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

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

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Foreword

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

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 8012 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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Compressors for the process industry — Reciprocating 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 reciprocating compressors used in the process industry. It also details the documentation requirements.

2 Field of application

This International Standard applies to reciprocating compressors used in the process industry. It covers the minimum requirements for compressors of the cross-head type with lubricated or non-lubricated cylinders handling air or gas, but excludes portable air compressors, diaphragm-type compressors, and standard utility air compressors with not more than 10 bar absolute discharge pressure.

This International Standard covers certain requirements for compressor drivers, drive equipment, lubricating systems, control, 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 1000, *SI units and recommendations for the use of their multiples and of certain other units*.

ISO 1217, *Displacement compressors — Acceptance tests*.

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, *Acoustics — Measurement of airborne noise emitted by compressor units including prime movers —*

Part 1: Engineering method for determination of sound power levels.¹⁾

Part 2: Method for determination of compliance with noise limits.¹⁾

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

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

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 × 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

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 swept volume for a displacement compressor: The volume swept in one cycle by the compressing element(s) of the compressor first stage.

5.1.6 displacement for a displacement compressor: The volume swept by the compressing element(s) of the compressor first stage per unit of time.

5.1.7 clearance volume: The volume inside a compression space, which contains gas trapped at the end of the compression cycle.

5.1.8 relative clearance volume: The ratio of the clearance volume of the stage under consideration to the swept volume of the compressing element of this stage.

5.1.9 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, inter-coolers, gears and couplings). See figure 1.

5.1.10 combined rod load: The force developed owing to differential pressure across the piston and the inertia forces transmitted through the piston rod.

5.1.11 allowable rod load: The maximum rod load permitted for continuous operation.

5.1.12 liquid-cooled rod packing: A rod packing which has direct liquid cooling of the packing cups.

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.

COMPRESSOR DATA SHEET No. 210											
ARRANGEMENT SKETCH										Page of	
USER :				PROJECT :				SUPPLIER :			
Ref. No.				Ref. No.				Ref. No.			
Typical two-stage compressor : A, C 1st stage cylinders B, D 2nd stage cylinders G, H intercoolers I, J 1st stage inlet manifold K, O inlet dampers L, N, P discharge dampers M 2nd stage discharge manifold Q inlet block valve Typical one-stage compressor : E, F 1st stage cylinders Transmission and driver : R fly wheel S low-speed coupling T gear set-speed reduction U high-speed coupling V driver Figure 1 — 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											

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 maximum expected discharge temperature: The highest predicted operating temperature resulting from any specified service condition, including part-load operation.

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).

5.5 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.

5.6 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 crankshaft.

5.7.2 shaft speed irregularity: The dimensionless number obtained when the difference between the maximum and the minimum instantaneous shaft speeds during one period is divided by the arithmetic mean of the two speeds:

$$\delta = 2 \frac{n_{\max} - n_{\min}}{n_{\max} + n_{\min}}$$

where n is the shaft speed, in revolutions per minute.

5.7.3 mean piston speed: The value of the piston linear speed determined using the formula

$$c_m = \frac{2sn}{60}$$

where

c_m is the mean piston speed, in metres per second;

s is the piston stroke, in metres;

n is the rotational speed, in revolutions per minute.

5.7.4 valve velocity: The mean gas velocity through any inlet or discharge valve group:

$$w = \frac{F}{f} c_m$$

where

w is the mean gas velocity, in metres per second;

F is the piston area, in square metres;

f is the valve opening area, in square metres;

c_m is the mean piston speed, in metres per second.

The valve opening area is the product of the valve lift and the sum of the valve opening perimeters of all suction or discharge valves of the cylinder end concerned.

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

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

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

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

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.

5.9.5 rails: Plates that run under the compressor frame for support of the compressor.

6 Basic requirements

6.1 General

6.1.1 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.

6.1.2 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.

6.1.3 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.

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

6.2 The enquiry

6.2.1 The USER shall complete the data sheets to the extent possible and specify all process requirements, any known abnormal conditions and 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.

6.2.2 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.

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

6.3 The proposal

6.3.1 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.

6.3.2 Unless otherwise specified in the enquiry, the SUPPLIER shall quote only for the instrumentation listed as mandatory in 11.2.1 and shall supply equipment to his own standard.

6.3.3 The proposal shall state the delivery time as being from the date of receipt of a fully released order.

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

6.3.5 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.

6.4 Rating

6.4.1 Performance rating

a) The flow rate of the compressor shall be within $\begin{matrix} +6\% \\ 0\% \end{matrix}$ 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).

b) The specific energy requirement shall not exceed the rated value by more than 6 % at the rating point(s) specified in the data sheets. Losses in external transmissions, such as gears, shall be stated in the data sheets.

6.4.2 Tests

Test procedures shall be in accordance with ISO 1217 (see also annex A).

6.5 Noise limitations

6.5.1 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.

6.5.2 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.

6.5.3 Methods of measurement and interpretation shall be as stated in ISO 3989.

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 at the worksite.

6.5.4 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.

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

6.5.6 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.

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

7 Compressor

7.1 General

The compressor, driver and auxiliary equipment shall be designed for continuous duty at the specified operating conditions and for rapid and easy maintenance, particularly regarding packings and valves.

7.2 Attendance interval

The attendance intervals specified shall apply to the complete compressor with drive and auxiliaries.

Five attendance intervals are defined. An attendance interval is a period during which no attention by personnel (e.g. topping up of lubricant and draining of condensate) is necessary for the compressor and auxiliaries.

The individual attendance operations to be carried out shall be stated in the instruction manual. The attendance intervals may be 1, 4, 8 or 24 h. Alternatively, if it is considered that routine attendance is not required, the USER shall specify the attendance-free operating period. Overhaul (servicing) after long operating periods shall be specified in the instruction manual by the SUPPLIER.

The checking of temperatures and pressures shall be carried out regularly and is not related to the attendance interval.

7.3 Allowable speeds

The crankshaft speed and mean piston speed shall be selected by the SUPPLIER so that satisfactory operation is obtained under the required service conditions over a suitable period according to the state of the art. The SUPPLIER shall state the mean piston speed in the data sheets.

The SUPPLIER shall specify the maximum and minimum crankshaft speeds in the operating instructions.

Limiting values of crankshaft speeds and mean piston speeds are not given in this International Standard as they depend not only on the compressor design but also on the compressor duty, i.e. type of gas, lubrication, pressure etc.

The USER should only give maximum allowable values in the enquiry and order specifications if special experience indicates that this is necessary.

7.4 Maximum allowable working temperature

Under all specified operating conditions, the maximum expected discharge temperatures shall be selected to ensure reliable operation. Detailed specifications of the maximum allowable working temperatures cannot be given in this International Standard as the limit values depend on the types of gas, lubricant, material and compressor design.

The SUPPLIER shall be notified of the regulations valid in the USER's country. Temperature limits due to process requirements, or calculated on the basis of experience, shall also be specified by the USER.

7.5 Rod load

The actual rod load, calculated on the basis of the relief valve set point for each stage, the normal suction pressure for each stage and taking into consideration part-load operation, if applicable, shall not exceed the allowable rod load.

7.6 Torsional vibrations and shaft speed irregularity

7.6.1 Torsional vibrations

The SUPPLIER is responsible for ensuring that the compressor driver and drive equipment are free from dangerous torsional vibrations within the operating range. This applies also where

the SUPPLIER does not supply the driver and/or drive equipment, unless it is belt driven.

However, where a reciprocating engine drive is provided and this is not furnished by the SUPPLIER, the manufacturer of the engine is the responsible party.

If the calculation of torsional vibration indicates that changes in drive parts not included in the scope of the SUPPLIER's supply are necessary, the costs for such modification are the responsibility of the USER.

The party ordering the drive is responsible for the procurement in good time of the necessary data for the calculations, enabling the calculation results to be received in sufficient time to allow any necessary modifications to be implemented without prejudicing the delivery.

For variable-speed drives, the SUPPLIER shall specify the speeds in the operating range and above, up to the overspeed trip, at which critical torsional vibration occurs (if any).

Where no torsional analysis has been carried out, the SUPPLIER shall provide proof, e.g. satisfactory running of identical sets, that the set will be free of dangerous torsional vibrations.

7.6.2 Shaft speed irregularity

The shaft speed irregularity shall not exceed the specified value under any required operating condition or for any variation in capacity. When resilient couplings are used, their influence shall be considered. If not specified otherwise, the shaft speed irregularity shall not exceed the values indicated in table 1.

Table 1

Component	Shaft speed irregularity δ for the following shaft powers			
	0 to 50 kW	51 to 100 kW	101 to 200 kW	More than 200 kW
Belt drive	1/50	1/60	1/70	1/80
Direct drive by electric motor	1/60	1/70	1/80	1/100
Gearbox	1/100	1/100	1/100	1/100

For compressors direct driven by variable-speed prime movers, the shaft speed irregularity of the set shall be agreed between the SUPPLIER and the engine manufacturer.

Any requirements for current fluctuation limitation shall be specified by the USER.

7.7 Foundation

The foundation drawing shall include the information specified in A.4.2.8.

The USER shall be responsible for the design and construction of the foundations. The foundation drawing prepared by the SUPPLIER is certified only in respect of the installation dimensions and loads for the compressor, driver and auxiliaries.

The foundations should preferably be designed as rigid foundations. If resiliently mounted foundations are necessary, e.g. because transmission of vibration to the building must be avoided, this shall be stated by the USER in his specifications.

7.8 Motion work

7.8.1 Bearings

Journal-type bearings are preferred. When rolling element bearings are used, this shall be stated by the SUPPLIER in the data sheets. The crankshaft bearing system shall be capable of dealing with any axial forces which may occur under the expected operating conditions, e.g. motor thrust.

7.8.2 Crankshaft and connecting rod

Crankshafts and connecting rods shall be made of ductile materials. These include suitable grades of spheroidal graphite cast iron.

7.8.3 Crankcase

The crankcase shall be sufficiently rigid such that under all conditions of full or partial loading of the compressor, the peak-to-peak amplitude of longitudinal movement measured along the cylinder axis at the cylinder cover shall not exceed 10^{-4} multiplied by the distance from the crankshaft centre line.

In special cases where the USER requires the crankcase to withstand a specified internal pressure, or where an explosion-type relief valve is to be fitted, the USER shall state his requirement in the enquiry.

7.9 Distance pieces

7.9.1 General

Distance pieces can be an integral part of the crankcase or of the cylinder, or they may be separate from either.

7.9.2 Types of distance pieces

The data sheets shall indicate which of the following types of distance piece is to be supplied.

- Short distance piece without oil wiper packing (see figure 2): the space between the cross-head guide and the cylinder is of sufficient length to permit dismantling of the packing by access through the distance piece openings.
- Short distance piece with oil wiper packing (see figure 3): the same as distance piece type a) but the distance piece compartment is separated from the motion work by an oil wiper packing.
- Long distance piece (see figure 4): this is the normal design for non-lubricated compressors. It is also used when specified by the USER. The distance piece shall be sufficiently long to allow an oil slinger ring fixed to the piston rod to be fitted to prevent fluid passing from the motion work to the cylinder or vice versa. The long distance piece is sealed on the crankcase side by an oil wiper packing.

d) Long distance piece with purge compartment inside the pressure packing (see figure 5): a long distance piece as described in c) but with the main pressure packing separated from an auxiliary pressure packing by a spacer or purge compartment. This type of distance piece fulfils the same function as the two-compartment distance piece e). The spacer compartment forms a part of the pressure packing.

e) Two-compartment distance piece (see figures 6 and 7): this is used when specified by the SUPPLIER, e.g. in order to prevent corrosive, flammable or toxic gases from escaping into the open or into the compartment adjacent to the crankcase, or to prevent water vapour from the atmosphere from entering the gas. It would be used for instance during the compression of chlorine, HCl etc. In this case, two compartments shall be provided between the pressure packing and the oil wiper packing. The compartment adjacent to the crankcase shall be designed as specified for the long distance piece described in c); in non-lubricated compressors there shall be an oil slinger ring on the piston rod. The compartment adjacent to the cylinder shall be sealed by an intermediate pressure packing from the compartment adjacent to the crankcase. The main pressure packing shall be fitted with a gas vent. The purge compartment shall have two purge connections (inlet and outlet) and one drain cock or plug.

