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BSI Standards Publication

Compressors and vacuum pumps — Safety requirements

Part 1: Air compressors

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National foreword

This British Standard is the UK implementation of EN 1012-1:2010. It supersedes BS 6244:1982 and BS EN 1012-1:1997 which are withdrawn.

The UK participation in its preparation was entrusted to Technical Committee MCE/8/-/1, Compressors - Safety.

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This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Foreword

This document (EN 1012-1:2010) has been prepared by Technical Committee CEN/TC 232 “Compressors, vacuum pumps and their systems”, the secretariat of which is held by SIS.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 2011, and conflicting national standards shall be withdrawn at the latest by September 2012.

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

This document supersedes EN 1012-1:1996.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EC Directive(s).

For relationship with EC Directive(s), see informative Annex ZA, which is an integral part of this document.

The responsibility of CEN/TC 232 includes coordination of safety standards with CEN/TC 182, "Refrigerating systems, safety and environmental requirements", and CEN/TC 234, "Gas infrastructure".

This document is in three parts:

— *Part 1: Air compressors;*

— *Part 2: Vacuum pumps;*

— *Part 3: Process compressors.*

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

This document is a type C standard as stated in the introduction to EN ISO 12100-1.

The machinery concerned and the extent to which hazards, hazardous situations and events are covered are indicated in the scope of this document.

When provisions of this type C standard are different from those which are stated in type A and B standards, the provisions of this type C standard take precedence over the provisions of the other standards for machines that have been designed and built according to the provisions of this type C standard.

This standard when published in 1996 applied to all types of compressors. The standard has now been divided into three parts with this part addressing compressors for compressed air, nitrogen and inert gases, a second part addressing vacuum pumps and a third part addressing compressors for process gases. It was considered a practical move so that if there were provisions that were laid down for compressors covered by CEN/TC 12 or ISO/TC 67, then any revision or amendments could be done to the process compressor part without affecting the provisions laid down for air compressors covered by this part of EN 1012.

Standards dealing with non-safety aspects of compressor units are:

- EN 61000-6-4 and EN 61000-6-2 for stationary compressor units;
- EN 13309 for skid-mounted and mobile compressor units on electromagnetic compatibility.

1 Scope

This part of EN 1012 is applicable to compressors and compressor units having an operating pressure greater than 0,5 bar and designed to compress air, nitrogen or inert gases. This document deals with all significant hazards, hazardous situations and events relevant to the design, installation, operation, maintenance, dismantling and disposal of compressors and compressor units, when they are used as intended and under conditions of misuse which are reasonably foreseeable by the manufacturer (see Clause 4).

This part of EN 1012 includes under the general term compressor units those machines which comprise:

— the compressor;

— a drive system;

— any component or device which is necessary for operation.

This part also covers the general requirements relating to process gas compressors; for specific requirements see prEN 1012-3 which applies.

This part covers compressors driven by any power media, including battery powered and which are fitted in or used with motor vehicles.

This part of EN 1012 does not cover requirements for compressors used in potentially explosive atmospheres.

This part of EN 1012 is not applicable to compressors which are manufactured before the date of publication of this document by CEN.

2 Normative references

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

EN 547-1, *Safety of machinery — Human body measurements — Part 1: Principles for determining the dimensions required for openings for whole body access into machinery*

EN 626-1:1994+A1:2008, *Safety of machinery — Reduction of risks to health from hazardous substances emitted by machinery — Part 1: Principles and specifications for machinery manufacturers*

EN 837-2, *Pressure gauges — Part 2: Selection and installation recommendations for pressure gauges*

EN 953:1997+A1:2009, *Safety of machinery — Guards — General requirements for the design and construction of fixed and movable guards*

EN 982:1996+A1:2008, *Safety of machinery — Safety requirements for fluid power systems and their components — Hydraulics*

EN 983:1996+A1:2008, *Safety of machinery — Safety requirements for fluid power systems and their components — Pneumatics*

EN 1005-2, *Safety of machinery — Human physical performance — Part2: Manual handling of machinery and component parts of machinery*

EN 12021, *Respiratory protective devices — Compressed air for breathing apparatus*

EN 13445-5:2009, *Unfired pressure vessels — Part 5: Inspection and testing*

EN 13445-6, *Unfired pressure vessels — Part 6: Requirements for the design and fabrication of pressure vessels and pressure parts constructed from spheroidal graphite cast iron*

EN 60204-1:2006, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements (IEC 60204-1:2005, modified)*

EN 60204-11, *Safety of machinery — Electrical equipment of machines — Part 11: Requirements for HV equipment for voltages above 1000 V a.c. or 1500 V d.c. and not exceeding 36 kV (IEC 60204-11:2000)*

EN 61310-2:2008, *Safety of machinery — Indication, marking and actuation — Requirements for marking (IEC 61310-2:2007)*

EN ISO 2151:2008, *Acoustics — Noise test code for compressors and vacuum pumps — Engineering Method (Grade 2) (ISO 2151:2004)*

EN ISO 4126-1, *Safety devices for protection against excessive pressure — Part 1: Safety valves (ISO 4126-1:2004)*

EN ISO 11688-1, *Acoustics — Recommended practice for the design of low-noise machinery and equipment — Part 1: Planning (ISO/TR 11688-1:1995)*

EN ISO 12100-1:2003*, Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology, methodology (ISO 12100-1:2003)*

EN ISO 12100-2:2003, *Safety of machinery — Basic concepts, general principles for design — Part 2: Technical principles (ISO 12100-2:2003)*

EN ISO 13732-1, *Ergonomics of the thermal environment — Methods for the assessment of human responses to contact with surfaces — Part 1: Hot surfaces (ISO 13732-1:2006)*

EN ISO 13732-3, *Ergonomics of the thermal environment — Methods for the assessment of human responses to contact with surfaces — Part 3: Cold surfaces (ISO 13732-3:2005)*

EN ISO 13849-1:2008, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design (ISO 13849-1:2006)*

EN ISO 13850:2008, *Safety of machinery — Emergency stop — Principles for design (ISO 13850:2006)*

EN ISO 13857:2008, *Safety of machinery — Safety distances to prevent hazard zones being reached by upper and lower limbs (ISO 13857:2008)*

EN ISO 14121-1, *Safety of machinery — Risk assessment — Part 1: Principles (ISO 14121-1:2007)*

EN ISO 14122-1, *Safety of machinery — Permanent means of access to machinery — Part 1: Choice of fixed means of access between two levels (ISO 14122-1:2001)*

EN ISO 14122-2, *Safety of machinery — Permanent means of access to machinery — Part 2: Working platforms and walkways (ISO 14122-2:2001)*

EN ISO 14122-3, *Safety of machinery — Permanent means of access to machinery — Part 3: Stairs, stepladders and guard-rails (ISO 14122-3:2001)*

EN ISO 14122-4, *Safety of machinery — Permanent means of access to machinery — Part 4: Fixed ladders (ISO 14122-4:2004)*

EN ISO 14163, *Acoustics — Guidelines for noise control by silencers (ISO 14163:1998)*

EN ISO 15667, *Acoustics — Guidelines for noise control by enclosures and cabins (ISO 15667:2000)*

ISO 3857-1:1977, *Compressors, pneumatic tools and machines — Vocabulary — Part 1: General*

ISO 3857-2:1977*, Compressors, pneumatic tools and machines — Vocabulary — Part 2: Compressors*

ISO 8573-1*, Compressed air — Part 1: Contaminants and purity classes*

ISO 8573-2, *Compressed air — Part 2: Test methods for oil aerosol content*

ISO 8573-3, *Compressed air — Part 3: Test methods for measurement of humidity*

ISO 8573-4*, Compressed air — Part4: Test methods for solid particle content*

IEC 60417 (2002-10), *Graphical symbols for use on equipment*[1)]

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 12100-1:2003 apply. Terms and definitions specifically needed for compressors are listed below and in ISO 3857-1:1977 and ISO 3857-2:1977.

