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МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ

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

Reference number
ISO 8012 : 1988 (E)

Foreword

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

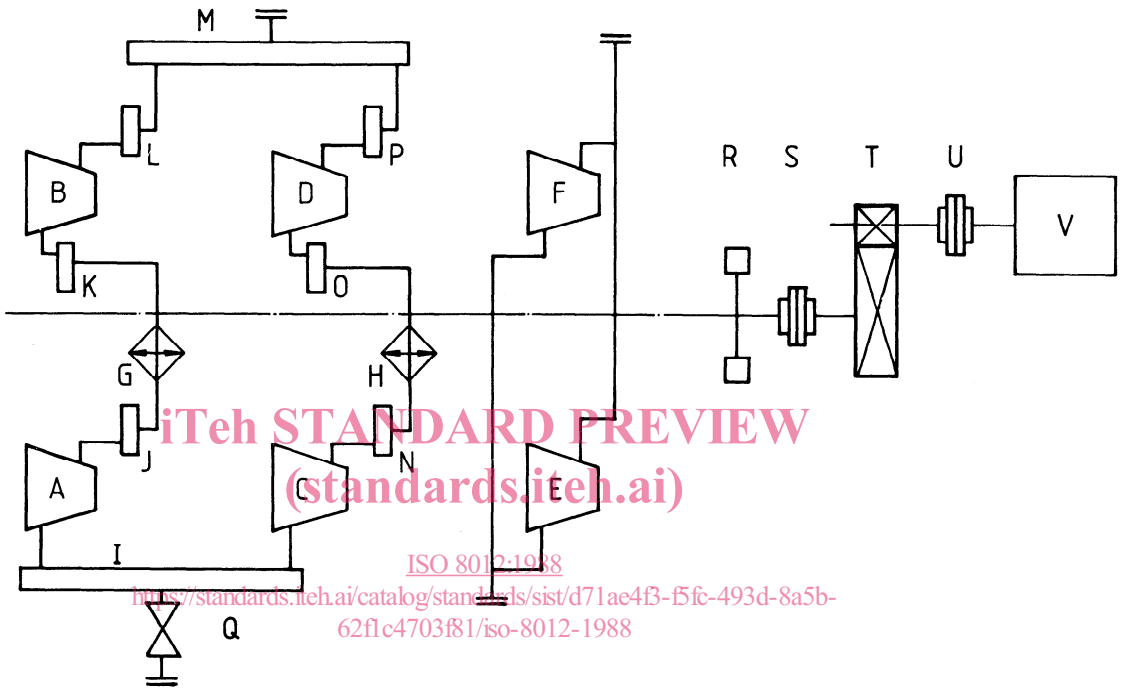
5.2.8 design pressure: The maximum pressure which the component is designed to withstand safely.

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.

Re-vision	Info.	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	1st stage inlet manifold
K, O	inlet dampers
J, 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 $^{+6\ \%}_{0\ \%}$ of the rated flow specified in the data sheets.

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

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.

a) 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.

b) 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.

c) 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 reboring 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
2 piston rod
3 pressure packing
4 compressor cylinder
5 oil wiper packing
6 oil slinger ring
7 access opening
8 intermediate pressure packing

A vent
B drain
C purge
D pressure packing vent
E pressure packing lubricant
F pressure packing cooling water inlet
G pressure packing cooling water outlet

