** are the documents submitted to the counter-party during the contract stage for the study of the whole supply.

Since the date of approval affects the time of delivery, the date of submission and that of approval shall be defined by mutual agreement. If approval is delayed for reasons beyond the SUPPLIER's control, delivery may be delayed accordingly.

A.4.2.3 The **final documents** are those certified as correct for the installation.

A.4.2.4 **Schematics** (piping and instrumentation diagrams) for process gas, coolant, lubrication and seal systems, and control and instrumentation shall be complete with legends and shall show the functioning of these systems and the limits of supply. Vent, purge and drain arrangements shall be included in the pertinent schematics.

Schematics shall show normal flow rates, pressures and temperatures at pertinent points, as well as pipe sizes and the functional location and identification of instruments, valves etc.

Electrical functional diagrams shall include the identification of terminals.

A.4.2.5 The **geometrical site data** shall allow the SUPPLIER to study the best disposition of his supply within the available space.

A.4.2.6 The **outline drawings** shall include:

a) overall outlines in at least two views;

b) dimensions to show overall sizes and centre lines;

c) maintenance withdrawal spaces where these project outside the outline;

d) lifting points;

e) the direction of rotation of drive shafts;

f) the function, position and nature of terminal points for the USER's connections;

g) the support positions and dimensions;

h) the heaviest mass for erection or normal maintenance.

A.4.2.7 The **coupling drawing(s)** shall give all dimensions necessary for the detailed design of the connections between shafts, including space requirements for assembly and dismantling.

A.4.2.8 The **drawing of the motor rotor** shall give the related information which is required for the torsional analysis.

A.4.2.9 The **compressor sectional drawing** shall illustrate the construction of the machine and enable the identification of parts.

A.4.2.10 The **pressure vessel drawings** shall show all the elements necessary to receive approval, in accordance with the code indicated in the order.

A.4.2.11 The **layout drawing** of the set, showing the position of the main components of the SUPPLIER's supply, shall allow the USER to study the design and disposition of the main elements of the USER's supply including those necessary for maintenance of the SUPPLIER's equipment.

A.4.2.12 The **installation drawing** of the set, showing the disposition of the whole supply, including the route of interconnecting piping, shall allow the USER to determine the proper connection of his equipment to the SUPPLIER's supply without interference and taking into account the maximum allowable forces and moments on piping ends and the clearance necessary for dismantling and maintenance purposes.

A.4.2.13 The **foundation drawing** shall provide data for the dimensioning and design of the civil work. The following information shall be included:

a) position of openings and anchor bolts;

b) values and direction of static and dynamic loads at points of supports and casing nozzles.

A.4.2.14 The **compressor performance curves** shall allow the USER to evaluate the performance of the compressor and its range of operation. Normally they will be plotted in the form of curves showing the pressure ratio, the capacity, the speed, the power, the variable stator blade angle, if any, at normal inlet pressure, the inlet temperature and the molecular mass.

A.4.2.15 The **compressor starting torque curves** and the **motor torque/speed curves**, if required, shall be prepared from an evaluation of the driver torque/speed characteristic and the torque/speed requirements of the driven equipment together with the associated inertia values of the shaft system masses.

A.4.2.16 The data for **torsional analysis** shall give the information necessary to identify the torsional critical speeds of the set.

A.4.2.17 The **list of instruments** is a synthesis of all instrumentation included in the supply. The following information shall be given:

a) identification mark (tag number);

b) service;

c) manufacturer;

d) type;

e) range;

f) connection size;

g) setting values.

A.4.2.18 The **instrument and control terminal interconnection identification** shall allow the USER to connect properly his electric cables and pneumatic and hydraulic pipes to those supplied by the SUPPLIER.

A.4.2.19 The SUPPLIER shall furnish an **instruction manual** by the date listed on data sheet 1101, but not later than the date of shipment. The manual shall reflect the specific characteristics of the application, describing the installation, operation and maintenance procedures for the compressor and principal components of the SUPPLIER's supply. The manual shall

a) be indexed;

b) describe the compressor constructional features and the operation of component parts or systems (including control and safety devices) in writing, by outline and sectional drawings, and by schematic and illustrative sketches in sufficient detail to identify all principal parts (including spares);

c) give adequate instructions for dismantling and reassembly of the compressor and auxiliaries for maintenance purposes;

d) describe the operating procedure (starting, operating, normal and emergency shut-down) of the set (prohibited speed ranges shall be indicated);

e) give limiting factors for part-load operation;

f) give the maintenance schedule for the compressor and auxiliaries, including advice on procedures during prolonged shut-downs;

g) include final copies of all relevant data sheets, performance curves and other documents describing the performance of the machine;

h) give a recommended spare parts list;

i) give normal and allowable clearances between fixed and moving parts.

A.4.2.20 **Lubricant specifications** shall be provided by the SUPPLIER for all appropriate items of his supply and shall constitute his recommendation to the USER for reliable operation.

For lubricants in contact with the process gas, the specifications shall be agreed between the SUPPLIER and the USER after account has been taken of the gas properties and the machine duties.

A.4.2.21 The **shipping instructions** supplied by the USER and the **shipping data** supplied by the SUPPLIER shall include markings, dimensions, masses, packing methods and inspection requirements (see A.2).

A.4.2.22 The **performance test data** shall be presented in accordance with ISO 5389.

A.4.2.23 A preliminary **spare parts list** shall be provided by the SUPPLIER for those spares which are considered to be desirable during commissioning of the compressor.

A complete spare parts list shall be agreed between the USER and the SUPPLIER during the course of the contract.

A.4.2.24 The **manufacturing schedule** is a list or chart indicating the sequence, the interrelationship and the timing of events and activities which comprise the contract.