The USER and the SUPPLIER shall agree on the pressure in the purge compartment.

7.9.3 Gas-tight crankcase

An alternative method to the use of distance pieces as described in 7.9.2 d) and e) is to seal the complete crankcase. A gas-tight crankcase is suitable primarily when there are extreme sealing requirements.

The crankshaft seal shall be replaceable without the need to remove the crankshaft.

7.9.4 Access openings

Access openings of adequate size shall be provided in all distance pieces to permit removal of the assembled packing case. On two-compartment distance pieces, the compartment adjacent to the cylinder may be accessible through a removable diaphragm.

Distance pieces (or compartments) shall be equipped with screened safety guards, louvred weather covers or gasketed solid covers as specified in the data sheets.

7.9.5 Design pressure

Where solid distance piece covers are provided or specified, the distance piece, diaphragms, covers, bolting and diaphragm packing shall be designed for a minimum effective pressure of 1 bar.

7.9.6 Drain, purge and vent connections

A drain connection shall be provided on all distance piece compartments and the compartment shall drain completely. If solid covers are supplied, a compartment vent connection shall be

included on the top of the respective closed distance piece compartment. A packing vent connection shall be provided on all distance pieces.

This vent connection shall be positioned below the piston rod to ensure drainage.

The minimum size of external vent, purge and drain connections to the distance piece shall be G 3/8.

7.10 Cylinder

7.10.1 Maximum allowable working pressure

The maximum allowable working pressure shall exceed the rated discharge pressure by at least 10 % or 1 bar, whichever is the greater, but shall not be lower than the relief valve set pressure.

7.10.2 Horizontal/vertical cylinders

If there is by reason of the process a possibility of liquid entrainment or condensation during compression, horizontal cylinders are to be preferred. These shall have discharge valves and discharge connections at the bottom.

Consideration shall be given to cylinder cooling and valve chamber drainage to prevent liquid entrainment by the cylinder.

7.10.3 Accessibility, dismantling arrangement and studs

The cylinders shall be arranged so that all valves and controls fitted on the cylinders and pressure packings are accessible without removing the cylinder covers or major piping.

Cylinder covers and valve covers shall be fixed by not less than three studs. If there is any possibility that removal may be difficult because of jamming, sticking or corrosion, cylinder covers and similar parts shall be provided with tapped holes for jacking screws or with suitable dismantling arrangements.

7.10.4 Cylinder liners

At the request of the SUPPLIER, or if severe wear is to be expected because of the operating conditions, e.g. the compression of dirty, corrosive or condensing gases, or for a discharge pressure exceeding about 50 bar and for cylinders of cast steel, replaceable liners are recommended. Cylinders without liners shall have walls of sufficient thickness to allow rebor-ing of at least 3 mm in the diameter without encroaching upon either the maximum allowable working pressure or the maximum allowable rod load (see also 7.17.6).

7.10.5 Cylinder cooling system

Cylinders shall have cooling arrangements as required by the conditions of service. In cases in which heating, filling with glycol or other such arrangement is preferable, this shall be stated by the SUPPLIER. Drains shall be provided at the lowest points. The cooling water outlet shall be at the top and shall be arranged so that no air pockets, which would adversely affect operation, can build up at any point.

Key for figures 2 to 7

- | | |
|---------------------------------|---|
| 1 motion work | A vent |
| 2 piston rod | B drain |
| 3 pressure packing | C purge |
| 4 compressor cylinder | D pressure packing vent |
| 5 oil wiper packing | E pressure packing lubricant |
| 6 oil slinger ring | F pressure packing cooling water inlet |
| 7 access opening | G pressure packing cooling water outlet |
| 8 intermediate pressure packing | |

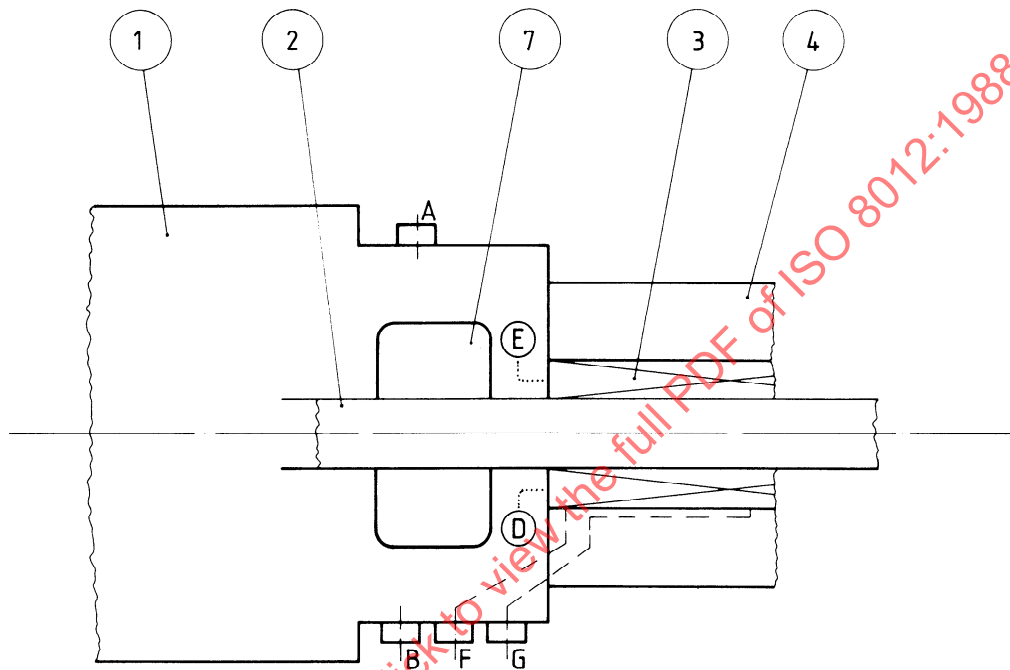


Figure 2 — Short distance piece without oil wiper packing

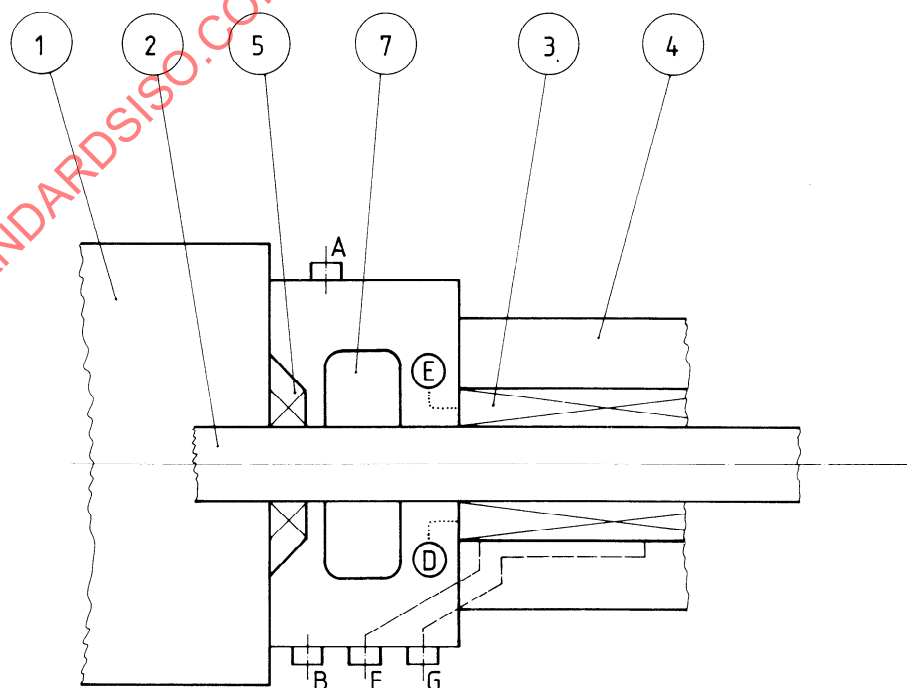


Figure 3 — Short distance piece with oil wiper packing

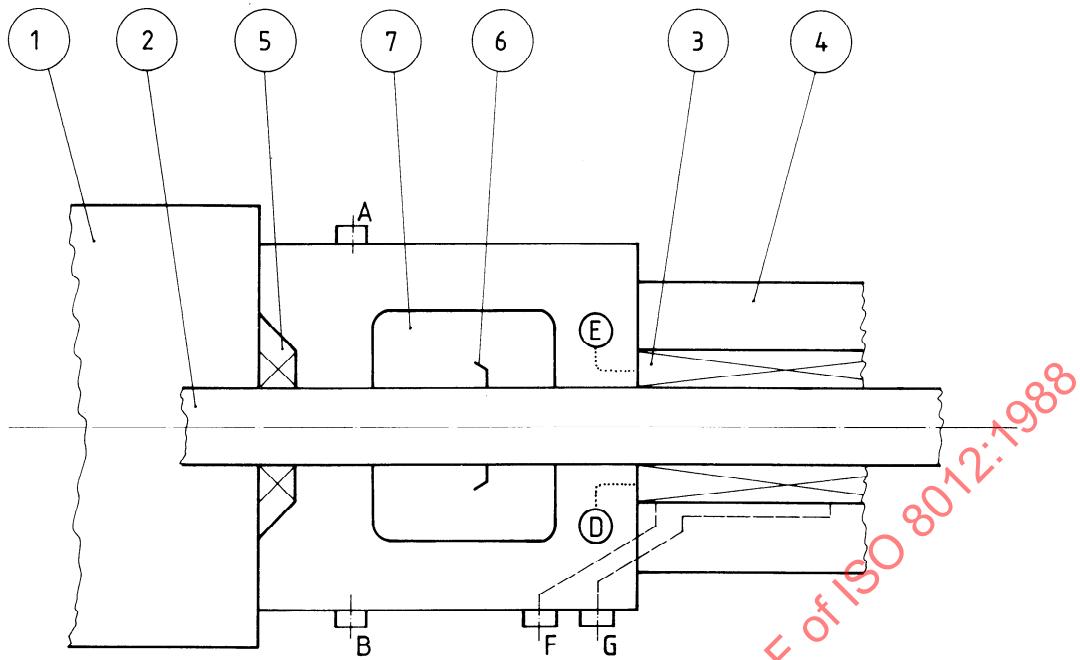


Figure 4 — Long distance piece

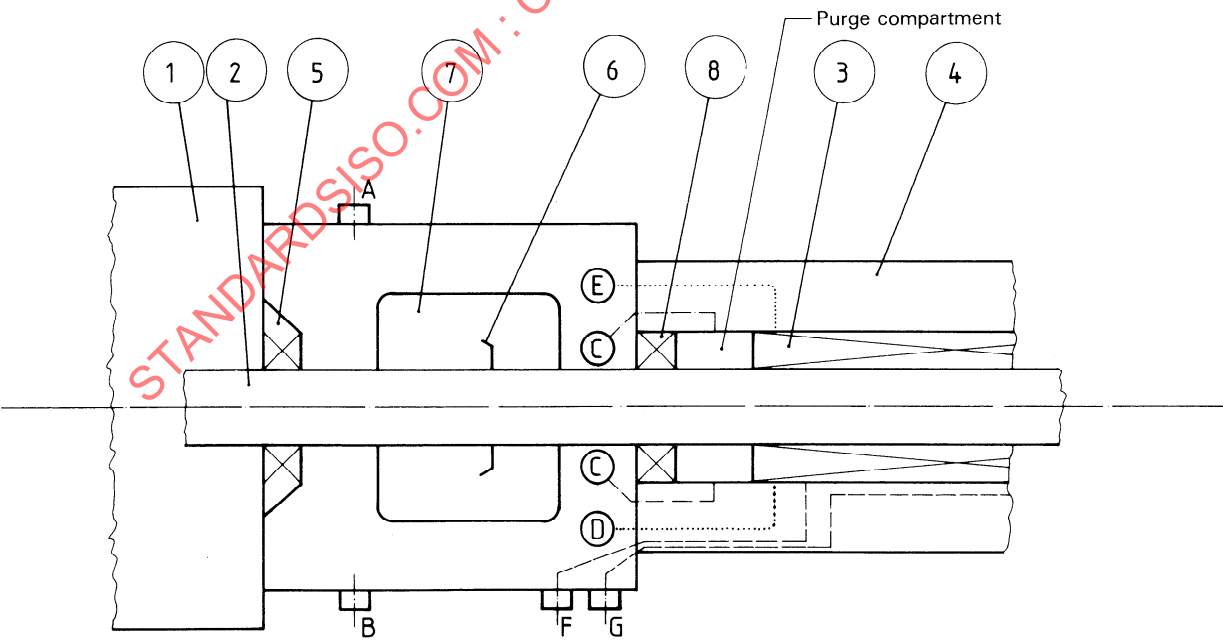


Figure 5 — Long distance piece with purge compartment inside the pressure packing