3.1 General terms

3.1.1
compressor
part of a compressor unit that compresses a gas or vapour media to a pressure higher than that at the inlet

3.1.2
compressor unit
unit that comprises the compressor, a drive system and any component or device which is necessary for operation

3.1.3
drive system
system that consists of a prime mover and coupling mechanism

NOTE 1 Prime mover may be an electric motor, steam engine (turbine), etc.

NOTE 2 Coupling mechanism may be a drive belt, shaft, gears, etc.

3.1.4
inert gas
chemically inactive gas which retains this characteristic even at elevated pressures

3.1.5
pressure
pressure relative to atmospheric pressure, i.e. gauge pressure

NOTE 1 In many cases, this is referred to as effective pressure.

NOTE 2 The unit bar for pressure is used. 1 bar = 100 kPa.

3.1.6
liquid shock
excessive force resulting from an attempt to compress incompressible media

3.1.7
maximum allowable pressure
maximum pressure for which the compressor or compressor unit is designed, as specified by the manufacturer

1) IEC 60417 is available only as a database which can be accessed, if necessary, by subscription through the IEC Website (see http://www.graphical-symbols.info/graphical-symbols/equipment/db1.nsf/welcome?OpenPage); those symbols relevant to this standard can be found in Annex A.

NOTE This is also identified as maximum allowable working pressure.

3.1.8
normal operating conditions
conditions considered to be when the compressor is properly maintained and operated within admissible limits in particular ambient temperature, as specified by the manufacturer when compressing the specified media

3.2 Specific terms

3.2.1
air compressor
compressor intended for compression of air, nitrogen or inert gases

3.2.2
compressor assembly
assembly of compressor units and ancillary equipment to provide a compression facility that functions as an integrated whole

NOTE The limits of the assembly are as defined by the manufacturer.

3.2.3
portable and skid mounted compressor

3.2.3.1
portable compressor unit
compressor unit which is wheel-mounted and can be towed on- and off-site

3.2.3.2
skid-mounted compressor unit
compressor unit which is mounted on skids and which can be towed short distances on-site or transported

3.2.3.3
gross mass
maximum specified mass of a skid-mounted or portable compressor unit (including tools, equipment and fuel)

NOTE Tools and equipment includes for example concrete breakers, picks and hoses likely to be carried for a typical working application.

3.2.4
process compressor
compressor intended for compression of all gases other than air, nitrogen or inert gases

3.2.5
water-injected compressor
compressor design in which the compressed media and the water are mixed

4 List of significant hazards — Hazard analysis and risk assessment

To provide the suitable level of safety taking into consideration the design, guarding and the provision of information, the appropriate risk assessment procedure shall be adopted in accordance with the principles identified in EN ISO 12100-1, EN ISO 12100-2 and EN ISO 14121-1.

Hazards listed in Table 1 are related to all compressors/compressor units within the scope of this standard.

Table 1 — Hazard listing

No.	Hazard type	Reference to safety requirement	
		By design or guarding	Information for use
1	**Mechanical hazards due to:**		
1.1	Machine parts or work-pieces, e.g.:		
	a) shape;	5.10.1	
	b) mass and stability (potential energy of elements which may move under the effect of gravity);		7.3.2 a) & d), 7.5.4.1
	c) mass and velocity (kinetic energy of elements in controlled or uncontrolled motion);		7.3.2 a)
	d) inadequacy of mechanical strength; 1) accumulation of energy inside the machinery	5.10.1	
	e) liquids and gases under pressure	5.10.1., 5.11.1, 5.11.2, 5.12	7.2.1.4 c), d) & g), 7.2.2 m)
1.2	Cutting or severing hazard friction or abrasion hazard	5.2.1.1	7.2.1.4 n), 7.2.2 a)
1.3	Drawing-in or trapping hazard	5.2.1.2	7.3.3
1.4	Impact hazard stabbing or puncture hazard		7.2.1.4 o)
1.5	High pressure fluid injection or ejection hazard	5.2.2	7.2.1.4 o)
2	**Electrical hazards due to:**		
2.1	Contact of persons with live parts (direct contact)		7.2.1.3.2, 7.4.2
2.2	Contact of persons with parts which have become live under faulty conditions (indirect contact)		7.4.2
2.3	Lack of isolation of energy source		7.2.1.3.2
2.4	Electrostatic phenomena	5.8.1	
3	**Thermal hazards, resulting in:**		
3.1	Burns, scalds and other injuries by a possible contact of persons with objects or materials with an extreme high or low temperature, by flames or explosions and also by the radiation of heat sources	5.5	7.2.1.4 k). 7.2.2 d)
4	**Hazards generated by noise, resulting in:**		
4.1	Hearing loss (deafness), other physiological disorders (e.g. loss of balance, loss of awareness)	5.6	7.2.2 a), 7.5.1, 7.6.2
5	**Hazards generated by materials and substances (and their constituent elements) processed or used by the machinery**		
5.1	Hazards from contact with or inhalation of harmful fluids, gases, mists, fumes, and dusts	5.2.2, 5.7.2, 5.10.1	7.2.2 e), 7.3.2 e), f)
5.2	Fire or explosion hazard	5.8	7.2.1.4 j), m), 7.2.2 f)
5.3	Biological or microbiological (viral or bacterial) hazards	5.7.1	7.2.2 i)
6	**Hazards generated by neglecting ergonomic principles in machinery design as, e.g. hazards from:**		

Table 1 *(continued)*

No.	Hazard type	Reference to safety requirement	
		By design or guarding	**Information for use**
6.1	Inadequate design, location or identification of manual controls	5.9	
7	**Unexpected start-up, unexpected over-run/over-speed (or any similar malfunction) from:**		
7.1	Failure/disorder of the control system		7.2.2 b)
7.2	External influences on electrical equipment	5.4.5	
8	**Failure of the power supply**		7.2.1.3.1
9	**Failure of the control circuit**	5.4	7.2.2 b)
10	**Errors of fitting**		
11	**Break-up during operation**	5.10, 5.11.1	7.2.1.4 i)
12	**Falling or ejected objects or fluids**		7.3.2 b), h)
13	**Loss of stability / overturning of machinery**	5.2.3	7.2.2 l)
14	**Slip, trip and fall of persons (related to machinery)**	5.2.4	7.4.2
Additional hazards, hazardous situations and hazardous events due to mobility			
15	**Linked to the work position (including driving station) on the machine**		
15.1	Exhaust gases/lack of oxygen at the work position		7.2.2 e) & h), 7.3.2, e) & f)
15.2	Noise at the operator's position		6.2.1, 7.6
16	**From handling the machine (lack of stability)**	5.9.2 b) & c)	7.3.2 d)
17	**Due to the power source and to the transmission of power**		
17.1	Hazards from the engine and the batteries	5.3.2	
17.2	Hazards from coupling and towing	5.9.2 b), 5.9.3	7.3.2 a), g)
18	**From/to third persons**		
18.1	Lack or inadequacy of visual or acoustic warning means		7.5
19	**Insufficient instructions for the driver/operator**		7.3.2
20	**Unhealthy postures or excessive effort**	5.9.3	

5 Safety requirements and/or protective measures

5.1 General

Machinery shall comply with the safety requirements and/or protective measures of this clause. In addition, the machine shall be designed according to the principles of EN ISO 12100 (all parts) for relevant but not significant hazards, which are not dealt with by this document.

When choices are necessary for the application of type B standards referred to in this European Standard, i.e. listed in Clause 2, the manufacturer shall carry out an appropriate risk assessment for making these choices.

The measures adopted to comply with the requirements of this clause shall take account of the state-of-the-art when more effective technical means become available.

5.2 Mechanical safety

5.2.1 Guards

5.2.1.1 General

When fixed guards have to be removed for periodic maintenance or repair their fixing systems shall remain attached to the guard or machinery when the guards are removed.