Annex B

Data sheets

(This annex forms an integral part of the standard.)

The short-form data sheets S1A and S2A may be used instead of the regular data sheets contained in this International Standard where the information supplied on them is sufficient for the particular application.

Re-vision	Info.	COMPRESSOR DATA SHEET No. 101		
		MAIN REFERENCES AND REVISIONS		Page of
		USER :	**PROJECT :**	**SUPPLIER :**
		Ref. No.	Ref. No.	Ref. No.

User to mark X in Info. column where data required in SUPPLIER's proposal

Revision No.	Original	1	2	3	4	5	6	7	8	9
Name										
Date										

Re-vision	Info.	TURBO-COMPRESSOR DATA SHEET No. 102A		
		TABLE OF CONTENTS	Page	of
		USER:	**PROJECT:**	**SUPPLIER:**
		Ref. No.	Ref. No.	Ref. No.

Data sheet [1]	Subject	No. of pages
101	Main references and revisions	
102A	Table of contents	
201	Conditions of service	
202	Gas composition	
203	Site conditions, arrangement	
204	Utilities 1 (electric power, fluids)	
205	Utilities 2 (cooling water)	
206	Machine mounting	
207	Miscellaneous	
208	Vibration and noise limitations	
209	Guarantees	
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301A	Compressor design 1	
302A	Compressor design 2	
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401	Couplings	
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403	Gears	
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505	Silencers and gas filters	
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701	Controls and instrumentation (general)	
702A	Controls	
703A	Instrumentation 1	
704A	Instrumentation 2	
801A	Inspection and quality control 1 (compressor)	
802	Inspection and quality control 2 (pipework, vessels)	
803A	Compressor tests	
901	Shipment and preservation	
1101	Documentation	
S1A	Turbo-compressor short-form data sheet	
S2A	Turbo-compressor short-form data sheet	

1) A for turbo-compressors only

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Revision No.	Original	1	2	3	4	5	6	7	8	9
Name										
Date										

Re-vision	Info.	COMPRESSOR DATA SHEET No. 201									
		CONDITIONS OF SERVICE							Page		of
		USER:	**PROJECT:**					**SUPPLIER:**			
		Ref. No.	Ref. No.					Ref. No.			
		Operating point ☒ = normal operating point		☐	☐	☐	☐				
		Process stage									
		Model designation									
		Gas designation (see data sheet 202)									
		Designation of operating point									
		Rating point		☐	☐	☐	☐				
		No. of units for service									
		No. of standby units									
		Inlet mass rate of flow ☐ kg/s ☐ kg/h ☐ wet ☐ dry									
		Discharge mass rate of flow									
		☐ kg/s ☐ kg/h									
		Mass rate of flow tolerance (%)									
		Inlet volume rate of flow ☐ m^3/s ☐ m^3/h ☐ wet ☐ dry									
		Inlet volume rate of flow tolerance (%)									
		Inlet volume rate of flow at surge limit ☐ m^3/s ☐ m^3/h									
		Inlet absolute pressure (bar)									
		Inlet temperature (°C)									
		γ (= κ = c_p/c_V for ideal gases only) [1]									
		Compressibility factor Z (= pV/RT)									
		Discharge absolute pressure (bar)									
		Discharge temperature (°C)									
		γ (= κ = c_p/c_V for ideal gases only) [1]									
		Compressibility factor Z (= pV/RT)									
		Absolute backpressure on relief valve (bar)									
		Settle-out pressure (bar)									
		Compressor required power (kW)									
		Specific energy requirement (kJ/m^3)									
		Specific energy tolerance (%)									
		Compressor speed (r/min)									
		Driver coupling power (kW)									
		Combined compressor and gear power (kW)									
		Recommended driver power (kW)									
		Driver shaft speed (r/min)									
		Type of driver ☐ electric motor ☐ steam turbine ☐ gas turbine									
		☐ diesel engine ☐ gas engine ☐ expander									
		☐ other:									
		Manufacturer of driver: **Furnisher:** ○ U ○ S									
		Inlet point ☐ standard									
		☐ other: (see data sheet 210)									
		Discharge point ☐ standard									
		☐ other: (see data sheet 210)									
		Attendance interval ☐ 1 h ☐ 4 h ☐ 8 h ☐ 24 h									
		☐ no routine attendance									
		Service ☐ 3 shifts ☐ 1 shift ☐ intermittent ☐ other:									
		1) pV^{κ} = constant for isentropic change of state.									
		USER to mark X in Info. column where data required in SUPPLIER's proposal									

Revision No.	Original	1	2	3	4	5	6	7	8	9
Name										
Date										

Re-vision	Info.	COMPRESSOR DATA SHEET No. 202					
		GAS COMPOSITION				Page	of
		USER:	**PROJECT:**		**SUPPLIER:**		
		Ref. No.	Ref. No.		Ref. No.		
		Operating point					
		Gas designation					
		Process stage					
		Relative water vapour pressure					
		Solid impurities (see constituents)	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no	
		Toxic (see constituents)	☐	☐	☐	☐	
		Flammable (see constituents)	☐	☐	☐	☐	
		Corrosive (see constituents)	☐	☐	☐	☐	

	Constituents	Symbol	Molar mass	mol. %	mol. %	mol. %	mol. %
	Water	H_2O	18,02				
	Hydrogen sulfide	H_2S	34,08				

	Molar mass M	(kg/kmol)
	Gas constant R	(kJ/kg·K)
	Specific heat capacity c_p	(kJ/kg·K)
	Reference temperature for c_p	(°C)
	Gas fouling factor for heat exchanger	(m^2·K/W)
	Temperature limits due to process requirements:	
	maximum	(°C)
	minimum	(°C)
	Material limitations:	
	Leakage limits:	
	Reference for thermodynamic properties:	
	USER to mark X in Info. column where data required in SUPPLIER's proposal	

Revision No.	Original	1	2	3	4	5	6	7	8	9
Name										
Date										

Re-vision	Info.	COMPRESSOR DATA SHEET No. 203		
		SITE CONDITIONS, ARRANGEMENT		Page of
		USER:	**PROJECT:**	**SUPPLIER:**
		Ref. No.	Ref. No.	Ref. No.