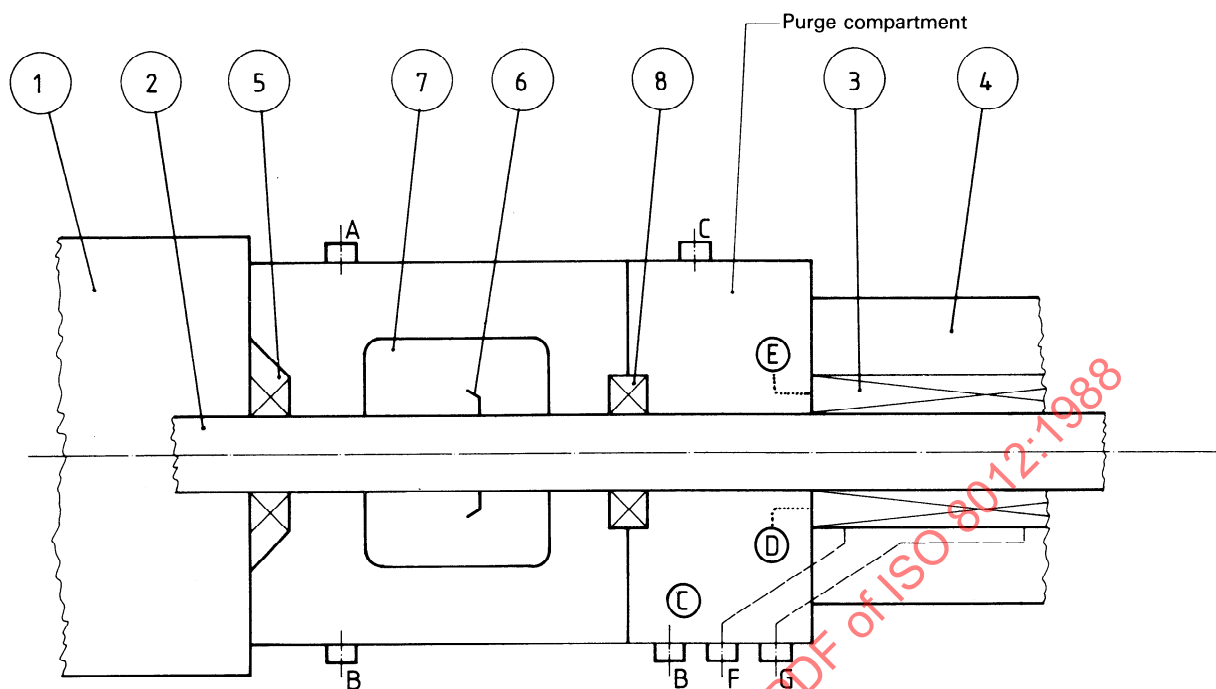


Figure 6 — Short two-compartment distance piece

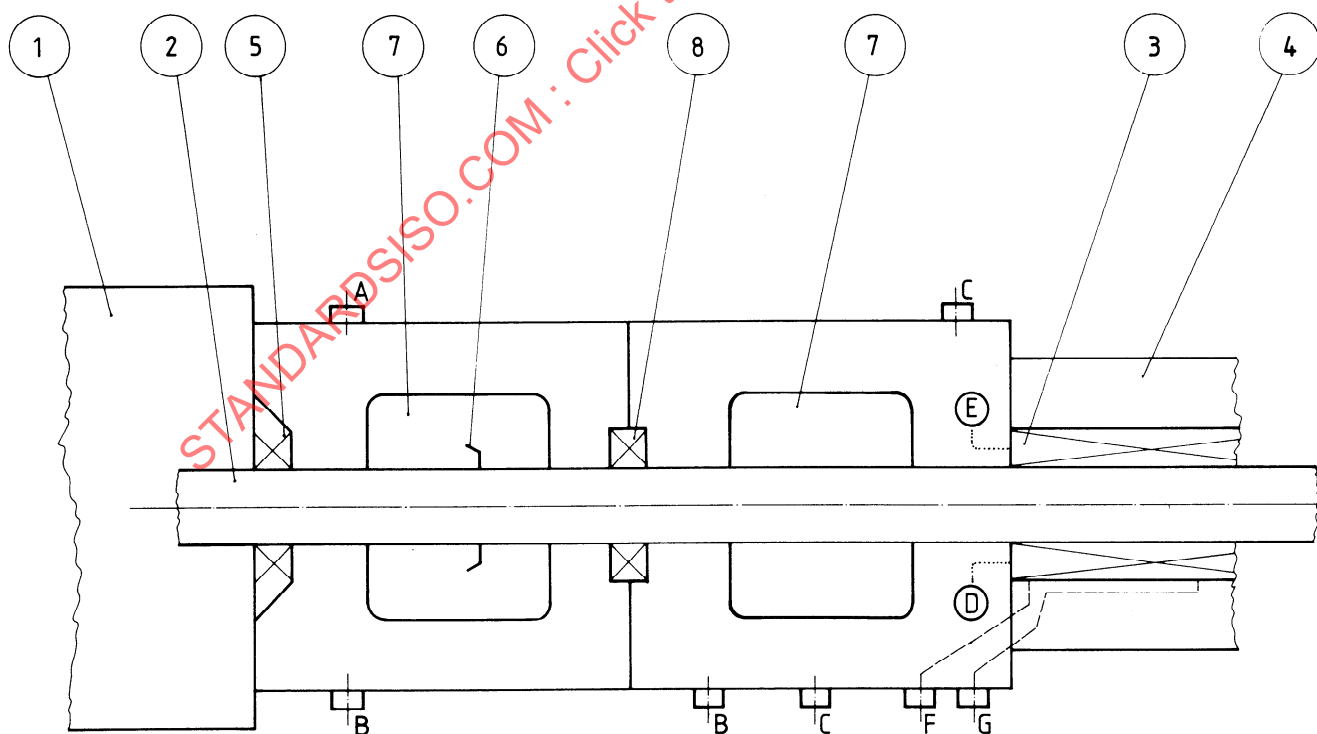


Figure 7 — Long two-compartment distance piece

Various types of coolant system may be used as follows.

- a) Forced liquid coolant circulation is required
 - 1) for maximum expected gas discharge temperatures above 95 °C ;
 - 2) for a temperature difference, between the gas inlet and the maximum expected discharge, greater than 80 K ;
 - 3) where cylinder unloading is used for capacity control and not only for unloaded start-up.

A forced coolant system shall be designed for an effective pressure of at least 5 bar working pressure and for a maximum pressure drop of 1 bar. The recommended flow rates shall be calculated on the basis that the increase in temperature is not greater than 35 K.

- b) A thermo-syphon coolant system may be supplied
 - 1) for maximum expected gas discharge temperatures up to 95 °C ;
 - 2) for a temperature difference, between the gas inlet and the maximum expected discharge, up to 80 K ;
 - 3) where cylinder unloading is used for start-up only.
- c) A static filled coolant system may be supplied
 - 1) for maximum expected gas discharge temperatures up to 80 °C ;
 - 2) for a temperature difference, between the gas inlet and the maximum expected discharge, up to 80 K ;
 - 3) where cylinder unloading is used for start-up only.
- d) For gas inlet temperatures below 0 °C, special consideration shall be given to the cooling arrangements.

For a closed liquid system, provision for the expansion of the liquid shall be incorporated.

7.10.6 Gas condensation

The cylinder cooling system provided shall be such as to prevent gas condensation which may dilute or remove lubricant or cause knocking. The required instrumentation shall be provided by the SUPPLIER. The cylinder coolant inlet temperature shall be a minimum of 5 K above the incoming gas temperature or a minimum of 5 K above the gas dew point temperature.

The SUPPLIER shall state in the instruction manual the minimum coolant temperature which is acceptable with regard to the condensation of liquids on the cylinder walls.

7.10.7 Coolant to gas leakage

When flammable, toxic or corrosive gas is handled, the cylinder cooling system shall be designed to prevent positively leakage of gas into the coolant and of coolant into the gas. The cooling compartments of cylinders and cylinder covers shall be connected by an external pipe or piped separately (i.e. a gasket, or gaskets with vents, are not permitted as a means of sealing the gas space from the coolant space).

Wet cylinder liners are not permitted for corrosive gases.

7.11 Valves

7.11.1 Fitting

Valve and valve port design shall be such that no inlet valve can be fitted instead of a discharge valve and that no discharge valve can be fitted the wrong way round.

7.11.2 Seats

Valve seats shall be removable. If gaskets are used between the valve seat and the cylinder, they shall be made of metal.

7.11.3 Plates

Metallic and non-metallic valve plates which can be installed with either side as the sealing surface shall have, on both sides, a surface finish which will produce an adequate seal on the valve seat.

7.11.4 Stops and bolts

Valve chambers or valves shall be designed so that neither the valve stop nor the valve bolt can drop into the cylinder in the event of failure or slackening of the bolt.

7.11.5 Springs

Ends of helical springs shall be ground parallel or provision shall be made to prevent damage to valve plates.

7.11.6 Hold-downs

Valve hold-downs shall bear reliably on the valve at not less than three points. Valves shall not be held down by the valve centre bolt. Valve hold-downs using a crab-type three-point loading may be used.

7.11.7 Unloaders

Automatically operating unloaders for compressors handling flammable gases shall be so designed that air used for unloading cannot be mixed with the gases being compressed, even in the event of diaphragm or other failure. A tapped gas vent connection shall be provided at the stem packing.

7.12 Piston and piston rod

7.12.1 Materials and design

The SUPPLIER shall specify in the data sheets the materials and design of piston rings and guide rings.

Where, in non-lubricated compressors, guide/bearer rings over-run valve ports, the SUPPLIER shall be able to demonstrate satisfactory experience with the design.

7.12.2 Venting

Hollow pistons shall be self-venting without removal of the piston rod.

7.12.3 Piston rods

Piston rods for non-lubricated compressors and for lubricated compressor packings shall be surface hardened in the packing areas to a minimum Rockwell hardness of 56 HRC. Special consideration shall be given to the hardness of the packing area when corrosive gases are present.

7.13 Pressure packings

7.13.1 Materials and design

The SUPPLIER shall specify the materials and design of all pressure packings.

7.13.2 Liquid cooling

The SUPPLIER shall specify whether liquid-cooled pressure packings are to be used. In this connection, only packings with direct liquid cooling of packing cups shall be termed as liquid cooled.

7.13.3 Radial clearance

In either lubricated or non-lubricated service, adequate radial clearance shall be provided for the piston rod and packing rings to eliminate possible contact when maximum wear of the guide rings or piston wear bands occurs.

7.14 Rating plates and rotation arrows

Rating plates and rotation arrows shall be fixed to the equipment at a clearly visible point. Rating plates, rotation arrows and their fixing pins shall be made of stainless steel or Monel.

The following minimum data shall be clearly stamped on the rating plate:

- a) manufacturer;
- b) model designation and serial number;
- c) flow rate;
- d) input drive shaft speed.