5.2.1.2 Cutting and severing, friction and abrasion

All moving parts shall be enclosed within the permanent compressor casing or compressor unit cover, enclosure or canopy. When this is not possible, separate guards shall be provided to prevent contact with all rotating and reciprocating parts to minimize the risk of cutting and severing, friction and abrasion to personnel in accordance with Clause 5 of EN 953:1997+A1:2009 and EN ISO 13857 for safety distances.

5.2.1.3 Bodily contact

Guards shall be sufficiently rigid so as not to deflect excessively as a result of bodily contact. Such deflections shall not result in contact with moving parts, or that the deflection should not result in permanent deformation of the guard. The provisions for rigidity of guards shall be in accordance with 5.5.3 of EN 953:1997+A1:2009.

5.2.1.4 Ejection of parts

Moving parts shall be designed and mounted in such a way that in all foreseeable modes of operation the risk of ejection of parts is minimised. Where the risk assessment identifies a remaining risk of ejection, e.g. a drive belt from a belt driven compressor, then the impact resistance for guarding shall be in accordance with 5.5.2 of EN 953:1997+A1:2009.

5.2.1.5 Entry to inlet ducts and enclosures

Atmospheric inlets and inspection openings in inlets shall be provided with protective devices, so that persons cannot be drawn in or danger zones reached when the compressor is running. For this purpose, any openings shall comply with Table 4 of EN ISO 13857:2008 for upper limbs and Table 7 of EN ISO 13857:2008 for lower limbs, when applicable.

Openings giving access to moving parts creating a risk of trapping or shearing shall be prevented by either:

— total enclosure with an interlocked means of access, e.g. door, cover, etc. such that the compressor is shut down when the access is opened and cannot be started until the access is closed; or

— total enclosure without interlock when access to moving parts, e.g. fan belts, barring gear, timing marks, etc., shall be prevented by local guarding; or

— without total enclosure when access to moving parts, e.g. fan belts, barring gear, timing marks, etc., shall be prevented by local guarding.

Where service, maintenance or inspection activities require access within the enclosure doors whilst the compressor is still operational, consideration shall be given to the additional hazards created and the measures taken shall be in accordance with 5.2.4 of EN ISO 12100-2:2003. The provisions of 7.3.3 shall also be applied.

Where whole body access is required to inlet ducts and enclosures for service, maintenance or inspection the provisions of EN 547-1 shall be followed when determining the minimum dimensions of openings for such whole body access.

Where whole body access is required to inlet ducts for service, maintenance or inspection, a guard shall be fitted to prevent unauthorised access. The guard shall be:

— interlocked such that when the guard is opened the compressor is shutdown and cannot be restarted until the guard is closed; and

— unintentional closure of the guard is prevented by the use of a trapped key interlock or a padlock where the only key for the trapped key or the padlock is retained by the person entering the inlet duct.

Where it is foreseeable that the compressor will remain operational during whole body access to the inlet duct for service, maintenance or inspection, the design of the inlet duct shall be such that the air flow at the entrance to the inlet duct shall be ≤ 2,5m/s^2 and in addition a protective grid shall be installed inside the duct to prevent personnel being drawn into the compressor.

A safe system of work shall also be identified in accordance with 7.4.1.

5.2.2 Fluid injection

The risk of fluid (gas or liquid) injection into the human body shall be minimized by:

— designing and supporting integral pipework, hoses and auxiliaries to withstand vibration, thermal expansion and their own mass, foreseeable external forces, influence of contaminants and external chemical substances;

— ensuring that all piping which is in a position likely to be damaged is protected, robust and sufficiently supported, but shall be free to move with changing temperature;

— ensuring that the design of oil/coolant filler plugs does not allow the dangerous release of fluid, e.g. by means of preventing the removal of the filler plug under pressure or an effective warning system;

— the design and location of pressure vents and drains, shall take account of the velocity of air, gas, vapour or liquid likely to be discharged.

5.2.3 Loss of stability

5.2.3.1 Generally applicable

Compressor units shall be in accordance with 4.6 of EN ISO 12100-2:2003.

5.2.3.2 Portable and skid-mounted compressor units

The centre of gravity, mainly associated with the engine/compressor combination shall be low enough to ensure that the compressor unit remains stable, without tipping or slipping, when used within intended limits. The provisions of 7.3.2 d) shall be applied to indicate the intended limits.

Tyres of a portable compressor unit shall be rated to carry the maximum gross mass of the portable compressor unit at the highest towing speed the compressor unit is intended for. All tyres shall be of the same construction.

The support leg or jockey wheel shall be capable of supporting the gross nose weight of the portable compressor unit as defined in the instruction handbook. It shall be possible to securely lock it in the support and towing positions by, for example, a clamping system or removable pin in locating holes.

The jockey wheel device shall be positively retained in the draw bar in the event of the operator leaving it unlocked.

NOTE Portable compressor units used on-road are also subject to regulations related to motor vehicles and their trailers.

5.2.4 Slip, trip and fall

If access to elevated areas around a compressor unit is necessary and is an integral part of a compressor unit then these access areas shall be in accordance with 5.5.6 of EN ISO 12100-2:2003. Where such access is

provided, permanent means of access to working platforms, walkways, fixed ladders and stairways shall be in accordance with EN ISO 14122-1, EN ISO 14122-2, EN ISO 14122-3 and EN ISO 14122-4.

If access to elevated areas is required and is not an integral part of the compressor unit, appropriate installation instructions shall be given in the instruction handbook.

5.3 Electrical safety

5.3.1 Generally applicable

The electrical equipment of a compressor unit shall be in accordance with EN 60204-1 and/or EN 60204-11 as appropriate.

5.3.2 Protection from overload

Where the compressor unit is not fitted with an over-current protection of the power circuit due to it being installed outside the compressor enclosure on site, the provisions of 7.2.1.3.1 shall be followed.

5.3.3 Protection from live parts

Where the compressor unit is not fitted with an electrical disconnecting device, the provisions of 7.2.1.3.2 shall be followed.

Electrical and instrument cabling shall:

— be adequately secured and protected;

— not be in contact with hot surfaces;

— have adequate electrical insulation.

Cabling and cabling practices shall be in accordance with Clauses 12 and 13 of EN 60204-1:2006.

5.3.4 Portable and skid-mounted compressor units

5.3.4.1 General

A suitable over-current protection device, e.g. fuse, shall be provided in the electrical installation to protect the wiring harness and the electric equipment. This excludes the pre-heat, starting and charging circuits. Where fuses are provided as over-current protection devices, a type readily available in the country of use shall be selected, or arrangements made for the supply of spare parts.

5.3.4.2 Fluid, corrosive action

Batteries shall be of the type with lifting handles or with lifting points. They shall be mounted and firmly secured so there is no risk of electrolyte splashing on personnel and surrounding equipment.

5.4 Control systems

5.4.1 General

Effective control system design shall be in accordance with 4.11 of EN ISO 12100-2:2003, 9.4 of EN 60204-1:2006 and EN ISO 13849-1.

5.4.2 Emergency stop

The need for and provision of an emergency stop shall be in accordance with 5.5.2 of EN ISO 12100-2:2003. A manual emergency stop shall be in accordance with Clause 5 of EN ISO 13849-1:2008 and specifically in 5.2.1 of that standard.

Where an emergency stop is identified as a requirement, then this and the stop category shall be in accordance with EN ISO 13850.

The emergency stop device shall be coloured in accordance with 4.4.5 of EN ISO 13850:2008 and as shown in A.14 of this standard.

5.4.3 Manual reset

The requirements for a manual reset after a stop command has been initiated shall be in accordance with 5.5.2 of EN ISO 13849-1:2008 and 9.2.5.3, 9.2.5.4 of EN 60204-1:2006.