SITE

Name:

Geographic location:

Altitude above sea:

CLIMATICS

☐ inland ☐ close to sea ☐ desert ☐ tropical

☐ very sandy ☐ very dusty ☐ winter-proof protection required

☐ corrosive atmosphere due to: concentration: mg/m³

Rain: mm/h (maximum rainfall to be expected)

Barometer reading: normal = mbar; min. = mbar; max. = mbar

Relative water vapour pressure: normal = ; min. = ; max. =

Ambient temperature outdoors: normal = °C; min. = °C; max. = °C

Ambient temperature indoors: normal = °C; min. = °C; max. = °C

INSTALLATION	Compressor	Lubrication system	Intercoolers	Aftercoolers	Control	Steam condensing unit
Outdoors without roof	☐	☐	☐	☐	☐	☐
Outdoors with roof	☐	☐	☐	☐	☐	☐
Indoors unheated	☐	☐	☐	☐	☐	☐
Indoors heated	☐	☐	☐	☐	☐	☐
Integral with casing			☐	☐		
At machine floor level		☐	☐	☐	☐	☐
Below machine centre line (m)						
Above machine centre line (m)						
Horizontal distance from compressor (m)						

☐ Overhead tank m above machine centre line

CRANE

Erection crane ☐ installed ☐ mobile Erection opening: m by m

Erection crane lifting capacity: kg

Maintenance crane ☐ installed ☐ mobile

Maintenance crane lifting capacity: kg

Crane hook: m above machine centre line

Machine centre line: m above machine floor level

Machine floor level: m above ground level

Space required below machine centre line: m

SITE TRANSPORTATION ☐ street ☐ rail ☐ waterway ☐ airfield

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Revision No.	Original	1	2	3	4	5	6	7	8	9
Name										
Date										

Re-vision	Info.	COMPRESSOR DATA SHEET No. 204		
		UTILITIES 1 (electric power, fluids)		Page of
		USER:	**PROJECT:**	**SUPPLIER:**
		Ref. No.	Ref. No.	Ref. No.

ELECTRIC POWER

	Direct current		Alternating current, 1 phase				Alternating current, 3 phases			
		V		V	50 Hz	60 Hz		V	50 Hz	60 Hz
Power up to: kW	☐		☐		☐	☐	☐		☐	☐
Power up to: kW	☐		☐		☐	☐	☐		☐	☐
Control instruments	☐		☐		☐	☐	☐		☐	☐
Switches, relay	☐		☐		☐	☐	☐		☐	☐

Total electric power consumption: main driver = kW; auxiliaries = kW

REQUIREMENTS FOR EXPLOSIVE GAS ATMOSPHERE

Applicable standards (see also data sheet 207):

Location	Area classification	Gas composition	Type of protection			
			Explosion-proof enclosure	Increased safety "e" 1)	Pressurizing allowable	Intrinsically safe system
Indoors				☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
Outdoors				☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
Control room				☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no

FLUIDS

	Medium	Pressure (bar)			Temperature (°C)			Relative water vapour pressure	Consumption	
		normal	min.	max.	normal	min.	max.		units	max.
Compressed air	air									
Instrument air	air									
Control gas										
Purge gas										
Seal gas										
Live steam	steam									
Exhaust steam	steam									
Heating steam	steam									
Fuel gas	2)									

Fuel oil: density = kg/m^3; lower calorific value = kJ/kg

1) See IEC 79.
2) See data sheet 202.

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Revision No.	Original	1	2	3	4	5	6	7	8	9
Name										
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Re-vision	Info.	COMPRESSOR DATA SHEET No. 205										
		UTILITIES 2 (cooling water)							Page		of	
		USER:		**PROJECT:**					**SUPPLIER:**			
		Ref. No.		Ref. No.					Ref. No.			
		COOLING WATER	Units	Design	min.	max.	Design	min.	max.	Design	min.	max.
		Circuit designation										
		Open circuit		☐			☐			☐		
		Closed circuit		☐			☐			☐		
		Recirculation system		☐			☐			☐		
		Inlet effective pressure	bar									
		Allowable pressure drop	bar									
		Inlet temperature	°C									
		Allowable temperature rise	K									
		Water consumption:										
		intercooler plus aftercooler	litre/s									
		oil cooler	litre/s									
		auxiliary equipment	litre/s									
		WATER QUALITY										
		Town water		☐			☐			☐		
		River water		☐			☐			☐		
		Cooling tower		☐			☐			☐		
		Sea water		☐			☐			☐		
		Brackish water		☐			☐			☐		
		Other										
		Solid impurities		☐			☐			☐		
		(see analysis)										
		Corrosive water		☐			☐			☐		
		(see analysis)										
		pH										
		Fouling factor water-side	$m^2 \cdot K/W$									
		WATER ANALYSIS										
		Constituents										
		Ammonia	g/m^3									
		Chlorides	g/m^3									
		ANTIFREEZE										
		Type										
		Concentration	%									
		User to mark X in Info. column where data required in supplier's proposal										

Revision No.	Original	1	2	3	4	5	6	7	8	9
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Re-vision	Info.	COMPRESSOR DATA SHEET No. 206		
		MACHINE MOUNTING		Page of
		USER:	**PROJECT:**	**SUPPLIER:**
		Ref. No.	Ref. No.	Ref. No.