7.15 Special tools and lifting gear

The SUPPLIER shall supply the special tools (e.g. installation tools for pistons, piston rods, cross-head pins and valves) required for practical assembly and maintenance. If there is a danger or difficulty in dismantling because of jamming after long service, the fitting parts shall be provided with tapped holes for jacking screws. The jacking screws shall also be provided. Machine parts that cannot be lifted by one person without danger shall be fitted with suitable devices for attaching them to lifting gear. If several machines needing the same tools are installed in the same location, only one set of tools will be supplied for all the machines. The SUPPLIER shall supply operating instructions for special tools. Standard tools shall not be included in the supply.

7.16 Weather protection and environmental conditions

The USER shall specify in the data sheets whether the installation is indoors, heated or unheated, or outdoors, with or without a roof. He shall also specify the weather and environmental conditions under which the compressor must operate, including the maximum and minimum temperatures.

Compressors and their auxiliaries shall be equipped by the SUPPLIER to ensure proper operation in the atmosphere specified by the USER. If heating is necessary, the USER shall state what the heating medium shall be. The SUPPLIER shall specify in the data sheets what additional equipment is necessary for weather protection.

7.17 Consideration of gas properties

7.17.1 General

The USER shall specify in the data sheets the exact gas analysis and shall draw the SUPPLIER's attention to any particular gas properties that are important for the design and operation of the compressor. This applies amongst other things to gas properties such as corrosiveness, toxicity, tendency to dissociation shocks, polymerization and condensation, and to dangers of explosion and fire, and to increases in corrosiveness, e.g. in the presence of traces of water or other substances.

The USER shall be responsible for advising the SUPPLIER where liquid may be present in the compressor inlet lines.

The SUPPLIER is not relieved of his responsibility to take into account carefully the gas properties and to arrange the design, selection of materials and operating instructions to ensure reliable and economic operation.

Where the thermodynamic properties of the gas to be compressed have not been specified by the USER, the SUPPLIER shall, on request, state the data on which the design has been based and the origin of these data.

7.17.2 Deposits

When solid deposits result from certain pressures, temperatures or impurities, either these pressures and temperatures shall be avoided under all possible service conditions or care shall be taken that separation will take place in devices specially designed for this, or provision shall be made for cleaning, e.g. by the injection of cleaning agents or by cleaning at standstill. Special reference shall be made in the instruction manual to the danger resulting from deposits on pistons, cylinder covers etc.

7.17.3 Low temperatures

Extremely low temperatures shall be taken into account in the design and selection of materials. The materials used shall be such that their mechanical properties do not deteriorate when there is a decrease in temperature from ambient temperature to low temperatures, as may occur during the process.

7.17.4 Explosive mixtures

The formation of explosive or of otherwise hazardous gas mixtures shall be prevented by the mode of operation, e.g. by purging before starting and stopping.

7.17.5 Non-metallic sealing elements

In oil-lubricated compressors which handle gases detrimental to the lubricant properties, non-metallic sealing elements shall be considered.

7.17.6 Non-lubricated compressors

In cases where liquid lubricants are not desirable, non-lubricated compressors shall be used. The piston and piston rods can be sealed either by sealing elements of self-lubricating materials or by contact-less labyrinth sealing.

For compressors handling corrosive gases, the corrosion of piston rods, packing cups, valves and cylinder liners shall be prevented by the use of corrosion-resistant materials.

For all installations other than heated indoor installations, even when non-corrosive gases are pumped, the piston rods and packing cups shall be made of corrosion-resistant materials.

8 Driver and drive equipment

8.1 General

8.1.1 The USER shall specify in the enquiry the type of driver required, e.g. electric motor, steam turbine, diesel, dual fuel or gas engine.

8.1.2 The drive system may be of the belt, gearbox, direct connected or integral types as appropriate.

8.2 Driver

8.2.1 The USER shall specify in the enquiry the standards, codes and classification applicable to the driver. He shall also provide the technical data necessary for the driver design, e.g. type of motor, electrical supply characteristics and steam conditions.

8.2.2 The continuous rated power of the driver shall be selected to be at least 110 % of the maximum driver coupling power (shaft input power plus transmission losses) required by the compressor, taking into account all process variations (including start-up) which have been specified by the USER.

NOTE — This 10 % margin covers any power required for the tolerances on flow rate and specific energy requirements [see 6.4.1, a) and b)].

The driver shall be designed for an overload of 10 % above the nominal rating to allow, for example, for running at relief valve set pressure.

8.2.3 The USER may indicate in the data sheets his preferred method of achieving unloaded starting. If the method is not stated, the SUPPLIER shall show in the data sheets the method to be adopted.

Where unloaded starting by suction valve unloaders is provided, the driver shall be capable of starting the compressor from a stopped condition and of running up to full speed when each cylinder contains gas at its rated duty suction pressure.

Allowance shall be made for any resistance effects which occur during unloaded starting (e.g. backwards and forwards gas flow through unloaded suction valves).

Where unloaded starting is not adopted, the driver shall be capable of starting the compressor from a stopped condition and of running it up to full speed, taking into account the fact that the compressor commences compressing against its rated discharge pressure from start-up.

8.2.4 When the driver is part of the SUPPLIER's supply, the SUPPLIER shall check the driver starting torque characteristic to ensure that the set will come up to speed.

When the driver is not part of the SUPPLIER's supply, the SUPPLIER shall provide the USER with the compressor and transmission starting torque characteristics together with all inertia values, the shaft speed irregularity and any requirements that the SUPPLIER has for the value of the driver inertia.

8.2.5 When requested, the driver shall be equipped with a trip speed switch and account shall be taken of the variations in this speed. In addition, the trip speed shall be such as to prevent the compressor from running at a speed either greater than the maximum allowable speed or lower than the minimum allowable speed.

8.3 Couplings

8.3.1 Couplings shall be suitable for the maximum (e.g. trip) speed, the maximum torque (including stopping under full-load conditions) and the highest torque fluctuation, taking into consideration the values of torque carry through and torsional vibration established by the shaft system analysis. In no instance shall the mean power transmission capability of the couplings, on a continuous operation basis, be less than twice the maximum shaft input power of the compressor.

8.3.2 The replacement of parts liable to wear shall be possible without disturbing the driver shaft or the other main drive components.

8.3.3 Couplings shall be suitable for expansion and other end movements of the shafts. When the driver has free axial float, this shall be taken into account in the design of the coupling so that the driver rotating element is centred under all operating conditions.

8.3.4 Couplings shall be designed to allow uncoupled operation of the driver, where the design of the driver permits such operation.

8.4 Gears

8.4.1 Gears shall be designed to take into account cyclic torque variations as specified by the SUPPLIER. In no instance shall the mean power transmission capability of the gear, on a continuous operation basis, be less than twice the maximum shaft input power of the compressor.

8.4.2 Thrust bearings, if provided, shall be sized to cater for axial thrust forces transmitted by the input and output couplings as well as any axial gear forces.

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

8.5 Belts

Belts shall be oil resistant and antistatic.

8.6 Guards

8.6.1 The USER shall specify in the data sheets the relevant codes or standards for the guards.

8.6.2 Guards shall be provided on all moving parts which may be hazardous to personnel.

8.6.3 If guards are not easily removable, access openings (if necessary, with covers) shall be provided in flywheel guards for barring the machine and to provide access to timing marks over the wheel centre or to any other parts which may require attention.

8.6.4 Guards shall be strong enough to prevent any mechanical contact with the coupling or shaft as a result of a load of 1 000 N.

8.6.5 Unless otherwise specified, guards shall be supplied by the SUPPLIER.

8.7 Barring device

8.7.1 Means shall be provided for barring over the compressor. Where barring cannot conveniently be operated by one man, power assistance shall be provided.

8.7.2 The data sheets shall specify whether the USER or the SUPPLIER shall supply the barring device.

9 Auxiliary equipment

9.1 General

9.1.1 All auxiliaries which come within the scope of pressure vessel codes (including gas coolers, pulsation dampers, silencers, separators and traps) shall be designed, manufactured, inspected and tested in accordance with any recognized

code specified by the SUPPLIER in the data sheets unless the USER specifically invokes a particular code at the time of enquiry.

9.1.2 All pressure vessels and pipework shall be designed to withstand gas pulsations and mechanical vibration which may be applied in service. The SUPPLIER shall advise his subcontractors of the conditions which are expected to exist so as to ensure proper design.

9.1.3 All pipework connections on auxiliaries shall be to the SUPPLIER's selected national standard, appropriate to the application, except where they form terminal points of connection to the USER's supply, in which case they shall be supplied in accordance with the USER's requirements if specified.

9.1.4 If so instructed by the USER, and at an agreed extra cost, the SUPPLIER shall study information provided by the USER on all piping and equipment (pulsation damping devices, coolers, separators or other vessels and so on) which are not of the SUPPLIER's supply and shall advise on any knowledge he has of their unsuitability for operation in conjunction with the compressor and auxiliaries of the SUPPLIER's supply. (See also 9.4.)

9.1.5 Suction vessels shall be self-draining so that any liquid entering, or condensing within, will not accumulate and be carried over to the cylinder in slugs. This applies to vessels on horizontal and vertical cylinders.

Any vessel connected to the delivery of a cylinder should be arranged to drain away from the compressor to avoid liquid running back into the machine when it is idle. (See also 7.10.2.)

9.2 Gas coolers

9.2.1 The fouling factor to be used for the water side of coolers shall be agreed between the SUPPLIER and the USER but in no case shall it be less than those values given in table 2.

Table 2

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

9.2.2 The water side of coolers shall be designed for a maximum working effective pressure of 6 bar and a maximum pressure drop of 1 bar.

9.2.3 If not otherwise specified, the increase in temperature of the cooling water shall be not less than 8 K through any one cooler, subject to the final water outlet from the coolers not exceeding 45 °C.

9.2.4 An approach temperature (i.e. gas outlet temperature minus coolant inlet temperature) of 10 K shall be used unless specified otherwise by the USER.

9.2.5 Coolers shall be fitted with G 3/4 minimum drain and vent bosses on the liquid side. These connections shall be fitted with cocks by the SUPPLIER. Coolers with gas on the shell side shall have a flanged drain connection on the shell.

9.2.6 Shell-and-tube-type coolers may have fixed tube plates at the SUPPLIER's option unless the USER stipulates removable tube bundles.

9.2.7 For shell-and-tube-type water-cooled coolers, the material for the tubes shall be selected to suit gas- and water-side conditions. Tubes shall have a minimum wall thickness of 1,5 mm and the tubes for conveying water shall have an inside diameter of not less than 15 mm. The USER shall specify any special design specifications which he wishes to be applied.

NOTE — If plain carbon steel tubes have to be used, they shall have a wall thickness of not less than 2 mm (except by instruction of the USER) as these tubes are liable to be affected by water-side corrosion.

9.3 Separators and traps

9.3.1 Where liquid (e.g. oil, water or liquified gas constituents) will be present at any cooler outlet at any specified operating conditions (including stand-down conditions), an appropriate separator device shall be installed. The USER shall state, at the stage of enquiry, whether this separation equipment shall be furnished by the SUPPLIER.

9.3.2 The USER shall provide in his enquiry adequate data to enable the SUPPLIER to establish whether liquefaction of any substance will occur in coolers or he shall state the quantity and nature of liquefaction at each stage cooler outlet.

9.3.3 If no level alarm is fitted, then interstage separators shall provide a storage volume, to avoid carryover, of not less than 1,25 times the liquid quantity calculated to be separated during the length of the attendance interval (see 7.2).

9.3.4 For continuously running machines, auto-drain traps, if fitted, shall be provided with isolating valves to allow trap maintenance while the compressor is running.

Drain traps shall incorporate balance connections where necessary.

A hand-operated blow-down shall be provided and arranged so that it can be operated even when any drain trap is being serviced.

A typical schematic illustration of the stipulations given above is shown in figure 8.

Auto-drain traps shall be designed to prevent, in normal circumstances, the escape of gas into the drainage system.