5.4.4 Start/restart

The requirements for a start and restart shall be in accordance with 5.2.3 of EN ISO 13849-1:2008.

Compressor units that are fitted with automatic or remote start controls shall follow the provisions of 7.2.2 b) and c). Automatic or remote start during service, maintenance or inspection shall be prevented by an interlock included in the control system, for example a trapped key system or if software controlled then password protected to prevent inadvertent automatic starting after each shutdown.

5.4.5 External influences on electrical equipment

The safety system and other electrical equipment shall be so designed and constructed that they cannot give rise to a hazardous situation in case of disturbances such as:

— short circuiting;

— external impacts;

— interruptions or variations in the supply voltage;

— earthing faults.

Failure of the power supply to the control system shall employ an "oriented failure mode system" in accordance with 4.12.2 of EN ISO 12100-2:2003 having a known failure mode, e.g. bring the machine to a stop.

5.4.6 Pneumatic and/or hydraulic control systems

5.4.6.1 General

Where pneumatic and hydraulic equipment forms part of a control system of a compressor unit this shall be in accordance with 4.10 of EN ISO 12100-2:2003 and the following shall apply.

5.4.6.2 Conditioning

Compressed air for measuring, control and safety systems shall be conditioned for the purpose and shall be in accordance with 5.3.4.1.1 of EN 983:1996+A1:2008. Hydraulic systems for measuring, control and safety shall be provided with a filter system and shall be in accordance with 5.3.4.1.3 of EN 982:1996+A1:2008. Where the level of contamination is critical in pneumatic control systems then those levels shall be identified by air purity classification system in accordance with ISO 8573-1. Confirmation of the level of aerosol oil contaminants shall be in accordance with ISO 8573-2, for humidity ISO 8573-3 and for particles ISO 8573-4.

5.4.7 Pressure or fluid level drops

A shut down device shall be fitted to stop the compressor unit in case of the hydraulic fluid level or hydraulic or pneumatic pressure falling below the levels necessary to maintain safe operation. The shut down device shall be in accordance with 5.3.3.2 of EN 983:1996+A1:2008 for pneumatic systems and 5.3.3.2 of EN 982:1996+A1:2008 for hydraulic systems.

5.5 Thermal safety

External surfaces, subject to extremes of temperature, exposed to personnel during normal operation of the machine and which may be accidentally touched shall be guarded, e.g. by insulation, where those temperatures cannot be controlled by design.

For surface temperatures exceeding + 70^0C, see EN ISO 13732-1; for surface temperatures below - 10^0C, see EN ISO 13732-3.

When guarding is not possible there shall be an adequate warning or a symbol as identified by A.7 (hot surface) or A.10 (cold surface).

To avoid the risk of hot surfaces due to overheating as a result of a lack of injected oil in the case of starting of oil injected air compressor units at ambient temperatures below 0 °C appropriate measures are required to decrease the oil viscosity before start up to ensure safe operation. The provisions of 5.11.2 shall be applied.

In order to avoid 'hot-spots' the immersion heaters used for heating the lubricant shall have power dissipation not greater than 25 kW/m^2. The heaters used shall be totally immersed in the oil at all times.

To avoid the risk of fire hot piping shall not be in contact with wood or flammable material.

5.6 Noise

Design considerations shall be given to noise reduction in particular at the source, see EN ISO 11688-1, EN ISO 14163, and EN ISO 15667. Design shall be such that continuous full load operation is possible at the maximum specified ambient temperature, with all noise attenuating devices and measures in place including all doors and access covers closed.

NOTE EN ISO 11688-2 gives useful information on noise generation mechanisms in machinery.

5.7 Materials and substances processed, used or exhausted

5.7.1 Micro-organisms, biological and microbiological substances

5.7.1.1 Condensate

Drainage facilities shall be provided to minimize the accumulation of stagnant liquid, which may promote the growth of micro-organisms. The drainage systems may be either manual or automatic types and shall allow for removal of accumulated liquid from piping and accessories such as water jackets, coolers, pulsation dampers and air receivers. The provisions of 7.2.2 i), j) and k) shall be applied.

The compressor unit shall be equipped with, for example, drain traps to allow containment of condensate fluids and subsequent safe draining and disposal.

5.7.1.2 Water-injected compressor units

The choice of materials in the compressor unit should be designed to prevent the growth of bacteria in the water.

5.7.2 Breathing difficulties

5.7.2.1 Compressor units driven by internal combustion engines

The relationship between the location of the exhaust outlet and the compressor inlet shall be such that in normal operation the exposure of the compressor inlet to exhaust fumes is minimized. In addition to this requirement the provisions of 7.2.2 d) and 7.3.2 e) and f) shall also apply.

5.7.2.2 Nitrogen and inert gases

Where nitrogen or inert gases are processed by a compressor unit leakage can lead to displacement of breathing air. In all areas accessible to personnel within the compressor unit, the concentration of gases that can displace breathing air shall be such that the oxygen level is maintained within the limits identified in EN 12021. Examples to reduce the build-up of nitrogen or inert gases are:

— the provision of ventilation in the compressor enclosures;

— installation of a venting line, to discharge the leakage to a safe area.

Where two or more compressor units of this type are in operation the provisions of 7.2.2 h) shall be applied.

5.8 Fire and explosion

5.8.1 Electrostatic phenomena

In oil flooded rotary compressor units the air/oil separator and all isolated parts in contact with the compressed air shall be electrically bonded to the containing vessel.

5.8.2 Oil-flooded rotary air compressor units

To reduce the risk of over-heating and the consequent potential for fire or explosion due to a lack of lubrication the compressor's lubrication system shall be so designed that a sufficient quantity of lubricant is injected under all operating conditions, i.e. under normal use as well as under abnormal conditions and operating modes not covered by safety devices, e.g. faulty starting, emergency stop.

To ensure a sufficient oil supply at least one of the following techniques shall be employed:

— oil filters in the main circuit shall have a bypass, which is opened by the differential pressure created across the filter as the filter becomes blocked; the opening pressure to the bypass shall be determined by the volume of oil required to maintain safe operation;

— the provision of an alarm and/or shut down device sensing the differential pressure across the oil filters in the main circuit; the operating pressure to the alarm and/or shut down device shall be determined by the volume of oil required to maintain safe operation;

— the provision of an alarm and/or shut down device sensing the oil pressure before entering the compressor; the alarm and/or shut down shall be activated once the oil pressure falls below the level required to maintain safe operation.

The design of oil-flooded rotary air compressor units shall be such that the maximum temperature at the delivery flange of the compressor before the oil separator does not exceed 110 °C under normal operating conditions.

Oil-flooded rotary air compressor units shall have an automatic shut-down device to switch the compressor off in the event that the temperature of the compressor oil exceeds the safe limit. The shut-down device shall be actuated at a temperature not exceeding 120 °C. Where temperatures higher than 120 °C are employed then lubricants capable of operating at elevated temperatures shall be used.

The following types of shut-down devices are acceptable:

— temperature sensing device acting via an electronic/electrical control or;

— temperature indicator/gauge switch.

The temperature measurement sensor shall be located in the discharge air stream such that the correct oil/air mixture temperature measurement is assured.

5.8.3 Oil-lubricated reciprocating air compressor units

The design shall be such that the formation of oil-coke in the outlet of each compression stage is reduced to a minimum, and provision shall be made for inspecting and cleaning the air cooler. Provisions for inspection and cleaning may include removable covers or plugs.

The following outlet temperatures shall not be exceeded under normal operating conditions when oils rated for these temperatures are used:

— 220 °C for single-stage compressors, with a maximum allowable pressure up to 10 bar;

— 200 °C for single-stage compressors, with a maximum allowable pressure greater than 10 bar,

— 180 °C for multi-stage compressors with maximum allowable pressure up to 10 bar,

— 160 °C for multi-stage compressors with maximum allowable pressure greater than 10 bar.