FOUNDATION

☐ Block foundation	☐ at ground level	☐ elevated:	m above ground level
☐ Elevated foundation	☐ concrete table	☐ concrete supports	
	☐ steel table	☐ steel supports	
Compressor mounting	☐ rigid	☐ resilient	
Supply of resilient elements	○ USER	○ SUPPLIER	
Table suspension	☐ high tuned	☐ low tuned	
Foundation design by	○ USER	○ SUPPLIER	
Subsoil condition	☐ piled	water table:	m below ground level
	☐ rocky		

Earthquake susceptibility factor (give applicable standards in data sheet 207):

BASEPLATES, SOLEPLATES, MOUNTING PADS

	Baseplates separate	Baseplates common	Soleplates	Mounting pads	Slide rails	Furnisher U	Furnisher S
Driver	☐	☐	☐	☐	☐	○	○
Gearboxes	☐		☐	☐		○	○
Compressors	☐		☐	☐		○	○
Coolers	☐		☐	☐		○	○
Oil systems	☐		☐	☐		○	○
Steam condensing unit	☐		☐	☐		○	○

PLATFORMS, STAIRS, RAILINGS

	☐ integral	☐ separate supports
Design	○ USER	○ SUPPLIER
Furnisher	○ USER	○ SUPPLIER

Level: m above ground level

FIXING

	Foundation bolts	Anchor with anchor plate	Rag bolts	Furnisher U	Furnisher S
Compressor	☐	☐	☐	○	○
Gearboxes	☐	☐	☐	○	○
Drivers	☐	☐	☐	○	○
Coolers	☐	☐	☐	○	○
Oil system	☐	☐	☐	○	○

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Name										
Date										

Re-vision	Info.	COMPRESSOR DATA SHEET No. 207		
		MISCELLANEOUS		Page of
		USER:	**PROJECT:**	**SUPPLIER:**
		Ref. No.	Ref. No.	Ref. No.
		This data sheet may be used to indicate:		
		Applicable standards (vibration and noise limitations, see data sheet 208)		
		Mandatory sub-furnishers		
		Prohibited sizes, ratings or materials		
		Exceptions		
		Special cleaning requirements		
		Major spare parts to be included in proposal		
		etc.		
		USER to mark X in Info. column where data required in SUPPLIER's proposal		

Revision No.	Original	1	2	3	4	5	6	7	8	9
Name										
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Re-vision	Info.	COMPRESSOR DATA SHEET No. 208		
		VIBRATION AND NOISE LIMITATIONS		Page of
		USER:	**PROJECT:**	**SUPPLIER:**
		Ref. No.	Ref. No.	Ref. No.
		SOUND POWER LEVEL		
		Item	Maximum permissible dB(A) re 10^{-12} W	Expected dB(A) re 10^{-12} W
		NOISE OUTPUT		
		Octave bands		
		Applicable standards		
		R.m.s. VIBRATION [1]		
		Item	Maximum permissible mm/s^2	Expected mm/s^2

1) R.m.s. = root mean square.

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Revision No.	Original	1	2	3	4	5	6	7	8	9
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Re-vision	Info.	COMPRESSOR DATA SHEET No. 209		
		GUARANTEES		Page of
		USER:	**PROJECT:**	**SUPPLIER:**
		Ref. No.	Ref. No.	Ref. No.

User to mark X in Info. column where data required in SUPPLIER's proposal

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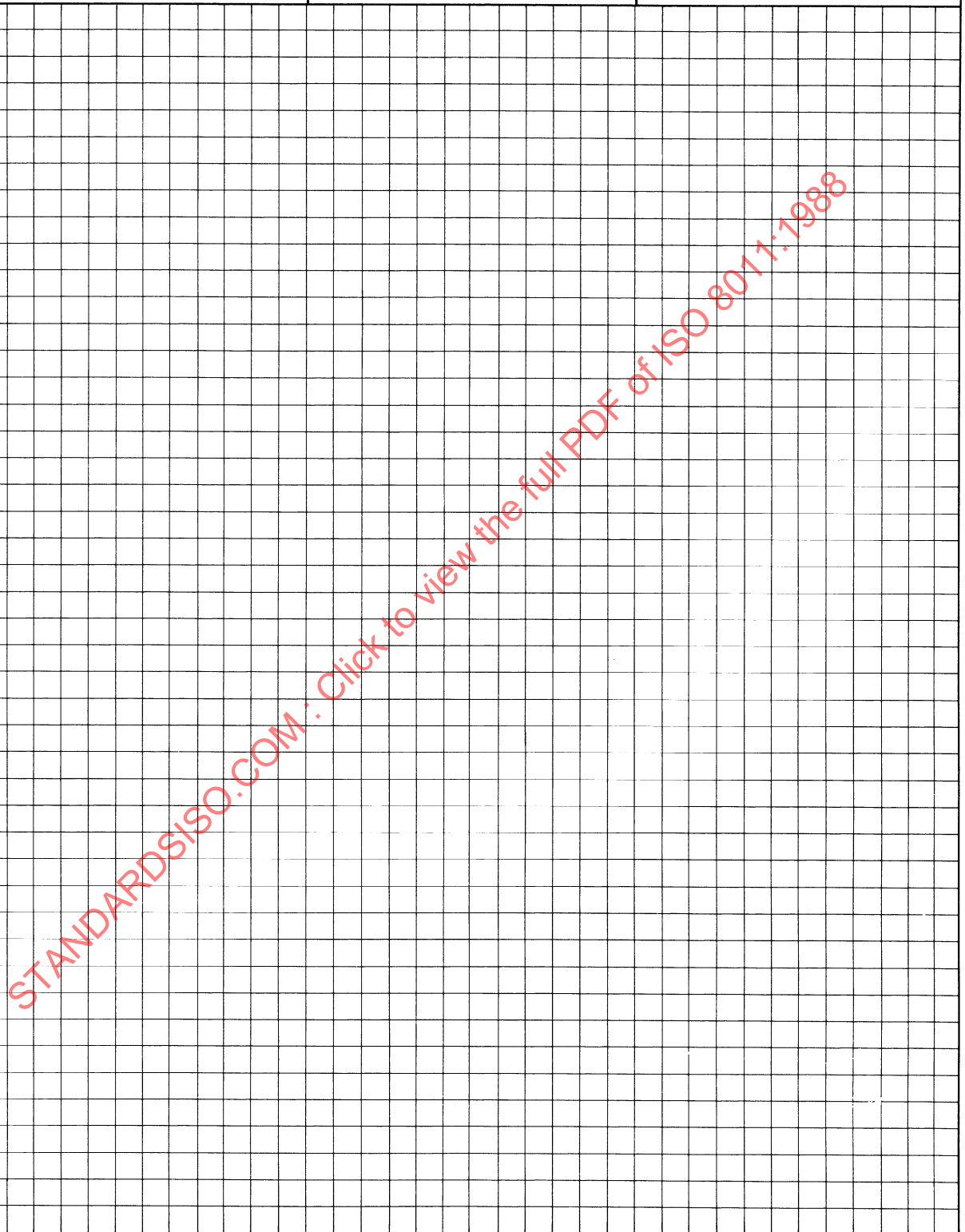
Name										
Date										