Traps shall be suitable for any liquid or liquid mixture which it is calculated will be present in the compressed gas.

The USER shall make provision for the checking of the flow and shall provide, when necessary, cold weather protection for traps and the drainage system.

9.3.5 Pipe connections to drain valves and traps shall be size DN 20 as a minimum; for effective pressures greater than 60 bar, the minimum size used shall be DN 10.

9.3.6 The USER shall arrange his drainage system to dispose safely of any process gas which gains access to the drainage system.

9.4 Gas pulsation damping and pipe vibration

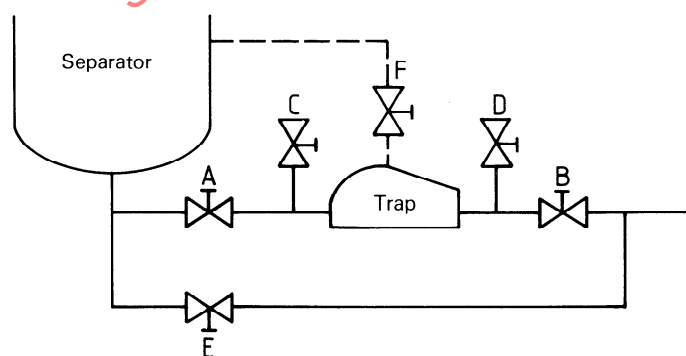
9.4.1 Piping and coolers of the SUPPLIER's supply shall be protected by the SUPPLIER, when he considers it necessary to do so, by the fitting of snubbers, volume bottles or other pulsation damping devices.

9.4.2 When specified by the USER, the SUPPLIER shall supply pulsation damping devices for intakes and discharges leading to and from the compressor. These pulse dampers shall be guaranteed to limit the line side pulsation amplitude to values not greater than the values given by lines X, Y or Z of figure 9.

For effective pressures greater than 10^3 bar, the allowable peak-to-peak pulse shall be agreed upon.

Unless otherwise specified by the USER, the pulsation damping requirements may be satisfied by providing

- a) a volume bottle, orifice system etc. designed using standard analytical techniques;



- A, B trap isolating valves
- C, D vents, if required
- E hand-operated blow-down valve
- F balance line isolating valve

Figure 8 — Auto-drain trap

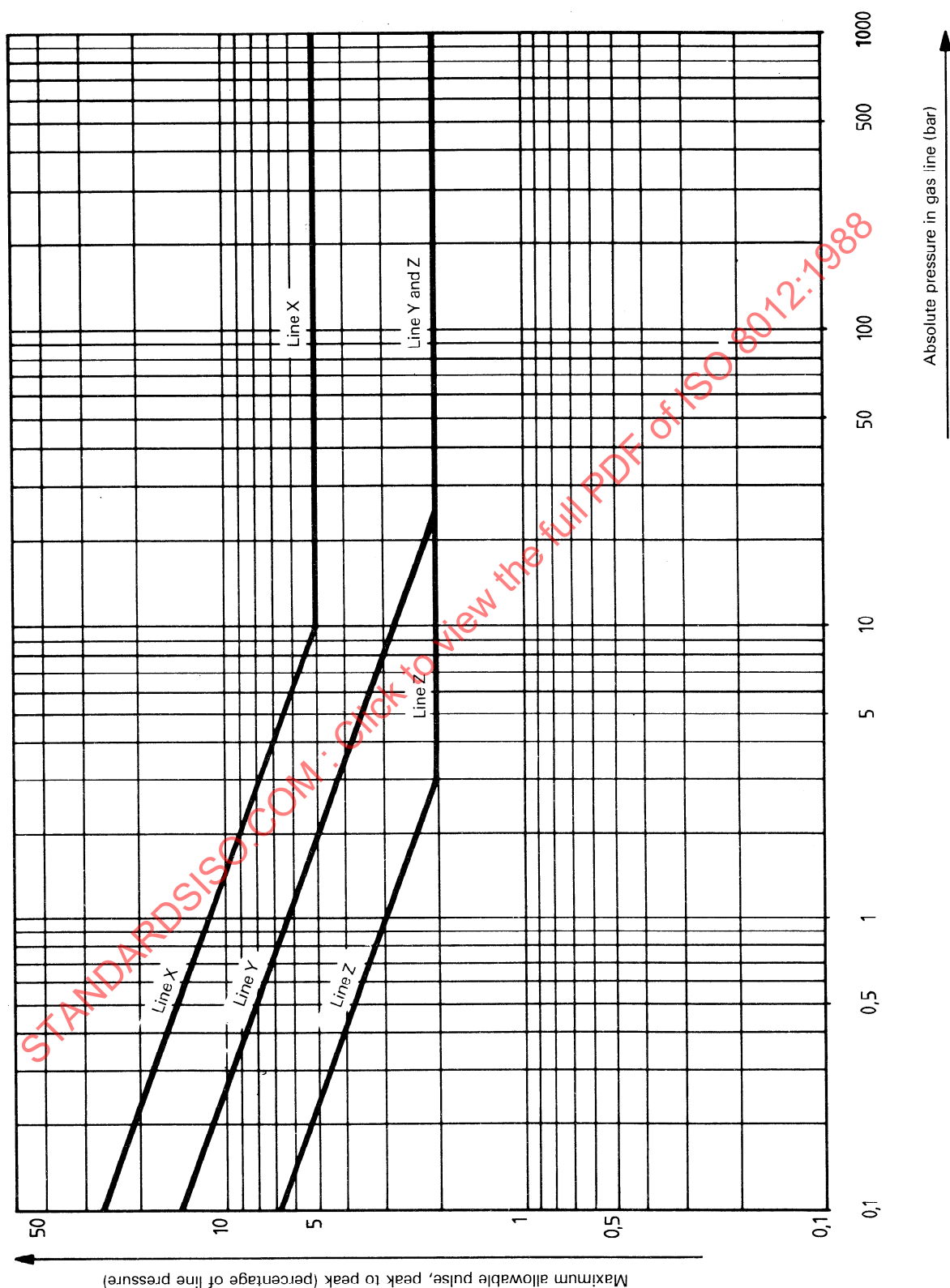


Figure 9 — Maximum allowable pulse

b) a commercially available pulsation snubber designed using proprietary techniques or by carrying out an evaluation according to c);

c) a digital or analogue computer evaluation of the piping, compressor and vessel system.

The use of lines Y or Z may be specified by the USER. Otherwise, the SUPPLIER shall use line X.

The volume of any capacity vessel snubber or cooler, or any compartment of such a capacity vessel snubber or cooler, connected directly to the cylinder of a compressor, shall be designed to prevent acoustical resonance within the cylinder to the vessel nozzle and compressor valve chamber.

9.4.3 When a computer analysis is required (and this would normally only be justified for complex or large systems) it may show that devices such as those specified in 9.4.2, a) or b), are not required. However, such an analysis shall show that the recommended system

- a) minimizes the gas pulsation amplitude;
- b) eliminates the coincidence of gas pulse and mechanical natural frequencies in the piping;
- c) minimizes the forces due to the pressure pulsations so that the piping vibrations may be controlled by conventional piping support techniques.

The pulsation-induced cyclic stresses shall not equal or exceed the endurance limit of the material.

9.4.4 G 1/2 pulse test connections shall be provided at each pulsation damper inlet and outlet nozzle. Minimum external drain connection(s) of G 3/4 or DN 20 shall be provided and arranged so that the vessel will drain completely in its mounted position.

9.5 Air or gas filters

9.5.1 For atmospheric air compressors, the USER shall specify the nature of atmospheric pollution adjacent to the compressor intake filter position, including reference to any vapours or fumes which could affect the compressor.

Provision shall be made to prevent the icing up of air filters where atmospheric conditions make this necessary.

9.5.2 The USER shall state in the data sheets the places where dust or other debris will come through the system continuously or in large quantities from time to time.

The SUPPLIER, unless otherwise specified, shall include in his supply for a suitable permanent filter if required to protect the compressor from this dust or debris.

9.5.3 Temporary strainers shall be incorporated by the SUPPLIER for commissioning purposes for any intake to the compressor from the USER's piping and/or system vessels. These strainers are for the purpose of protecting the compressor until the system has been shown to be clean of pipe scale or other

fine debris. Provision shall be made to ensure that the pressure drop does not become excessive.

Such temporary suction strainers shall be constructed of non-corroding materials and shall be strong enough not to collapse even when 50 % of their free passage area is blocked.

NOTE — This does not supersede the requirement to ensure that the piping upstream of such strainers is cleaned (see 9.6.17).

9.6 Pipework (general)

9.6.1 The process gas pipework is that pipework which carries the gas being pumped by the compressor.

The auxiliary pipework systems are as follows:

- a) lubricating oil (frame and cylinders);
- b) cooling water;
- c) drain, vent and purge (excluding those containing process gas);
- d) control air and instrument air.

9.6.2 The pipework provided by the SUPPLIER for each circuit shall be defined by him according to the following categories.

Category 1: Piping completely fabricated and installed at the SUPPLIER's works but which may be removed for transportation. Any removal shall be done in such a way that the pipework will merely require assembly at the site.

Category 2: Part of the pipework is fabricated and installed at the SUPPLIER's works (and, as in category 1, may be removed for transportation). The remainder of the SUPPLIER's supply is provided as category 3 or 4, as may be defined by him.

Category 3: Pipework fabricated to match the intended site arrangement but supplied with closing lengths for final fabrication at site.

Category 4: Piping supplied as straight lengths (or coils as appropriate) with bends and other fittings necessary for fabrication at site to an agreed arrangement of pipe runs or to an agreed quantity.

9.6.3 The SUPPLIER shall supply all pipework to interconnect items of his supply, reducing the number of terminal points for the USER's connection to a minimum, provided that the position of equipment and the routing of pipework has been agreed.

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

9.6.5 The SUPPLIER shall supply all jointing and bolting together with mating flange/coupling for all connections to which the USER couples if not otherwise specified. (See data sheet 501B for the scope of supply as it may over-ride the above requirement.)

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

9.6.7 The SUPPLIER shall always incorporate lubrication, cooling, vent and purge connections (where any of these are required) from piston rod glands to connection points on distance pieces, allowing external connecting tappings or flanged terminals to be used as take-away points.

9.6.8 Where interconnecting pipework is not part of the SUPPLIER's supply and a number of separate connections will be required between two units (e.g. the compressor and a control console) then the SUPPLIER will group the terminal points on each item of his supply in a neat compact manner appropriate to the application.

9.6.9 Unless otherwise specified, the SUPPLIER shall supply pipework to recognized national standards of his own choice.

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

9.6.11 Pipework runs lying in a horizontal plane or which might otherwise be used by personnel for support shall either be provided with guards by the SUPPLIER or be robust enough, when supported, to carry a load of 1 500 N without harmful deflection or damage.

Unguarded piping (other than local gauge, cylinder lubrication, instrument and control air and similar pipes) shall not be less than size DN 15 and shall be of a wall thickness robust enough to resist damage by accidental impact by hand, tools etc.

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

9.6.13 Where the SUPPLIER supplies pipework 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, pipe and fittings masses, pulsation and mechanically induced vibrations and imposition of strain on machine connections.

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

9.6.15 The SUPPLIER and the USER shall jointly agree on the nature of the tests to be applied by the SUPPLIER to pipework fabrications furnished by him.

9.6.16 The use of flexible joints to allow for thermal expansion and to reduce stresses in the pipework system is permitted subject to the USER's agreement. Express attention is drawn to the fact that the manufacturer of such joints shall be consulted with regard to the necessary procedures to be adopted for the installation and support of these items.

9.6.17 Pipework shall be free of loose rust, slag, welding beads and other foreign matter.

9.6.18 External tapped openings not connected to piping (except core-support-type holes) shall be sealed with removable metal plugs.

9.7 Process gas pipework

9.7.1 The maximum allowable working pressure for all gas piping and fittings shall exceed the rated discharge pressure by at least 15 % or 1 bar, whichever is the greater, and shall correspond as a minimum to the safety valve set pressure.