Temperatures higher than those specified above may be permissible when oils rated for higher temperature applications are used and/or special precautions have been taken to minimize the formation of oil-coke. Minimizing the formation of coke is achieved by such measures as reducing the oil carry-over into the top of the cylinder by the use of accurately designed and fitted piston rings. In addition to these requirements the provisions of 7.2.1.4 e) shall also be applied.

5.8.4 Oil-lubricated reciprocating compressor units operating above 50 bar

For oil-lubricated reciprocating compressor units operating above 50 bar the following additional measures shall be taken into consideration:

— design for low compression temperatures and moderate pressure ratios;

— specify the lubricant carefully;

— the incorporation of a gas filter to absorb reactive impurities or impurities having a catalytic action;

— ensure that any lubricant injected into cylinders is free from air or gas bubbles.

5.8.5 Compressor units driven by combustion engines

The refuelling point on a combustion engine-driven air compressor unit shall be located away from any hot surfaces. The refuelling point shall be so designed as to minimise any spillage which shall be contained within the structure holding the compressor/engine by the use, for example, of a catchment tray fitted under the engine. Provision shall be made for the collected spillage to be easily drained off.

5.9 Ergonomic principles

5.9.1 General

Consideration shall be given to ergonomic design principles to include elements such as instruments which shall be located so as to be easily visible from the position in which the controls related to those instruments are operated. Controls and instruments shall be designed and arranged to assist the operator to understand their function and hence avoid operator error. See EN 13861 and EN 614-1 for the application of ergonomic principles to machinery.

Manual controls and other frequently used devices shall be arranged to be easily reached and operated without excessive effort. See EN 61310-3 for the location of actuators on machinery.

Start and stop devices shall be easy to operate and shall be clearly marked in accordance with EN ISO 13850 and IEC 60417-DB-12M. Where separate start/stop controls are used then the start control shall be identified as given in A.11 and the stop control as given in A.12. Where the start/stop control is combined into one device then this shall be identified as given in A.13.

The compressor unit shall be designed and constructed to permit safe handling of fluids during filling, purging, venting, recovery and draining. See EN 614-1 for the interactions between operators and machinery during maintenance and repair.

5.9.2 Manual handling of compressor units

The general provisions for easy and safe handling of compressor units and their heavy parts shall be in accordance with 5.5.5 of EN ISO 12100-2:2003 and EN 1005-2 including the specific items identified as follows:

a) Off-road portable compressor units shall meet the following requirements:

   1) for machines with a gross mass over 750 kg a parking brake system shall be fitted;

   2) for machines with a gross mass less than 750 kg where a parking brake system is not fitted then 7.3.2 i) applies;

NOTE Portable compressor units used on-road are also subject to regulations related to motor vehicles and their trailers.

b) When the lifting of a compressor unit is required it should preferably have only one lifting point. The design of a lifting bail or bails shall be based on:

   1) a minimum vertical load of 2,5 times the machine gross mass which can occur due to acceleration during the lifting;

   2) any additional load due to unequal distribution of machine mass.

c) Lashing points (tie down) for portable and skid mounted compressor units shall be provided to allow safe securing to a vehicle on which the compressor unit may be transported. Lashing points (tie down) shall be marked according to A.20.

5.9.3 Portable and skid-mounted compressor units

If the load on the tow bar at the point where it is lifted is more than 50 kg, a mechanism shall be provided for lifting the tow bar.

Refuelling points shall be easily accessible.

NOTE Portable compressor units used on-road are also subject to regulations related to motor vehicles and their trailers.

5.10 Breaking down of machinery parts and other functional disorders

5.10.1 Break-up during operation

Components and assemblies shall be designed for adequate strength taking into consideration the maximum allowable pressure, cyclic load and temperature.

The shape of parts under cyclic pressure variation shall be chosen to reduce stress concentrations and stress levels.

Materials selected shall have sufficient ductility and fatigue resistance for the specified and foreseeable stress level that occur. The pressure bearing parts of the compressor/compressor unit made from spheroidal graphite cast iron shall be in accordance with EN 13445-6 including verification of material properties and pressure testing. Pressure containing properties other than for spheroidal graphite cast iron shall be verified by the application of pressure testing identified in 6.1.

Materials used shall be compatible with the specified lubricants or other fluids and with the gases being processed.

Precautions shall be taken to ensure that the inter-connection of the compressor and the piping system are designed to avoid transmission of unacceptable loads to the piping system. The inter-connection may for instance be formed from flexible piping rated to accept the pressure of the compressed media and the forces generated such as vibration, thermal expansion and foreseeable external forces, e.g. impacts.

To prevent the unintended release of stored energy from joints between connecting elements within a compressor unit, e.g. flanged pipes and compressor unit outlet point, seals and gaskets shall be made from materials selected to withstanding the extremes of pressure and temperature to be encountered.

Pressurised components, such as the head and cylinder of a reciprocating compressor or the casing of a rotary compressor, where pressure is not a significant design requirement shall have sufficient strength, rigidity and stability to meet the static and dynamic operational effects of the compressor.

5.10.2 Low temperature operation

Compressors shall be provided with the means of attaching devices to prevent damage from freezing during off-load or non-operational periods. These devices shall be available when compressors are used at temperatures below 0 °C, e.g. heating equipment which may be by direct heating of the coolant/lubricant functions or space heating under the enclosure of a compressor unit. The provisions of 7.2.1.4 a), b), g) and k) shall be applied.

5.10.3 Liquid shock

Liquid shock can result in almost complete destruction of the compressor unit and can therefore be the cause of the ejection of parts, the liquid causing the shock or the media processed and leakage of coolant or lubricant.

In order to prevent liquid shock either the compressor has to be of a type without internal compression or the intake of liquid in amounts likely to cause the shock shall be avoided.

Where liquid resulting from injection, priming or condensation can be present or be formed upstream or inside the compressor, adequate separators, traps and draining facilities shall be installed. If this equipment is not part of the compressor unit then the provisions of 7.2.2 k) shall be applied.

5.10.4 Coolant system

5.10.4.1 General

Precautions shall be taken to prevent detectable pressure rise in the coolant system caused by gas leakage. The cooling system shall be provided with either a means of discharging the coolant due to the excess pressure to a safe area or a means to detect the pressure increase and then bring the compressor unit to a controlled stop.

5.10.4.2 Compressor units driven by combustion engines

Provision shall be made to monitor and shut-down a combustion engine driven compressor unit where over-heating of the engine can cause either a breakdown of machinery parts or the risk of fire. The temperature and/or coolant level sensing device shall provide a signal to initiate for example the direct shut-off of the fuel supply to the engine or a managed shut down through an electronic control unit if fitted.

5.11 Pressure relief – fragmentation

5.11.1 General

A pressure relief device or devices shall protect pressure-containing parts if their maximum allowable pressure can be exceeded.

A separate pressure relief valve is not required in those cases where the maximum allowable pressure in a separate compartment can only be exceeded due to external pressure supplies. Where a pressure relief valve is not supplied then the provisions of 7.2.1.4 i) shall apply.

It shall be determined that, under all foreseeable conditions, the design shall not result in maximum allowable pressure of any compressor compartment being exceeded. Where the maximum allowable pressure is exceeded then this shall not be by more than 10 % and only as a momentary transition. Selection of the pressure relief device shall take into account the operational requirements of pressure and flow rate during the 10 % momentary transition phase.

Devices to prevent the maximum allowable pressure from being exceeded shall be:

a) pressure relief valves; or

b) bursting discs and buckling pins; or

c) pressure sensing devices, whose performance level is determined with reference to 4.5 of EN ISO 13849-1:2008. Such devices shall employ 'redundancy' in accordance with 4.12.3 of EN ISO 12100-2:2003. There shall be at least two of them and they shall be protected against unauthorized adjustment. These devices may provide any one of the following actions:

   1) stopping of the prime mover;

   2) isolating the pressure system from its supply by shut-off devices;

   3) opening of a control valve to exhaust the excess pressure.