Re-vision	Info.	COMPRESSOR DATA SHEET No. 210		
		ARRANGEMENT SKETCH		Page of
		USER:	**PROJECT:**	**SUPPLIER:**
		Ref. No.	Ref. No.	Ref. No.



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Revision No.	Original	1	2	3	4	5	6	7	8	9
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Re-vision	Info.	TURBO-COMPRESSOR DATA SHEET No. 301A										
		COMPRESSOR DESIGN 1							Page		of	
		USER:	**PROJECT:**					**SUPPLIER:**				
		Ref. No.	Ref. No.					Ref. No.				
		Compressor model										
		Process stage										
		Reference letter of data sheet 210										
		100 % speed	r/min									
		Maximum allowable speed	r/min									
		Minimum allowable speed	r/min									
		Trip speed	r/min									
		Overspeed test speed	r/min									
		First lateral critical speed	r/min									
		Second lateral critical speed	r/min									
		Third lateral critical speed	r/min									
		Direction of rotation [1]										
		Number of stages axial/centrifugal										
		Rotor — moment of inertia [2]	$kg \cdot m^2$									
		— centrifugal impeller design (open, shrouded)										
		— outer diameter of largest impeller	mm									
		— impeller trip speed	m/s									
		— adjustable inlet guide vanes										
		Axial — rotor design (drum, disc etc.)										
		— rotor hub diameter	mm									
		— hub circumferential speed	m/s									
		— adjustable inlet guide vanes										
		— adjustable stator blades: stage										
		Casing split horizontal/vertical										
		Casing joint sealing										
		Casing drains at — inlet										
		— discharge										
		— each stage										
		Casing design effective pressure	bar									
		Casing design temperature range	°C									
		Maximum diaphragm differential pressure	bar									
		1) Clockwise or anticlockwise when looking at the compressor driven shaft end.										
		2) Referred to compressor coupling speed.										
		USER to mark X in Info. column where data required in SUPPLIER's proposal										

Revision No.	Original	1	2	3	4	5	6	7	8	9
Name										
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Re-vision	Info.	TURBO-COMPRESSOR DATA SHEET No. 302A								
		COMPRESSOR DESIGN 2						Page of		
		USER:	**PROJECT:**					**SUPPLIER:**		
		Ref. No.	Ref. No.					Ref. No.		
		Compressor model								
		Process stage								
		Reference letter of data sheet 210								
		Injection — suctionline/casing								
		— medium								
		— flow rate	kg/s							
		— effective pressure	bar							
		— temperature	°C							
		— density	kg/m³							
		Number of intercooling stations								
		Diaphragm coolers		☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no		
		Integral coolers		☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no		
		Aftercoolers		☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no		
		Thrust balancing device								
		Radial bearings — type								
		Main thrust bearing								
		— type								
		— suitable for reverse rotation		☐ yes ☐ no						
		Reverse thrust bearing								
		— type								
		— suitable for reverse rotation		☐ yes ☐ no						
		Thrust collar replaceable		☐ yes ☐ no						
		Shaft seal type:								
		— labyrinth		☐	☐	☐	☐	☐		
		— labyrinth plus seal gas		☐	☐	☐	☐	☐		
		— mechanical seal		☐	☐	☐	☐	☐		
		— liquid film seal		☐	☐	☐	☐	☐		
		Admissible gas leakage	kg/s							
		Maximum erection lifting capacity required	kg							
		Maximum maintenance lifting capacity required	kg							
		Total mass	kg							

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Re-vision	Info.	TURBO-COMPRESSOR DATA SHEET No. 303A									
		COMPRESSOR DESIGN 3 (casing nozzles)							Page		of
		USER:		**PROJECT:**				**SUPPLIER:**			
		Ref. No.		Ref. No.				Ref. No.			
		Compressor model									
		Process stage									
		Reference letter of data sheet 210									
		Nozzle 1	Function								
			Orientation								
			Size								
			Facing								
			Rating								
			Standard								
		Nozzle 2	Function								
			Orientation								
			Size								
			Facing								
			Rating								
			Standard								
		Nozzle 3	Function								
			Orientation								
			Size								
			Facing								
			Rating								
			Standard								
		Nozzle 4	Function								
			Orientation								
			Size								
			Facing								
			Rating								
			Standard								
		Nozzle 5	Function								
			Orientation								
			Size								
			Facing								
			Rating								
			Standard								
		Nozzle 6	Function								
			Orientation								
			Size								
			Facing								
			Rating								
			Standard								
		USER to mark X in Info. column where data required in SUPPLIER's proposal									
		Revision No.	Original	1	2	3	4	5	6	7	8	9
		Name										
		Date										