9.7.2 Gas piping up to size DN 50 may have screwed connections when accepted by the USER. For larger sizes and for gases which are defined by the USER as corrosive, toxic or flammable, welded or flanged connections shall be used.

9.7.3 Provision shall be made for the incorporation of low-point drains in the gas pipework.

9.7.4 For flammable, toxic or corrosive gases (i.e. where entry of air or moisture into the gas system cannot be tolerated) and in other cases where specified by the USER, the SUPPLIER shall provide size DN 20 connections at the inlet and outlet of his supply to permit venting and purging of the compressor and piping system.

9.7.5 Drain lines, other than from instruments or controls, shall be of size DN 20 as a minimum; however, for effective pressures greater than 60 bar, a minimum size of DN 10 is permitted.

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

9.8 Process gas relief valves

The specifications concerning process gas relief valves are as follows.

- a) Relief valves shall be fitted for each stage and dimensioned for the full compressor flow rate.
- b) The set pressure shall not exceed the maximum allowable working pressure of the compressor stage.

The full-flow pressure shall not exceed the maximum allowable working pressure by more than 10 %.

- c) The USER shall state any regulations which the valves have to meet.

- d) The USER shall advise the SUPPLIER in his enquiry of any pressure which may exist on the outlet of relief valves. If such pressure is a variable, it shall be stated.

- e) The relief valves shall be mounted in such a manner that their setting is not disturbed by vibrations. The outlet from relief valves shall not constitute a hazard to the personnel.

f) Where gas-side fouling of coolers may occur, the relief valves shall be situated upstream of the cooler.

g) Bursting discs may be supplied instead of relief valves with the agreement of the USER.

9.9 Auxiliary pipework

9.9.1 Auxiliary piping may be supplied as non-ferrous alloy, stainless or carbon steel or as non-metallic materials, where non-metallic materials are agreed upon between the USER and the SUPPLIER.

Auxiliary piping and fittings shall be of types and material suitable for the duty and as considered acceptable by the SUPPLIER (e.g. compression- or bite-type connectors may be used with appropriate piping for instrument air etc.) unless otherwise specified by the USER in the data sheets.

For connections of less than size DN 25 which are used for gauge lines, lubrication lines etc., screwed connections as well as welded or flanged connections may be provided for all services (auxiliary).

9.9.2 Water piping up to size DN 50 may have screwed connections. For sizes greater than DN 50, welded or flanged connections shall be used.

9.9.3 Water pipework shall be fitted with high-point vent and low-point drain connections such that the entire system may be vented and drained.

9.9.4 Auxiliary pipes downstream of the oil filter and made of carbon steel shall be pickled after fabrication. When site erected, all piping between the filter and the compressor bearings shall be made of austenitic stainless steel.

9.9.5 Each parallel water circuit shall incorporate a flow indicator and a flow-regulating valve. Parallel circuits shall be provided with isolating, drain and vent valves (or cocks as appropriate) to allow drainage of any one circuit for the maintenance of equipment associated with it. Provision shall be made for measuring the pressure drop across the coolers.

9.10 Platforms, stairs and railings

9.10.1 The USER shall instruct the SUPPLIER if he requires him to supply platforms (with stairs and rails) and shall also inform him of any relevant safety codes or other rules and regulations pertaining to the construction of such items.

They shall be positioned such that the operator may gain access to all areas where routine maintenance or operator inspection is necessary. Their positioning, however, shall not interfere with the maintenance of any parts with respect to accessibility or lifting.

9.10.2 Stairs shall be no steeper than 50°, anything above this being classed as a ladder.

Platforms/floors shall be of grid or plate construction and fitted with kick plates. All open sides shall be guarded with two safety rails set at 1 050 and 600 mm above the platform. Stairs or ladders of more than four risers shall have a safety rail on one side as a minimum.

9.10.3 The structure shall be protected from corrosion. Plated floors shall incorporate a non-slip paint or similar finish.

9.11 Electrical equipment (ancillary)

9.11.1 Unless otherwise specified, ancillary electrical equipment shall comply with the safety specification relating to the main driver and instrumentation.

9.11.2 The SUPPLIER shall completely describe any ancillary electrical equipment in his supply, detailing its type, rating, safety codes and function.

9.11.3 The SUPPLIER shall state his scope of supply, and shall define the electrical wiring etc. to be undertaken by the USER for such ancillary equipment.

10 Lubrication

10.1 General

10.1.1 Lubricant quality

The SUPPLIER shall specify in the data sheets the lubricant quality to be used in the motion work and cylinder lubrication systems (see also 10.3.6).

10.1.2 Supply to other equipment

The USER may use lubricant from the motion work lubrication for his own needs, e.g. for the lubrication of drive motor bearings, if this is approved by the SUPPLIER.

The furnisher of the equipment furnished with lubricant from the motion work lubrication system shall indicate to the SUPPLIER of the system his requirements as follows:

- a) the lubricant flow rate (minimum, normal and maximum);
- b) the lubricant pressure (minimum, normal and maximum);
- c) the lubricant's physical characteristics;
- d) the heat to be dissipated;
- e) the degree of filtration;
- f) the lubricant temperature limits.

10.2 Motion work lubrication

10.2.1 Lubrication system

Machines with a maximum shaft input power of 150 kW may utilize splash lubrication. For shaft input powers greater than 150 kW, the motion work shall have a pressure lubrication system to all bearings and cross-head guides.

10.2.2 Scope of supply

Unless otherwise specified, pressure lubrication systems shall be supplied complete by the SUPPLIER with all parts, safety devices and instruments necessary for safe operation of the compressor. The lubricant pump may be driven by a separate motor or from the crankshaft either directly or by chain or gear-box, but not by belts.

If specified by the USER in the data sheets, duplex filters, double coolers and/or an additional lubricant pump (standby lubricant pump) shall be supplied.

10.2.3 Standby lubricant pump

The standby lubricant pump shall have the flow rate and discharge pressure rating required for normal continuous operation.

The standby lubricant pump shall be automatically started to provide lubricant and to maintain operation before reduction in pressure below a safe level.

10.2.4 Relief valve

Lubricant systems shall be provided with a full flow rate relief valve with a return line piped to the lubricant reservoir.

10.2.5 Lubricant reservoir

The lubricant reservoir may form part of the crankcase or be separate from the compressor. The lubricant reservoir shall be suitably vented to avoid the ingress of contaminant. A suitable, locally mounted and protected lubricant level gauge indicating the maximum filling, maximum operating and minimum operating levels shall be supplied.

10.2.6 Lubricant heating

When specified or when necessary owing to ambient conditions, a removable steam heating element or a thermostatically controlled electrical immersion heater shall be provided for heating the lubricant prior to start-up in cold weather.

The heating device shall have sufficient power to heat the lubricant in the reservoir from the specified minimum site ambient temperature to the SUPPLIER's minimum required temperature in 12 h. If an electrical immersion heater is used, it shall have a maximum energy dissipation of 2,5 W/cm².

If steam heating is employed, the operating lubricant shall not be in direct contact with the steam pipe. If a failure of steam heating piping occurs, it shall not allow water to enter the compressor lubrication system.

When specified by the USER or considered to be necessary by the SUPPLIER, a standby lubricant pump shall be installed to allow operation of the lubricant system during standstill periods of the compressor, thus allowing lubricant warm-up (to enable compressor start-up in low ambient temperatures).

10.2.7 Lubricant filter

For compressors with pressure lubrication, the SUPPLIER's standard full-flow filter shall be supplied provided that it is capable of filtration of 40 µm particles, or finer if the bearing design requires it.

If continuous operation is necessary, i.e. if shut-down for filter cleaning should be avoided, full-flow duplex filters or self-cleaning filters shall be used. Duplex filters shall provide full flow during switch over.

The lubricant filter shall not be equipped with a relief valve or by-pass. Filter cartridge materials shall be corrosion resistant. The clean pressure drop shall not exceed 0,35 bar at the normal operating temperature.

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

Filters shall be located downstream of the coolers.

10.2.8 Lubricant cooler

Lubricant coolers may be air cooled or water cooled. The latter shall be of the shell-and-tube type with water inside the tubes.

Coolers shall be equipped with vent and drain connections on the lubricant and water sides. For water-cooled units, cooler tubes shall be made of corrosion-resistant material with an outside diameter of not less than 10 mm and a wall thickness of not less than 1 mm.

Removable bundle design is not required unless specified by the USER.

If specified by the USER, twin coolers shall be provided. Each cooler shall be sized for the total heat load.

Coolers shall be suitable for lubricant systems operating at a pressure of not less than the relief valve setting.

Unless otherwise specified, the lubricant cooler materials shall be as follows:

- a) shell coolers shall be made of steel;
- b) channels and covers shall be made of steel or cast iron;
- c) tube sheets shall be made of steel or 60 Cu-40 Zn alloy;
- d) tubes shall be made of brass.

The fouling factor to be used for the water side of coolers shall be agreed between the SUPPLIER and the USER but in no case shall it be less than the values shown in table 2.

10.2.9 Schematic piping and instrumentation diagram

The schematic illustration shown in figure 10 outlines the typical requirements for motion work lubrication systems. This figure is given for guidance only.

Alternative designs are indicated in table 3.

Table 3

Equipment	Alternative
Main oil pump	Shaft driven Separately driven
Standby oil pump	No standby pump Hand-operated standby pump Separately driven standby pump
Cooler	No cooler Coil in crankcase Single cooler Change-over duplex cooler
Filter	Single filter Change-over duplex filter
Oil reservoir	In crankcase Separate tank

10.3 Cylinder and packing lubrication

10.3.1 General

The USER shall specify the type of lubrication in the data sheets as follows:

- a) lubricated — cylinders and pressure packings lubricated;
- b) minimum lubricated — cylinders and pressure packings lubricated, but piston rings and packing elements made of polytetrafluoroethylene or similar dry-running materials;
- c) partially lubricated — only pressure packings lubricated;
- d) non-lubricated — cylinders and pressure packings non-lubricated.

10.3.2 Scope of supply

The SUPPLIER shall supply the complete lubrication system including forced-feed equipment, piping, sight flow indicators and non-return valves for each lubrication point and all other parts that may be necessary to ensure reliable operation.

10.3.3 Lubricant feed holes

The lubricant feed to the cylinder bore shall be through a drilled hole in the cylinder material. If a pipe through a water jacket cannot be avoided, the pipe shall be made of corrosion-resistant material.

10.3.4 Lubricator

Cylinder lubricators shall have provision for operation prior to compressor start-up. All controls on the cylinder and packing lubrication system shall be adjustable while the compressor is in operation.

Minimum ambient temperature conditions shall be considered with regard to start-up.

10.3.5 Lubricant heating

For the heating of the cylinder lubricator reservoir, the requirements specified in 10.2.6 shall apply.

10.3.6 Other lubricants

The USER or the SUPPLIER shall state when the compressor cylinders have to be lubricated with lubricants other than mineral oils. The USER shall specify the lubricant composition on the data sheets unless the SUPPLIER's recommendation is desired. All materials that may come in contact with the lubricant shall be compatible with it. (See also 7.17.3.)

11 Controls and instrumentation

11.1 Flow rate control

In the enquiry, the USER shall specify in detail his requirements regarding flow rate control and unloading by filling in the respective section of the data sheets.

If the compressor has to work in parallel or in conjunction with other compressors, the USER shall specify this at the time of the enquiry.

11.2 Instruments

11.2.1 Data sheets 703B and 704B give the instrumentation applicable for reciprocating compressors.

If the USER requires special instruments or special furnishers, this shall be specified in the data sheets at the time of the enquiry.

Unless otherwise specified in the enquiry, the SUPPLIER shall quote only for the items listed in table 4, which are regarded as "normal" requirements for general applications, and will supply equipment of his own standard (see 6.3.1).