5.11.2 Design specifications of pressure relief devices

Where a pressure relief valve is intended as a safety function device designed to protect pressure equipment against the allowable limits being exceeded, it shall be in accordance with EN ISO 4126-1.

5.11.3 Turbo compressor units

Turbo compressor units with atmospheric suction which, by design, cannot attain a pressure of more than 110 % of the maximum allowable pressure are not required to be fitted with a pressure relief device.

5.11.4 Multi stage compressor units

All stages and intermediate sections of multi stage compressor units shall be equipped with pressure relief devices set for the respective design pressures to ensure that each stage design pressure cannot be exceeded.

If it can be shown that none of the stages can be exposed to pressures higher than the final stage under all foreseeable circumstances including failure mode conditions, and each stage and intermediate section is designed for the maximum allowable pressure of the final stage, then only the final stage requires a pressure relief valve.

5.11.5 Application of pressure relief devices at the cooling medium side

Volumes on the cooling media side of a compressor that can be isolated and potentially subject to temperature rises, or in some cases temperature fall, shall be subject to protective measures. Those protective measures may for example include the use of expansion chambers connected to the discharge side of pressure relief devices or where acceptable direct discharge to a safe area to avoid the build-up of pressures in excess of the maximum allowable pressure for the cooling media side.

5.12 Information and warning devices

A suitable pressure indicator shall be provided either on the compressor unit or remotely to display the pressure:

— existing at the final outlet of a compressor;

— in each separate stage of diaphragm compressors with a maximum allowable pressure exceeding 3 bar;

— on the pressure side of each separate stage of positive displacement compressors having a shaft input power of more than 20 kW;

— of lubricant systems equipped with oil pumps on compressors having an input power of more than 75 kW;

— at the inlet of a compressor having inlet pressure above atmospheric.

For additional information on pressure gauges see EN 837-2. Where pressure transducers are used in conjunction with an electronic display the accuracy of the reading shall be equal to or better than the equivalent pressure gauge identified in EN 837-2.

6 Verification of safety requirements and/or protective measures

6.1 Pressure testing

The components or assemblies forming the pressurized gas side and coolant side of the compression space shall be tested in accordance with 10.2.3 of EN 13445-5:2009.

For parts pressurised above 2000 bar a test pressure equivalent to 1,3 times the maximum allowable pressure shall be applied. The safe testing practices shall be in accordance with 10.2.3 of EN 13445-5:2009.

For compressor produced in batches and designed to operate at maximum allowable pressure not greater than 16 bar, then sample testing is allowed if the energy content of the component does not exceed 200 bar litres.

6.2 Noise

6.2.1 General

The noise emission values, i.e. the A-weighted emission sound pressure level at the workstation and the A-weighted sound power level, shall be measured, reported, declared and verified in accordance with EN ISO 2151.

Compliance with 5.6 may be verified through the comparison of the noise emission values with those for other machines of the same family, of similar size and performance characteristics.

6.2.2 Sound power level of compressor units for use outdoors

The sound power level of compressor units for use outdoors is subject to a specific European regulation. As an exception to 6.2.1, the determination of the sound power level for such compressor units shall comply with this regulation.

6.3 Stability of portable compressor units

The safe road towing stability of a portable compressor unit shall be verified by practical tests. The test shall be conducted on a portable compressor unit loaded as intended for use, e.g. including fuel, hoses and tools. Tyre pressures shall be adjusted as specified in the instructions for use. The portable compressor unit shall be towed on a representative highway road surface for use at intended road speeds up to the maximum rated speed as given in the information for use.

6.4 Structure of verification

Table 2 — Structure of verification

Safety requirements	Visual check	Functional check	Measurement	Reference to clauses of this standard or to other standards
5.2 Mechanical safety				
5.2.1 Guards	X		X	
5.2.1.2 Cutting and severing, friction and abrasion	X	X		EN 953
5.2.1.3 Bodily contact	X	X		EN 953
5.2.1.4 Ejection of parts				
5.2.1.5 Entry to inlet ducts and enclosures Drawing-in, trapping	X	X	X	EN ISO 13857 EN ISO 12100-2 EN 547-1
5.2.2 Fluid injection	X	X		
5.2.3 Loss of stability	X	X		
5.2.4 Slip, trip and fall	X	X	X	EN ISO 12100-2 EN ISO 14122-1 EN ISO 14122-2 EN ISO 14122-3 EN ISO 14122-4
5.3 Electrical safety				
5.3.2 Protection from overload	X	X		EN 60204-1 EN 60204-11
5.3.3 Protection from live parts	X	X		EN 60204-1 EN 60204-11
5.3.4.2 Fluid, corrosive action	X	X		
5.4 Control systems				
5.4.2 Emergency stop	X	X		EN ISO 13849-1 EN ISO 13850 EN 60204-1
5.4.3 Manual reset	X	X		EN ISO 13849-1 EN 60204-1
5.4.4 Start/restart	X	X		EN ISO 13849-1
5.4.5 External influences on electrical equipment		X		
5.4.6 Pneumatic and/or hydraulic control systems				
5.4.6.2 Conditioning		X	X	ISO 8573-2 ISO 8573-3 ISO 8573-4
5.4.7 Pressure or fluid level drops		X		

Table 2 *(continued)*

Safety requirements	Visual check	Functional check	Measurement	Reference to clauses of this standard or to other standards
5.5 Thermal safety	X	X	X	EN ISO 13732-1 EN ISO 13732-3
5.6 Noise		X	X	6.2 EN ISO 2151
5.7 Materials and substances processed, used or exhausted				
5.7.1 Micro-organisms, biological and microbiological substances	X	X		
5.7.2 Breathing difficulties	X	X		EN 12021
5.8 Fire and explosion				
5.8.1 Electrostatic phenomena	X	X		
5.8.2 Oil-flooded rotary air compressor units		X	X	
5.8.3 Oil-lubricated reciprocating air compressor units		X	X	
5.8.4 Oil lubricated reciprocating compressor units operating above 50 bar		X	X	
5.8.5 Compressor units driven by combustion engines	X			
5.9 Ergonomic principles				
5.9.1 General	X	X		EN 614-1 EN 13861 EN 61310-3 EN 13850 IEC 60417-DB-12M
5.9.2 Manual handling of compressor units			X	EN ISO 12100-2 EN 1005-2
5.9.3 Portable and skid-mounted compressor units	X		X	
5.10 Breaking down of machinery parts and other functional disorders				
5.10.1 Break-up during operation	X	X	X	6.1 EN 13445-6
5.10.3 Liquid shock	X	X		
5.10.4 Coolant system		X	X	

Table 2 *(continued)*

Safety requirements	Visual check	Functional check	Measurement	Reference to clauses of this standard or to other standards
5.11 Pressure relief – fragmentation				
5.11.1 General		X		EN ISO 13849-1 EN ISO 12100-2
5.11.2 Design specifications of pressure relief devices		X		EN ISO 4126-1
5.11.3 Turbo compressor units		X	X	
5.11.4 Multi stage compressor units		X	X	
5.11.5 Application of pressure relief devices at the cooling medium side		X		
5.12 Information and warning devices	X	X		

7 Information for use

7.1 General requirements

The requirements for 'information for use' are in accordance with Clause 6 of EN ISO 12100-2:2003. Documentation drawn up by the manufacturer shall be supplied with each compressor/compressor unit to cover its intended use. It shall lay down procedures for safe installation, use, maintenance and disposal and shall warn against known dangerous practices, misuses and residual risks.

The text shall be simple, adequate, complete and be suitable for the personnel responsible for the compressor/compressor unit. Where a compressor unit may be used by non-professional user then information for use should be written in a form that is readily understood by the non-professional user.