Re-vision	Info.	TURBO-COMPRESSOR DATA SHEET No. 304A										
		COMPRESSOR DESIGN 4 (materials)								Page	of	
		USER:		**PROJECT:**				**SUPPLIER:**				
		Ref. No.		Ref. No.				Ref. No.				
		Compressor model										
		Process stage										
		Reference letter of data sheet 210										
		Casing										
		Innercasing (if barrel type)										
		Stator blade carrier (axial compressor)										
		Diaphragm										
		Diffusor										
		Compressor shaft										
		Shaft sleeve										
		Impeller — hub disc										
		— vanes										
		— shroud										
		Axial compressor — rotor										
		— rotor blades										
		— stator blades										
		— tie rod (if any)										
		Balance piston										
		Bearings — housing										
		— shell or pads										
		— liner										
		Labyrinth — inserts										
		— tips										
		Floating rings										
		Floating ring liner										
		Mechanical seal stationary element										
		Mechanical seal rotating element										
		Main casing joint seal										
		Corrosion allowance casing wall thickness										mm
		USER to mark X in Info. column where data required in SUPPLIER's proposal										
		Revision No.	Original	1	2	3	4	5	6	7	8	9
		Name										
		Date										

Re-vision	Info.	COMPRESSOR DATA SHEET No. 401				
		COUPLINGS			Page of	
		USER:	**PROJECT:**		**SUPPLIER:**	
		Ref. No.	Ref. No.		Ref. No.	
		LOCATION (reference letter of data sheet 210)				
		Location				
		Furnisher	○ U ○ S	○ U ○ S	○ U ○ S	○ U ○ S
		Manufacturer				
		Manufacturer's model designation				
		Manufacturer's coupling torque capability [1] (Nm)				
		Application factor [2]				
		Rated coupling torque [3] (Nm)				
		Starting torque ratio [4]				
		Maximum continuous speed (r/min)				
		Inertia [5] ($kg \cdot m^2$)				
		Type of design				
		Spacer				
		Idling adaptor				
		Limited end float (mm)				
		Protection	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
		— Furnisher	○ U ○ S	○ U ○ S	○ U ○ S	○ U ○ S
		Type of lubrication				
		Lubricant kinematic viscosity : mm^2/s at °C				
		Lubricant volume (litre)				
		Lubricant consumption of coupling (litre/min)				
		Lubricant inlet effective pressure (bar)				
		Lubricant oil from (e.g. compressor, gear)				
		Coupling mass (kg)				
		Coupling driving end mounted by				
		Coupling driven end mounted by				

1) Torque indicated by manufacturer as design value in his documentation.

2) See 9.2.4.

3) Highest torque required at any specified operating point of compressor.

4) Ratio of starting torque to rated coupling torque.

5) Approximate figure for electric drive only, inertia defined as the mass times the radius of gyration squared.

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Name										
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Re-vision	Info.	COMPRESSOR DATA SHEET No. 402										
		TRANSMISSION AND BARRING DEVICE								Page	of	
		USER:		**PROJECT:**				**SUPPLIER:**				
		Ref. No.		Ref. No.				Ref. No.				
		TRANSMISSION									Furnisher	
											U	S
		Flywheel	☐ yes	☐ no							○	○
			– diameter:			mm						
			– width:			mm						
			– grooved	☐ yes	☐ no							
			– mass:			kg						
			– inertia [1]:			$kg \cdot m^2$						
		Motor pulley	☐ yes	☐ no							○	○
			– diameter =			mm; speed ratio =						
			– width:			mm						
			– grooved	☐ yes	☐ no							
			– mass:			kg						
			– inertia [1]:			$kg \cdot m^2$						
			– bore	☐ prebored								
				☐ on required tolerance								
			– mounted	☐ in workshop by:								
				☐ on site by:								
		Belt-drive	☐ yes	☐ no							○	○
			☐ V-belt; type =			; number =						
			☐ flat-belt; width =			mm						
			application factor =			; belt tension =		N				
			approximate centre distance for the drive:			mm						
		Outboard bearing										
			– for extension shaft of flywheel			☐ yes	☐ no				○	○
			bearing type	☐ journal		☐ rolling elements						
			– for extension shaft of motor			☐ yes	☐ no				○	○
			bearing type	☐ journal		☐ rolling elements						
		Guard	☐ yes	☐ no							○	○
			– non-sparking design			☐ yes	☐ no					
		Barring device	☐ yes	☐ no							○	○
			– location (reference letter of data sheet 210):									
			– type of design (e.g. manual, electric etc.):									
			– barring speed of compressor shaft:			r/min						
			– electric motor: type =								○	○
			power =		kW;		V					

1) Approximate figure for electric drive only, inertia defined as the mass times the radius of gyration squared.