Table 4

Application	Item and/or function
Gas	Cylinders, outlet; pressure, local indicator Cylinders, outlet; temperature, local indicator
Lubricant	Sump motion work; level, local indicator Cylinders; flow rate, local indicator Cylinders, lubrication tank; level, local indicator
Coolant	Cylinders; flow rate, local indicator Gas cooler; flow rate, local indicator

11.2.2 Pressure gauges for the process gas shall be protected against gas pulsations (because of the possible damaging effect and difficulty in readability) and shall be provided with a safety window and a blow-out disc.

The minimum dial diameter shall be 100 mm. The connection shall be G 1/2. The operating pressure should not exceed two-thirds of the full-scale reading.

An isolating valve shall be fitted on all pressure gauge connections.

11.2.3 Temperature gauges shall be of the industrial type with a dial, although the glass-stem type in a metal case may be used for a location subject to mechanical vibration.

The minimum dial diameter shall be 100 mm. The connection shall be G 1/2 or Rc 1/2. Thermowells for G 3/4 or Rc 3/4 shall be provided for all thermometers. Smaller thermowells are permitted on small piping.

11.2.4 Switching instruments shall be totally enclosed, with single-pole double-throw contacts resistant to vibrations. The switches shall be mounted in such a way as to prevent them from being adversely affected by vibrations.

Contact-free and pneumatic instruments may also be used.

Instruments providing a protective function shall normally be supplied for fail-safe operation, i.e. a break of electric circuit or a loss of pneumatic pressure will actuate the protective circuit.

11.2.5 The function of all instruments shall be clearly indicated.

11.2.6 Locally mounted instruments shall be readable without the need to climb onto the compressor or pipework.

11.2.7 For step-wise flow rate control, the engaged step shall be indicated.

11.3 Panels

Panels shall be mounted in such a way as to prevent damage due to vibration.

If equipment of the USER's supply has to be incorporated in a panel of the SUPPLIER's supply, the USER shall define his requirements in the enquiry.

11.4 Wiring and piping for controls and instruments

The SUPPLIER shall state in his proposal the extent of piping and wiring which will be completed in his works. The interconnection between the unit and the panel shall be the USER's responsibility.

12 Data sheets

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

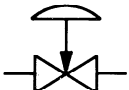
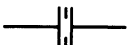
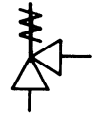
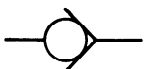
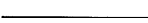
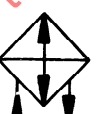
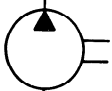
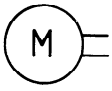
- a) the enquiry from the USER;
- b) the proposal from the SUPPLIER;
- c) the contract.

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

Key for figure 10

The use of symbols in figure 10 is according to ISO 3511-1, ISO 3511-2, ISO 3511-3 and ISO 1219.

	Differential pressure indicator		Pressure control valve (spring force to close)
	Temperature indicator		Restriction orifice
	Pressure indicator		Relief valve
	Level indicator		Check valve or non-return valve
	Pressure switch alarm		Lubricant line
	Pressure switch emergency trip		Signal line
	Pressure switch		Filter
	Flow indicator		Cooler
	Capped or plugged connection		Pump
	Valve (open during normal operation)		Electric motor

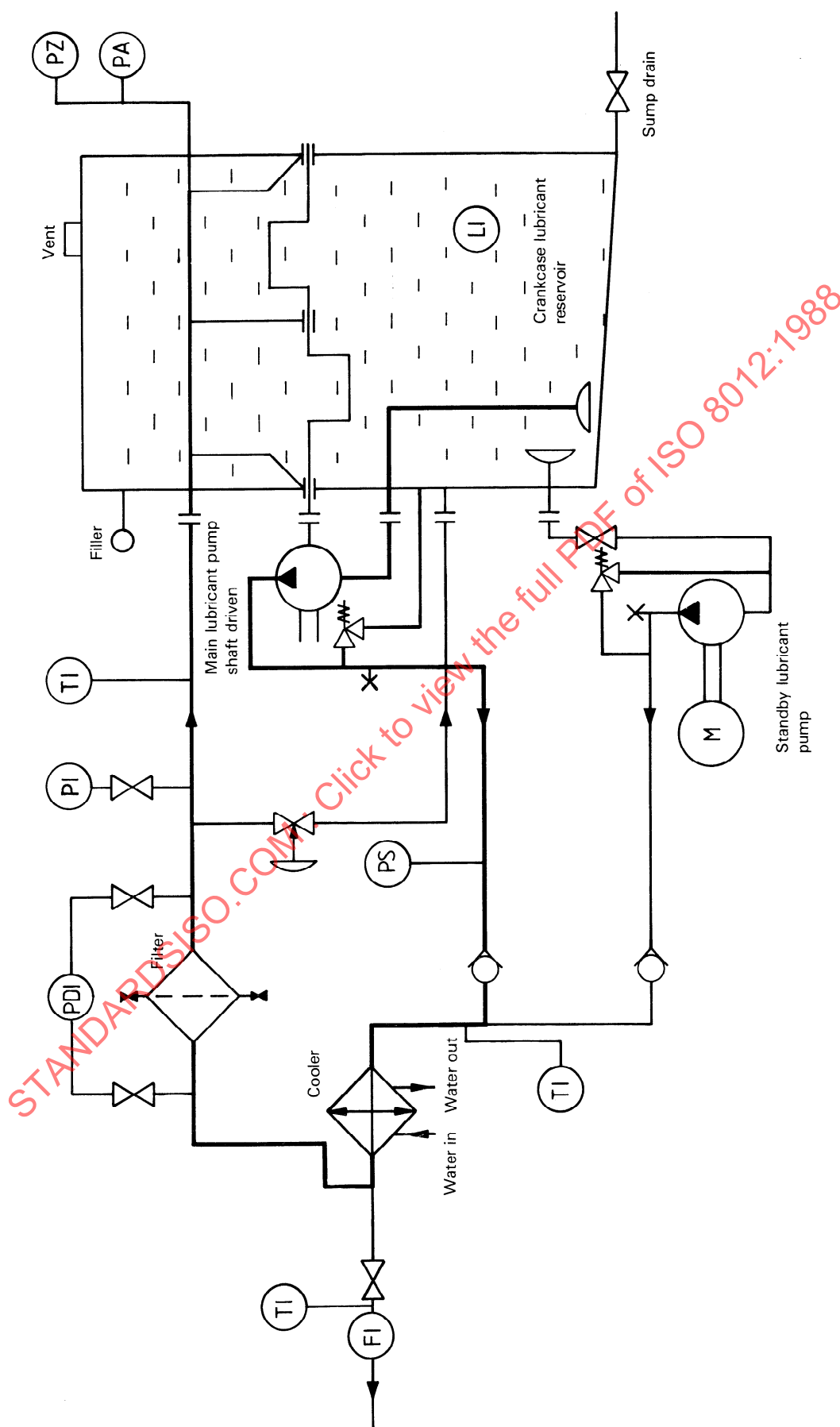


Figure 10 — A typical piping and instrumentation diagram

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 Quality control for materials of construction

A.1.2.1 Standard parts

The SUPPLIER shall indicate in the data sheets, at the time of quoting, the classes of certification and the type(s) of material test which he will provide for components of the compressor which are standard parts, i.e. components which have not been made specially for the contract.

A.1.2.2 Parts specially made for the contract

The SUPPLIER shall indicate in the data sheets at the time of quoting, the type(s) of material test which are appropriate to the defined component and shall include in his price for these tests and, unless otherwise specified by the USER, for certification by the manufacturer on the basis of an individual test of each item.

The USER shall indicate in the data sheets at the time of enquiry the class of certification which he wishes for any component made especially for the contract.

A.1.2.3 Classes of certification and types of material test

These are shown in the data sheets.

A.1.3 Hydrostatic test

A.1.3.1 The gas side of compressor cylinders shall be hydrostatically tested and the test shall be at a pressure of not less than 1,5 times the maximum allowable stage working pressure. For a working pressure greater than 2 000 bar, the test pressure shall be agreed between the USER and the SUPPLIER.

A.1.3.2 The heat exchangers and other pressure vessels shall be hydrostatically tested according to the applicable code.

A.1.3.3 The cooling jackets shall be hydrostatically tested to not less than an effective pressure of 9 bar.

A.1.3.4 The hydrostatic test shall be performed on finally machine-finished parts.

A.1.3.5 The test shall last sufficiently long to allow a complete examination of the pressurized parts. The minimum period at the test pressure shall be 30 min.

A.1.4 Sealing test

In certain cases, a gas test may be requested by the USER. In the exceptional case that a gas test is required, it shall always take place after the hydrostatic test and shall be to the maximum allowable working pressure or to 140 bar, whichever is the lower.

A.1.5 Running tests

The compressor shall be given the SUPPLIER's standard running tests in the workshop and/or at the site and these shall be indicated in the data sheets at the time of quotation.

Auxiliary equipment, including lubricant pumps, lubricant coolers, filters, alarms, trips, controls, intercoolers and aftercoolers need not be used for any shop test of the compressor unless specified in the enquiry.

Running tests shall be one of the following types.

- a) No mechanical running test: in this case, the machine shall be barred over and the SUPPLIER shall state, in the data sheets, why no running test is provided.
- b) No load running test: this test shall be over a period of 4 h minimum, shall be without pressure, with open outlet, with or without valves and shall be at the rated speed.
- c) Load running test: this test shall be over a period of 4 h minimum. It shall be a simulation of operating conditions, e.g. it shall be at the operating pressure ratio. For units of over 50 kW load, load running tests are not performed.

A.1.6 Performance acceptance tests

Performance tests (e.g. flow rate and power input) shall only be carried out when specified by the USER. The USER and the SUPPLIER shall jointly determine the nature of any required performance tests and the performance test procedure shall be in accordance with ISO 1217.

A.1.7 Dismantling for inspection after tests

Subsequent to satisfactory operation during tests, the compressor shall be examined. The standard procedure for such inspection after running and performance tests shall be as follows.

- a) There shall be a visual inspection of the condition of the bore and other parts which can be seen without disconnecting the piston-rod in any way. This inspection shall be carried out by the removal of one valve, or access may be gained through other points at each end of each cylinder. A check shall be made of the piston-to-cylinder end clearances.
- b) A visual examination of the condition of the exposed parts of the piston rods shall be made.
- c) A visual examination of the exposed parts of the cross-head guide bore, without dismantling of the motion work, shall be made.

- d) A check, by hand or using a temperature probe as appropriate, shall be made immediately after shut-down of the big-end bearings and, where accessible, the small ends and main bearings, to detect excessive temperature.
- e) One main bearing cap shall be removed for examination of the bearing shell and crank pin.

For the purpose of examining properly the unit as defined in a) to e) above, the compressor shall be barred over by hand to allow the maximum possible access.

A.1.8 Warranties

A.1.8.1 All equipment, components and spare parts supplied with the compressor 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.1.8.2 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.1.8.3 The guarantee period for spare parts supplied with the compressor shall be as stated in A.1.8.2.

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 after leaving the SUPPLIER's premises.

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 1101C 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 the data sheets.

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 1101.

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, cooling system, lubricating system, control and instrumentation, seal, vent, purge and drain shall be complete with legends, shall show the functioning of these systems and shall show the limits of supply.

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

A.4.2.5 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 USER connections ;
- g) support positions and dimensions ;
- h) the heaviest mass for normal maintenance.

A.4.2.6 The coupling drawings shall give all dimensions necessary for the detailed design of the connections between shafts, including space requirements for assembly and dismantling.

A.4.2.7 The pressure vessel drawings shall show all the elements necessary to receive the approval in accordance with the code or standard indicated in the order.

A.4.2.8 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 support and at pipe connections.

A.4.2.9 Data for pulsation analysis shall permit the party carrying out the analysis to do the necessary calculations.

Results of pulsation analysis shall constitute statements confirming the results of any pulsation analysis calculations (see 5.4).

A.4.2.10 The **list of instruments** is a summary of all instrumentation included in the supply. The following information shall be given :

- a) identification mark ;
- b) service ;
- c) manufacturer ;
- d) type ;
- e) range ;
- f) connection size ;
- g) setting values.