The documentation supplied shall be appropriate to the complexity of the compressor/compressor unit and shall consist of:

a) instruction handbook, including safety relevant instructions for both the user and operator;

NOTE The Instruction handbook shall be kept permanently with the compressor and be available for the operator.

b) service instruction, comprising the instructions for the tasks to be carried out by specialised personnel;

c) specification of spare parts to be used, where these affect the safe use of the compressor unit.

The information identified may appear in more than one document.

7.2 Accompanying documents (in particular, instruction handbook)

7.2.1 Instruction handbook

7.2.1.1 General

The requirements of the instruction handbook shall be in accordance with 6.5 of EN ISO 12100-2:2003 and the following where applicable. An indication that the instruction hand book should be read shall be placed on the compressor unit and visible from the control panel. The marking shall be as identified in A.1.

7.2.1.2 Data plate information

The same information as on the data plate.

7.2.1.3 Information relating to installation and commissioning of the compressor/compressor unit

7.2.1.3.1 Over-current protection

Over-current protection of the power circuit, where this is not supplied, then a statement shall be made that the user has to make provision for the installation of the over-current protection of the power circuit. Information relevant to this provision shall be given, e.g. current, voltage, phases. The instructions shall make reference to the over-current protection being in accordance with 7.2 of EN 60204-1:2006.

7.2.1.3.2 Electrical disconnecting device

Electrical disconnecting device, where this is not supplied then a statement shall be made that the user has to make provision for the installation of the electrical disconnecting device of the power circuit. Information relevant to this provision shall be given, e.g. current, voltage, phases. The instructions shall make reference to the supply disconnection device being in accordance with 5.3 of EN 60204-1:2006.

7.2.1.4 Information relating to the compressor/compressor unit

a) Intended media;

b) Inlet, intermediate and discharge temperatures;

c) Inlet, intermediate and discharge pressures;

d) Maximum pressure ratio;

e) Specification of lubricants and filters concerning quality, quantity and recommended frequency of replacement;

f) Specification of hydraulic transmission fluids;

g) Limiting pressures and temperatures of the lubrication system;

h) Maximum and, if applicable, minimum speed;

i) Pressure relief devices and other protective devices, where these are not supplied then a statement shall be made that the user has to make provision for the installation of the pressure relief devices and other protective devices. Information relevant to this provision shall be given, e.g. pressure, flow rate;

j) Compressor unit in a potentially explosive atmosphere:

   1) as this standard gives no requirements specific to the design of compressors for use in a potentially explosive atmosphere a warning shall be given that the compressor shall not be used in such applications unless suitable additional precautions are taken;

k) Information on operation of compressors at an ambient temperature below 0 °C:

1) precautions to prevent ice and snow interfering with the operation of the machine, in particular that pressure relief devices, intake air filters of the compressor and of the cooling air may be blocked;

2) actions to be taken to prevent freezing of cooling water systems, water traps, valves and fittings;

3) measures to avoid the freezing of accumulations of condensate;

4) actions to be taken to protect the control system against being inoperative;

5) the specification of lubricants for low temperatures or measures to be taken to keep the lubricating system warm;

l) Warnings shall be given that high oil viscosity during cold start up, clogged oil filters or valve malfunction can result in oil starvation;

m) To prevent the risk of oil fires occurring information shall be given on:

1) the choice of oil;

2) the operation and maintenance of the compressor;

3) that information on reducing the risk of oil fires shall give details for:

4) regular and complete oil changes;

5) ensuring that the oil cooling arrangements are kept clean and protective devices maintained in working order;

6) regular check and maintenance of oil level;

n) Where openings are provided in flywheel guards when required for barring over the compressor and to provide access to timing marks, wheel hub and any other part which may require attention instructions shall be given to inform the operator that openings shall be closed when the compressor is in operation. A sign stating "Access for maintenance only keep closed" shall be provided in a prominent position and close to the movable guard where the guard is not self closing;

o) Steps necessary to avoid transmission of unacceptable loads to the piping system at the inter-connection of the compressor unit and the piping system shall be identified, e.g. the use of flexible hoses.

7.2.2 Information relating to the use of the compressor/compressor unit

a) Operation with lids and doors shut if the compressor unit is designed to be operated in this mode;

b) Identify when the compressor unit is under automatic or remote control and the actions necessary to prevent starting automatically or from a remote position when the compressor is being serviced, maintained or inspected, e.g. locking of the main electrical isolator or in the case of steam driven systems a means of isolating the steam inlet valve to a steam turbine and locking this in the “off” position;

c) Indication of automatic or remote control of the compressor unit using the sign as given in A.6;

d) Location of excessively hot or cold surfaces;

e) Risk of inhalation of harmful gases, mists and fumes;

f) Risk of coke formation in the delivery piping causing a fire or explosion (reciprocating compressor);

g) Instructions for routine servicing and simple repairs together with drawings and diagrams, when required, and appropriate safety procedures;

h) Warnings shall be given that in all areas accessible to personnel, the concentration of processed gases that can displace breathing air shall be kept within acceptable levels. Reference shall be included for the user to see EN 12021 for acceptable levels of contaminants in breathing air;

i) Water cooled and water injected compressor units:

   1) water supplied for water-injected compressors should be of potable quality and treated where necessary to prevent harmful bacteria from entering the compressed air, maintenance regimes should be stipulated that will assist in this and prevent persons from coming in contact with harmful bacteria;

   2) the user should be advised as to the risks associated with water cooled compressors that utilise open circuit cooling towers, e.g. growth of Legionella pneumophila bacteria;

j) How contaminated condensates are contained effectively and disposed of safely;

k) The need for separators, traps and draining facilities are required to process liquids produced by the compressor before putting the compressor unit into use as these are not supplied;

l) The safe limits of angles for cables or chains shall be clearly indicated on the machine and in the information for use;

m) The requirement for pressure relief valve maintenance and testing at regular intervals to confirm their correct operation at their specified setting.

7.3 Specific types of compressors

7.3.1 General

In addition the information for use shall contain the following information for specific types of compressors:

7.3.2 Portable and skid-mounted air compressor units

a) All necessary instructions for correct operation, inspection, lifting and transportation;

b) A warning that all hoses and fittings shall be suitable for site use at the maximum allowable pressure of the portable compressors;

c) A recommendation that for pressures above 7 bar, delivery hoses should be fitted with a safety cord, e.g. wire rope;

d) Information on the greatest permissible inclination from the horizontal;

e) Warning against the use of an internal combustion engine-driven compressor in a confined space. In addition a warning according to A.9 shall be applied to the compressor unit;

f) Warning shall be given that where a combustion engine driven compressor unit is to be used to provide breathing air then the engine exhaust outlet shall be arranged to be downwind of the compressor inlet. In addition information shall be given on the air treatment equipment and the adoption of safe systems of work necessary to provide breathing air;

g) Before towing a portable compressor:

   1) the jockey wheel or support stand is raised;

   2) the coupling is securely fastened to the towing vehicle;

   3) a safety device is installed to stop the compressor if the towing connection fails while towing;

   4) lighting leads are correctly connected;

5) parking brake to be disengaged, where fitted;

h) The appropriate purging of associated piping and equipment;

i) Where a parking brake is not fitted the use of wheel chocks shall be recommended when parked and in use.

NOTE Portable compressor units used on-road are also subject to regulations related to motor vehicles and their trailers.

7.3.3 Entry to inlet ducts and enclosures

Where access is to be gained through openings in air compression inlet ducts, intended for internal service, maintenance or inspection, instructions shall be given to indicate the safe operation of the interlock/entry procedure taking into account measures provided in accordance with 5.2.1.2.

Where service, maintenance or inspection activities require access to the inside of an enclosure, instructions shall be given to indicate safe entry procedures taking into account measures provided in accordance with 5.2.1.2.

Warnings shall be given of the hazards of opening and entering intake ducts and compressor/compressor unit enclosures.