USER to mark X in Info. column where data required in SUPPLIER's proposal

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Name										
Date										

Re-vision	Info.	COMPRESSOR DATA SHEET No. 403			
		GEARS		Page of	
		USER:	**PROJECT:**	**SUPPLIER:**	
		Ref. No.	Ref. No.	Ref. No.	
		Location (reference letter of data sheet 210)			
		Location			
		Furnisher	○ U ○ S	○ U ○ S	○ U ○ S
		Manufacturer			
		Manufacturer's model designation			
		Manufacturer's gear torque capability [1] (Nm)			
		Application factor [2]			
		Rated gear torque [3]			
		Starting torque ratio [4]			
		Speed ratio input/output			
		Maximum continuous speed of input shaft (r/min)			
		Direction of rotation of input shaft [5]	☐ cw ☐ acw	☐ cw ☐ acw	☐ cw ☐ acw
		Direction of rotation of output shaft [5]	☐ cw ☐ acw	☐ cw ☐ acw	☐ cw ☐ acw
		Inertia related to input shaft [6] ($kg \cdot m^2$)			
		Power loss at normal operating load (kW)			
		Maximum permissible thrust bearing load (N)			
		Type of design: single (s) or double (d) helical	☐ s ☐ d	☐ s ☐ d	☐ s ☐ d
		Design effective pressure of gear casing (bar)			
		Shaft sealing type			
		Bearings: journal (j) or rolling elements (r.el.)	☐ j ☐ r.el.	☐ j ☐ r.el.	☐ j ☐ r.el.
		Lubrication system: splash (spl.) or pressure (press.) system	☐ spl. ☐ press.	☐ spl. ☐ press.	☐ spl. ☐ press.
		Lubricant kinematic viscosity at 50 °C (mm^2/s)			
		Lubricant volume (if self-contained system) (litre)			
		Lubricant consumption of gear (litre/min)			
		Lubricant inlet effective pressure (bar)			
		Integral lubricant pump	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
		Flow rate at 100 % speed (litre/min)			
		Separately driven lubricant pump	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
		Lubricant pump power at 100 % speed (kW)			
		Lubricant oil from (e.g. compressor, driver)			
		Lubricant cooler	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
		single (s) or duplex (d) type	☐ s ☐ d	☐ s ☐ d	☐ s ☐ d
		coolant flow rate (litre/min)			
		Lubricant filter	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
		single (s) or duplex (d) type	☐ s ☐ d	☐ s ☐ d	☐ s ☐ d
		filtration rating (μm)			
		Lubricant heater ☐ electrical ☐ steam	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
		Gear mass (kg)			
		Baseplate, foundation bolts, see data sheet 206			

1) Torque indicated by manufacturer as design value in his documentation.

2) See 9.2.4.

3) Highest torque required at any specified operating point of compressor.

4) Ratio of starting torque to rated gear torque.

5) Clockwise (cw) or anticlockwise (acw) when looking from driving towards driven end of respective coupling.

6) Approximate figure for electric drive only, inertia defined as the mass times the radius of gyration squared.

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Revision No.	Original	1	2	3	4	5	6	7	8	9
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Re-vision	Info.	COMPRESSOR DATA SHEET No. 404		
		ELECTRIC MOTOR FOR COMPRESSOR DRIVE		Page of
		USER:	**PROJECT:**	**SUPPLIER:**
		Ref. No.	Ref. No.	Ref. No.
		Furnisher ○ USER ○ SUPPLIER		
		Manufacturer:		
		Manufacturer's model designation:		
		Type of motor ☐ synchronous ☐ induction ☐ squirrel cage		
		☐ wound motor ☐ other		
		MOTOR CHARACTERISTICS		
		Voltage = V; Phases = ; Frequency = Hz; Fault level = MVA		
		Rated driver power: kW (full load)		
		Speed: at full load = r/min; at 3/4 load = r/min; at 1/2 load = r/min		
		Efficiency: at full load = %; at 3/4 load = %; at 1/2 load = %		
		Power factor: at full load = %; at 3/4 load = %; at 1/2 load = %		
		Full-load current [1] = A; Locked rotor current = % of full-load current [1]		
		Full-load torque = Nm; Locked rotor torque = % of full-load torque		
		Starting torque: % of full-load torque		
		Torque fluctuation during start-up: ± % of full-load torque		
		Starting procedure ☐ direct on line ☐ ⅄ — △ ☐ other:		
		Reduced voltage starting: % of full-line voltage		
		Phase connection ☐ ⅄ ☐ △ Number of terminals:		
		External excitation: V; kW		
		Insulation class [2] = ; Maximum temperature = K		
		Coolant = ; Flow rate = m^3/s; Inlet temperature = °C		
		Type of enclosure:		
		Explosion-proof design ☐ yes ☐ no		
		Class [3] = ; Pressurizing with =		
		Bearing type ☐ journal ☐ rolling elements number of bearings:		
		Thrust bearing ☐ yes ☐ no		
		Maximum permissible axial end float of rotor: ± mm		
		Direction of rotation ☐ clockwise ☐ anticlockwise, when looking at the coupling		
		Lubrication ☐ self-contained ☐ Lubricant:		
		☐ bearing inlet effective pressure = bar; flow rate = litre/min		
		Space heater ☐ yes (W; V; phase) ☐ no		
		Winding temperature detectors ☐ yes (No. ; Ω; at °C)		
		☐ no		
		Rotor inertia [4]: $kg \cdot m^2$		
		☐ baseplate ☐ slide rails ☐ mounting pads (see data sheet 206)		
		Motor mass: kg		
		Maximum lifting capacity — for erection: kg		
		— for maintenance: kg		
		Applicable standards (see data sheets 207 and 208):		
		Motor testing:		

1) At the lower limit of the nominal voltage range.
2) According to IEC 85.
3) According to IEC 79.
4) Inertia defined as the mass times the radius of gyration squared.

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Re-vision	Info.	TURBO-COMPRESSOR DATA SHEET No. 501A											
		PIPEWORK									Page		of
		USER:		**PROJECT:**							**SUPPLIER:**		
		Ref. No.		Ref. No.							Ref. No.		