A.4.2.11 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.4.2.12 The **instruction manual** shall be supplied by the SUPPLIER and furnished by the date listed on data sheet 1101 but no 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 supply. It shall

- a) be indexed ;
- b) describe the compressor constructional features and the functioning 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 ;
- e) state the maximum and minimum allowable speeds ;
- f) give the maintenance schedule for the compressor and auxiliaries, including advice on the 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 reference to the danger resulting from deposits on pistons, cylinder covers, etc. ;
- i) give a recommended spare parts list ;
- j) give normal and allowable clearances between fixed and moving parts ;
- k) contain maintenance instructions for valves.

A.4.2.13 **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.4.2.14 The **performance test certificate** for the compressor shall be presented in accordance with ISO 1217 (see clause A.1).

A.4.2.15 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.

Annex B

Data sheets

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

The short-form data sheets S1B and S2B 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.

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COMPRESSOR DATA SHEET No. 201												
Re- vision	Info.	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 absolute pressure (bar)										
		Inlet temperature (°C)										
		$\gamma (= \kappa = c_p/c_v \text{ for ideal gases only})^1)$										
		Compressibility factor $Z (= pV/RT)$										
		Discharge absolute pressure (bar)										
		Discharge temperature (°C)										
		$\gamma (= \kappa = c_p/c_v \text{ for ideal gases only})^1)$										
		Compressibility factor $Z (= pV/RT)$										
		Absolute backpressure on relief valve (bar)										
		Compressor required power (kW)										
		Specific energy requirement (actual) (kJ/m ³)										
		Specific energy tolerance (%)										
		Compressor speed (r/min)										
		Driver coupling power (kW)										
		Combined driver coupling power (kW)										
		Recommended driver power (kW)										
		Driver shaft speed (r/min)										
		Type of driver ☐ electric motor ☐ steam turbine ☐ combustion engine or gas turbine										
		☐ diesel engine ☐ gas engine ☐ expander										
		☐ other :										
		Manufacturer of driver :							Furnisher : ☐ U ☐ S			
		Inlet point ☐ standard (see 5.1.4)										
		☐ other :										
		Discharge point ☐ standard (see 5.1.4)										
		☐ other :										
		Attendance interval ☐ 1 h ☐ 4 h ☐ 8 h ☐ 24 h										
		☐ no routine attendance										
		Service ☐ 3 shifts ☐ 1 shift ☐ intermittent ☐ other :										
		1) $pV^\kappa = \text{constant}$ 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										

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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/m ³										
		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 con- densing 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										
		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										

COMPRESSOR DATA SHEET No. 204											
Re-vision		Info.		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	
						☐ yes ☐ no		☐ yes ☐ no		☐ yes ☐ no	
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	
				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.											
USER to mark X in Info. column where data required in SUPPLIER's proposal											
Revision No.		Original		1		2		3		4	
Name											
Date											

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 · 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		
		Name												
		Date												

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								
			☐ skid mounted	☐ other								
		Compressor mounting	☐ rigid	☐ resilient								
		Furnisher of resilient elements	☐ USER	☐ SUPPLIER								
		Subsoil condition	☐ piled	water table :		m below ground level						
			☐ rocky									
		Earthquake susceptibility factor (give applicable standards in data sheet 207) :										
BASEPLATES, SOLEPLATES												
			Baseplates separate	Baseplates common	Soleplates	Rails						
		Driver	☐	☐	☐	☐						
		Gearboxes	☐	☐	☐	☐						
		Compressors	☐	☐	☐	☐						
		Coolers	☐	☐	☐	☐						
		Oil systems	☐	☐	☐	☐						
		Steam condensing unit	☐	☐	☐	☐						
FIXING												
		Foundation bolts							Furnisher			
									U	S		
		Compressor	☐						☐	☐		
		Gearboxes	☐						☐	☐		
		Drivers	☐						☐	☐		
		Coolers	☐						☐	☐		
		Oil system	☐						☐	☐		
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										

1	Re-	Info.	COMPRESSOR DATA SHEET No. 207										1	
2	vision		MISCELLANEOUS							Page		of	2	
3			USER :			PROJECT :			SUPPLIER :				3	
4													4	
5													5	
6			Ref. No.			Ref. No.			Ref. No.				6	
7													7	
8			This data sheet may be used to indicate :											8
9			Applicable standards (vibration and noise limitations, see data sheet 208)											9
10			Mandatory sub-suppliers											10
11			Prohibited sizes, ratings or materials											11
12			Exceptions											12
13			Special cleaning requirements											13
14			Major spare parts to be included in proposal											14
15			etc.											15
16														16
17														17
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54			USER to mark X in Info. column where data required in SUPPLIER's proposal											54
55			Revision No.	Original	1	2	3	4	5	6	7	8	9	55
56			Name											56
57			Date											57

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1	Re- vision	Info.	COMPRESSOR DATA SHEET No. 209										
2			RATINGS							Page of			
3			USER :			PROJECT :			SUPPLIER :				
4													
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6			Ref. No.			Ref. No.			Ref. No.				
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54			USER to mark X in Info. column where data required in SUPPLIER's proposal										
55			Revision No.	Original	1	2	3	4	5	6	7	8	9
56			Name										
57			Date										

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RECIPROCATING COMPRESSOR DATA SHEET No. 302B												
Re- vision	Info.	COMPRESSOR DESIGN 2 (cylinders)							Page	of		
		USER :		PROJECT :				SUPPLIER :				
		Ref. No.		Ref. No.				Ref. No.				
		CYLINDERS										
		Cylinder No. (cf. schematic diagram on data sheet 301B)		1	2	3	4	5	6			
		Compressor stage										
		Cylinder diameter (mm)										
		Piston stroke (mm)										
		Piston rod diameter (mm)										
		Relative clearance volume (%)										
		Single acting		☐	☐	☐	☐	☐	☐	☐		
		Double acting		☐	☐	☐	☐	☐	☐	☐		
		Suction pressure (absolute) (bar)										
		Discharge pressure (absolute) (bar)										
		Relief valve set pressure (absolute) (bar)										
		Suction temperature (°C)										
		Discharge temperature (°C)										
		Allowable rod load (kN)										
		Actual rod load (kN)										
		Rated mean piston speed (m/s)										
		Cylinder liner fitted		☐	☐	☐	☐	☐	☐	☐		
		Cylinder — lubricated		☐	☐	☐	☐	☐	☐	☐		
		— minimum lubricated		☐	☐	☐	☐	☐	☐	☐		
		— non-lubricated		☐	☐	☐	☐	☐	☐	☐		
		Packing — lubricated		☐	☐	☐	☐	☐	☐	☐		
		— minimum lubricated		☐	☐	☐	☐	☐	☐	☐		
		— non-lubricated		☐	☐	☐	☐	☐	☐	☐		
		Packing cooled by liquid circulation		☐	☐	☐	☐	☐	☐	☐		
		Valves — type										
		— number per cylinder end suction/discharge		/	/	/	/	/	/	/		
		— velocity (m/s)										
		Distance piece: Figure (cf. data sheet 301B)										
		Cylinder cooling — air cooled		☐	☐	☐	☐	☐	☐	☐		
		— liquid filling		☐	☐	☐	☐	☐	☐	☐		
		— thermosyphon		☐	☐	☐	☐	☐	☐	☐		
		— liquid circulation		☐	☐	☐	☐	☐	☐	☐		
		Coolant — fluid										
		— flow rate (normal) (kg/s)										
		— inlet temperature normal (°C)										
		max. (°C)										
		min. (°C)										
		— temperature rise (normal) (K)										
		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.	RECIPROCATING COMPRESSOR DATA SHEET No. 303B										
		COMPRESSOR DESIGN 3 (materials)						Page	of			
		USER :		PROJECT :			SUPPLIER :					
		Ref. No.		Ref. No.			Ref. No.					
MOTION WORK MATERIALS												
		Crankcase :										
		Distance pieces :										
		Crankshaft :										
		Connecting rods :										
		Crossheads :										
		Crosshead guides :										
		Bearings — main :										
		— crank pin :										
		— crosshead :										
		Crosshead faces :										
CYLINDER MATERIALS												
		Cylinder No. (cf. schematic diagram on data sheet 301B)	1	2	3	4	5	6				
		Compressor stage										
		Cylinder										
		Cylinder head										
		Liner										
		Liner surfacing										
		Piston										
		Piston rings										
		Piston rider rings										
		Piston rod										
		Piston rod surfacing										
		Packing rings										
		Packing cups										
		Valve body										
		Valve plates										
		Valve springs										
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										

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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⁾ (Nm)																					
				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·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											
				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 (turbine driven)																					
				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											
				Heater : voltage/current/power						/ /		/ /		/ /											
				Gear mass (kg)																					
				Baseplate, foundation bolts, see data sheet 206																					
				1) Torque indicated by manufacturer as design value in his documentation.																					
				2) See 8.4.1.																					
				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.																					
				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. 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 : $\pm$ % of full-load torque										
		Starting procedure ☐ direct on line ☐ Δ — Δ ☐ other :										
		Reduced voltage starting : % of full-line voltage										
		Phase connection ☐ Δ ☐ Δ Number of terminals :										
		External excitation : V ; kW										
		Insulation class ²⁾ = ; Maximum temperature = °C										
		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 : $\pm$ 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·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.										
		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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		Date										

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Re- vision		Info.		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																					
				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																					
				— heat 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 ·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 ·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																					
				Date																					

COMPRESSOR DATA SHEET No. 503											
Re- vision		Info.		SEPARATORS AND DRAINAGE						Page of	
				USER :			PROJECT :			SUPPLIER :	
				Ref. No.			Ref. No.			Ref. No.	
				SEPARATORS							
				Compressor stage							
				Separator designation							
				Location							
				Separator required				☐ yes ☐ no		☐ yes ☐ no	
				Furnisher				☐ 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							
				Drainage required				☐ yes ☐ no		☐ yes ☐ no	
				Furnisher				☐ 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							
				Revision No.		Original		1		2	
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				Name							
				Date							

Re- vision	Info.	COMPRESSOR DATA SHEET No. 504										
		PULSATION DAMPERS, PRESSURE VESSELS						Page		of		
		USER :			PROJECT :			SUPPLIER :				
		Ref. No.			Ref. No.			Ref. No.				
		PULSATION DAMPERS										
		Compressor stage										
		Damper designation										
		— inlet (i) or discharge (d) ☐ i ☐ d ☐ i ☐ d ☐ i ☐ d ☐ i ☐ d ☐ i ☐ d ☐ i ☐ d										
		Location (reference letter of data sheet 210)										
		Damper required ☐ yes ☐ no ☐ yes ☐ no ☐ yes ☐ no ☐ yes ☐ no ☐ yes ☐ no ☐ yes ☐ no										
		Furnisher ☐ U ☐ S ☐ U ☐ S ☐ U ☐ S ☐ U ☐ S ☐ U ☐ S ☐ U ☐ S										
		Damper type (e.g. volume bottle, snubber etc.)										
		Design										
		Inlet absolute pressure (bar)										
		Pulse level (see 9.4.2) X/Y/Z X/Y/Z X/Y/Z X/Y/Z X/Y/Z X/Y/Z										
		Pressure drop (%)										
		Design effective pressure (bar)										
		Design temperature (°C)										
		Volume (litre)										
		Materials — vessel										
		— internals										
		Corrosion allowance (mm)										
		Mass of damper (kg)										
		SYSTEM PULSATION ANALYSIS ☐ yes ☐ no										
		Furnisher ☐ USER ☐ SUPPLIER ☐ other										
		from : to :										
		from : to :										
		PRESSURE VESSELS (other than coolers, separators, dampers, silencers, filters)										
		Vessel designation										
		Function										
		Location (reference letter of data sheet 210)										
		Furnisher ☐ U ☐ S ☐ U ☐ S ☐ U ☐ S										
		Design effective pressure (bar)										
		Design temperature (°C)										
		Volume (litre)										
		Materials — vessel										
		Corrosion allowance (mm)										
		Mass of vessel (kg)										
		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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		Date										