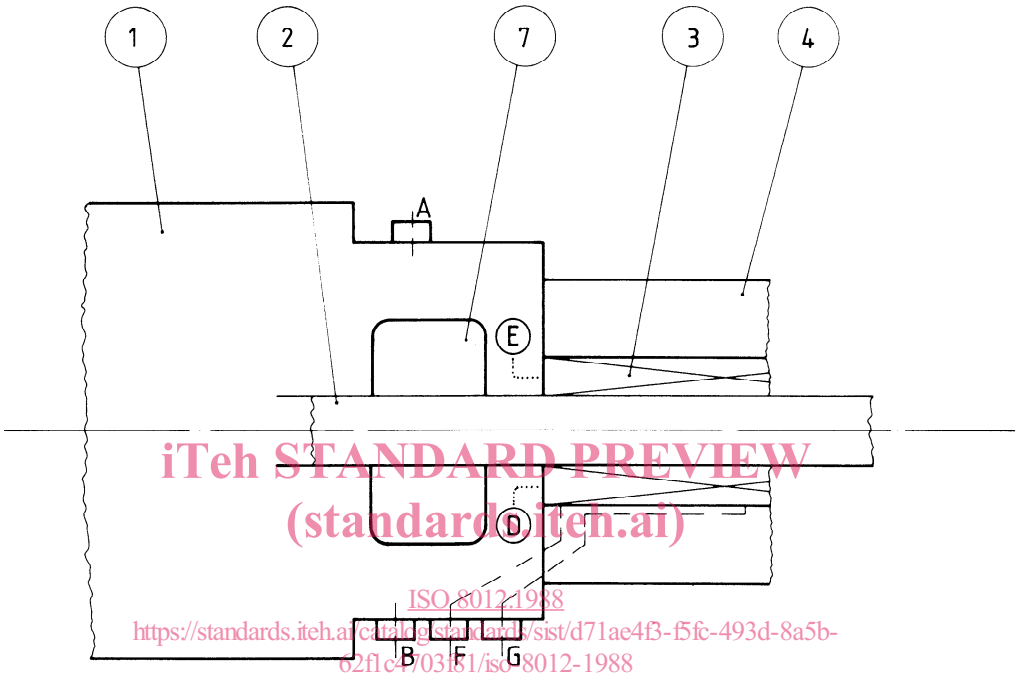


Figure 2 — Short distance piece without oil wiper packing

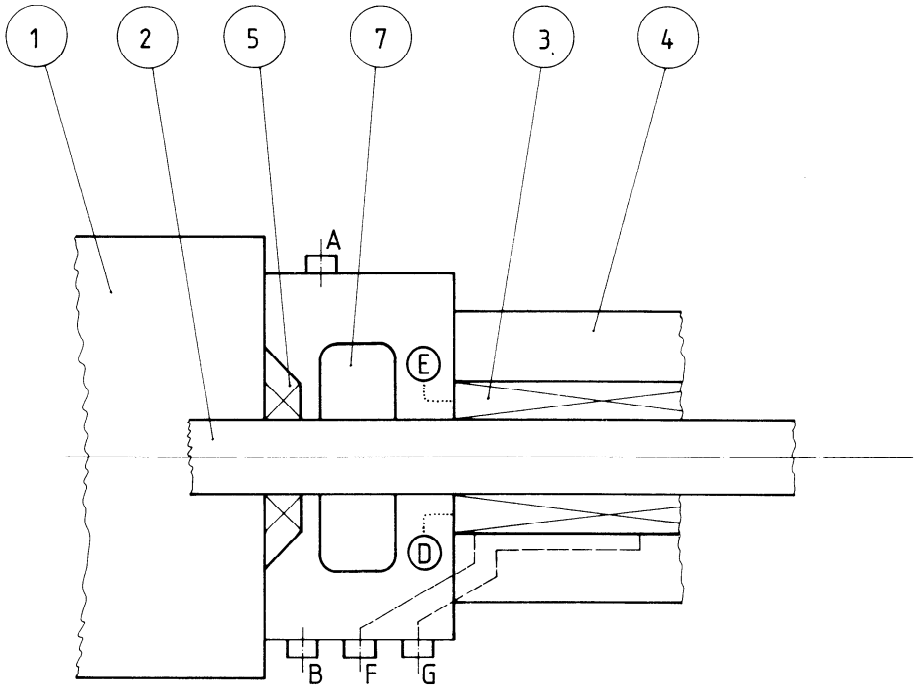


Figure 3 — Short distance piece with oil wiper packing