Item [1]	Pipework material [2]	Flange requirements [2] (e.g. facing, rating)	Low point drains [3]		Furnisher [1]		Prefabrication extent of [4]				Mating flanges [1]	
			T	W	U	S	1	2	3	4	U	S
Process gas inlet					○	○					○	○
Process gas sidestreams					○	○					○	○
Process gas interstage (to and from coolers)					○	○					○	○
Antisurge recycle					○	○					○	○
Process gas discharge					○	○					○	○
Blow-off					○	○					○	○
Balance					○	○					○	○
Lubricant — upstream of filters					○	○					○	○
Lubricant — filter to compressor					○	○					○	○
Lubricant — compressor to tank					○	○					○	○
Lubricant — overhead tank and lines					○	○					○	○
Seal medium — upstream of filters					○	○					○	○
Seal medium — filters to compressor					○	○					○	○
Seal medium — return from seals					○	○					○	○
Seal medium — overhead tank and lines					○	○					○	○
Gas balance line to overhead tank					○	○					○	○
Instrument air					○	○					○	○
Pulse and sensing lines					○	○					○	○
Purge — compressor, panel etc.					○	○					○	○
Injection system					○	○					○	○
Vents — compressor to stack					○	○					○	○
Drains from compressor					○	○					○	○
Coolant					○	○					○	○
Steam heating					○	○					○	○
					○	○					○	○
					○	○					○	○
Supports					○	○						
— for process gas pipework					○	○						
— for auxiliary pipework					○	○						
Foundation bolts for supports					○	○						

1) For limits of supply, refer to the pertinent schematics.

2) For applicable standards and prohibited sizes, ratings and material, see data sheet 207.

3) T, valved; W, plugged.

4) 1, completely fabricated; 2, partially fabricated (mixture 1 + 3); 3, prefabricated, with closing lengths for site matching; 4, straight tube lengths, bends and fittings.

For inspection and quality control, see data sheet 802.

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Revision No.	Original	1	2	3	4	5	6	7	8	9
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Re-vision		COMPRESSOR DATA SHEET No. 502				
		GAS COOLERS			Page	of
		USER:	**PROJECT:**		**SUPPLIER:**	
		Ref. No.	Ref. No.		Ref. No.	
		COOLANT ☐ water (see data sheet 205)		☐ air	☐ other	
		Compressor stage				aftercooler
		Cooler designation				
		Location (reference letter of data sheet 210)				
		Cooler required	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
		Furnisher	○ U ○ S	○ U ○ S	○ U ○ S	○ U ○ S
		Cooler type (e.g. shell plus tube, finned tubes, double pipe etc.)				
		Removable bundle	☐	☐	☐	☐
		Gas through the tubes	☐	☐	☐	☐
		Thermostatic control of coolant flow	☐	☐	☐	☐
		Furnisher	○ U ○ S	○ U ○ S	○ U ○ S	○ U ○ S
		Design conditions				
		— head load (kW)				
		— gas inlet temperature (°C)				
		— gas discharge temperature (°C)				
		— gas mass rate of flow (kg/s)				
		— gas inlet absolute pressure (bar)				
		— gas pressure drop (bar)				
		— gas-side fouling factor ($m^2 \cdot K/W$)				
		— coolant inlet temperature (°C)				
		— coolant temperature rise (K)				
		— coolant mass rate of flow (kg/s)				
		— coolant pressure drop (bar)				
		— coolant-side fouling factor ($m^2 \cdot K/W$)				
		Mechanical design				
		gas side — design effective pressure (bar)				
		— design temperature (°C)				
		coolant side — design effective pressure (bar)				
		tubes — inner diameter × wall thickness (mm)	×	×	×	×
		Materials — shell				
		— tubes				
		— fins				
		— tube plates				
		— baffles				
		— heads				
		Corrosion protection — gas side by				
		— coolant side by				
		Mass of cooler — empty (dry) (kg)				
		— with coolant (wet) (kg)				
		Foundation bolts — furnisher	○ U ○ S	○ U ○ S	○ U ○ S	○ U ○ S
		Cooler integral to compressor	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
		Applicable specifications (see data sheet 207):				
		Inspection and quality control (see data sheet 802):				
		USER to mark X in Info. column where data required in SUPPLIER's proposal				

Revision No.	Original	1	2	3	4	5	6	7	8	9
Name										
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Re-vision	Info.	COMPRESSOR DATA SHEET No. 503				
		SEPARATORS AND DRAINAGE			Page	of
		USER:	**PROJECT:**		**SUPPLIER:**	
		Ref. No.	Ref. No.		Ref. No.	
		SEPARATORS				
		Compressor stage				
		Separator designation				
		Location (reference letter of data sheet 210)				
		Separator required	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
		Furnisher	○ U ○ S	○ U ○ S	○ U ○ S	○ U ○ S
		Separator type (centrifugal, impingement etc.)				
		Separator integral to cooler				
		Design conditions				
		— inlet absolute pressure (bar)				
		— inlet temperature (°C)				
		— pressure drop (bar)				
		— calculated separated liquid (litre/h)				
		— design effective pressure (bar)				
		— design temperature (°C)				
		— liquid storage volume (litre)				
		Material — vessel				
		— internals				
		Corrosion allowance (mm)				
		Mass of separator (kg)				
		DRAINAGE				
		Vessel designation (e.g. cooler, separator)				
		Location (reference letter of data sheet 210)				
		Drainage required	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
		Furnisher	○ U ○ S	○ U ○ S	○ U ○ S	○ U ○ S
		Drainage type (valve, trap)				
		Operation — manual	☐	☐	☐	☐
		— automatic continuous	☐	☐	☐	☐
		— automatic periodic	☐	☐	☐	☐
		Absolute back pressure (bar)				
		Materials — body				
		— internals				
		Applicable specifications (see data sheet 207):				
		Inspection and quality control (see data sheet 802):				
		User to mark X in Info. column where data required in supplier's proposal				

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