7.4 Service instructions

7.4.1 General

The Service instructions shall identify the work that shall be performed by specialist personnel, which is in addition to the routine checks, cleaning and replacements identified in 7.2.2 g).

The Service instructions shall include:

— a list of spare parts for safety critical use;

— drawings and diagrams;

— list of parts and consumables that need periodic inspection or replacement;

— instructions for fault analysis;

— schedule for periodic inspection and replacement of parts and consumables;

— instructions on how to enable service work and subsequent testing to be carried out safely on compressor units in multiple installations;

— instructions on how to safely start, stop and isolate any unit, independently of the other compressor units, in a multiple installation;

— instruction on the use of a restraint attached to the outside of an opening and to the maintenance personnel of a length sufficient only to allow access to the item being inspected or serviced, e.g. intake filter assembly. the restraint used and the attachment shall be inspected before each use for effectiveness;

— address of maintenance agent(s) approved by the manufacturer.

NOTE In addition to the service instructions provided with all machines the manufacturer will have available, instructions in one language that his authorized maintenance agents understand, identifying all procedures for carrying out major servicing and repairs of the compressor/compressor unit.

The manufacturer shall provide a list giving information on all relevant parts used for service with an unambiguous identification, and indicating the location of the part on the compressor.

7.4.2 Precautions for service/maintenance

The following minimum information is to be provided so that service and maintenance actions may be carried out safely:

— disconnection from all energy supplies;

— measures against reconnection, including the need to display a sign using A.3 and A.8;

— neutralising of residual energy;

— testing of the safe state of the machine (absence of energy);

— precautions to be taken if the compressor unit is required to be operational during service/maintenance.

Other specific information such as the requirement to remove lubricants, cooling water supplies or condensate shall also be given as required and in accordance with the complexity of the compressor unit. When reviewing the information to be provided this shall be in accordance with 7.1.4, 7.1.5 and 7.2 of EN 626-1:1994+A1:2008.

Where access is required for ease of service or maintenance and this will be achieved by the use of ladders or platforms this information shall be provided.

7.5 Markings, signs and written warnings

7.5.1 Generally applicable

Signs and warnings fixed to the machine shall be durable and their requirements shall be in accordance with Clause 7 of EN 61310-2:2008.

Where the relevant hazard exist appropriate symbols from Annex A shall be applied to the machine and a list of those symbols with an explanation of their meaning included in the instructions for use. The direction of rotation shall be marked on the compressor by means of an arrow, as given in A.15. If relevant a sign to recommend the use of hearing protectors, as given in A.2 shall be displayed.

7.5.2 Compressor unit enclosures

A warning sign in accordance with A.7 for touchable hot surfaces and A.10 for touchable cold surfaces shall be provided. These warnings shall be affixed on access points to such surfaces in enclosures (see also 5.6).

7.5.3 Off-road portable and skid-mounted air compressor units

Suitable warning signs shall be attached to the compressor unit:

a) to operate only with doors and lids closed, as given in A.4;

b) that the outlet cocks of the compressor shall not be opened unless a hose is attached, as given in A.5;

c) for hot surfaces, as given in A.7;

d) stating the correct fuel at the point of refuelling;

e) marking of input point for fuel, as given in A.16;

f) marking of input point for oil, as given in A.17;

g) marking of input point for coolant, as given in A.18;

h) marking of the specified tyre pressure;

i) marking of lashing and lifting points, as given in A.19.

NOTE Portable compressor units used on-road are also subject to regulations related to motor vehicles and their trailers.

7.5.4 Markings (in particular, data plate)

7.5.4.1 Generally applicable

Markings, including data plates, shall be permanently attached and clearly visible.

Compressor units shall have a data plate(s) with at least the following information:

a) business name and full address of the manufacturer and, where applicable, his authorised representative;

b) mandatory marking[2)];

c) year of manufacture (that is the year in which the manufacturing process is completed);

d) designation of series or type, if any;

e) serial or identification number, if any;

f) rating information to include the following;

1) maximum allowable pressure at the outlet of the compressor, expressed in bar;

2) maximum rotational shaft speed as rotational speed of prime mover interface or compressor;

3) the gross mass of the compressor unit, expressed in kg (also included in other information for use as required and as identified in 7.2.1.2).

7.5.4.2 Electrically driven

Additional marking on the data plate to be applied:

— Total of rated power of all installed motors.

Any additional information given shall be in accordance with 16.4 of EN 60204-1:2006.

7.5.4.3 Portable and skid-mounted air compressors

Additional marking on the data plate to be applied:

— nominal power expressed in kilowatts (kW);

— mass of the most usual configuration, in kilograms (kg);

and, where appropriate:

— maximum drawbar pull provided for at the coupling hook, in Newtons (N);

— maximum vertical load provided for on the coupling hook, in Newtons (N).

2) For machines and their related products intended to be put on the market in the EEA, CE marking as defined in the applicable European directive(s), e.g. Machinery, Outdoor Noise, and Pressure Equipment.

NOTE Portable compressor units used on-road are also subject to regulations related to motor vehicles and their trailers.

7.6 Noise

7.6.1 A-weighted emission sound pressure level and A-weighted sound power level declaration

The instructions shall include:

— the value of the A-weighted emission sound pressure level at the workstation; the value of the associated uncertainty shall be given in accordance with Clause 8 of EN ISO 2151:2008;

— the value of the A-weighted sound power level where the A-weighted emission sound pressure level at the workstation exceeds 80 dB(A); the value of the associated uncertainty shall be given in accordance with Clause 8 of EN ISO 2151:2008;

— the reference number of the noise test code, EN ISO 2151:2008.

Exceptionally for compressor units for use outdoors the value of the declared A-weighted sound power level shall be a single number, i.e. the sum of the measured value and the value of the associated uncertainty, according to the relevant regulation.

7.6.2 Hearing protection

Information on the use of hearing protectors shall be provided.

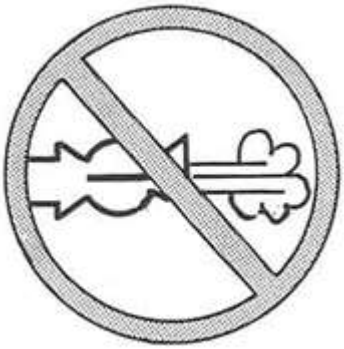
7.7 Dismantling

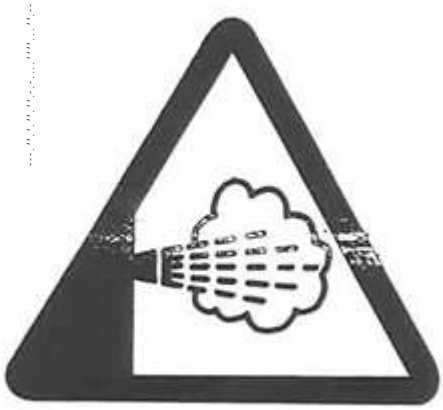
Information on safe dismantling, disabling and disposal shall be provided. This will include safe disposal of all fluids used in the compressor unit such as lubricants, coolants and refrigerant gases, and shall be in accordance with 7.1.4 of EN 626-1:1994+A1:2008. Compressor units containing materials which may be classified as hazardous substances when scrapped and where specific disposal methods are required then this information shall be given.

Annex A
(informative)

Labels, signs and tags

Symbol	Reference	Colours	Corresponding standard and registration number
A.1 	Mandatory: Read the instruction manual	Background: blue Symbol: white	ISO 6405-1:1991
A.2 	Mandatory action: Hearing protection must be worn	Background: blue Symbol: white	ISO 3864:1984 – B.2.5 EN 61310-1-1:1995
A.3 	Prohibition: Do not start	Background: white Circular band: red Symbol: black	

A.4 	Prohibition: Do not operate the portable compressor with the doors or enclosure open	Background: white Circular band: red Symbol: black	
A.5 	Prohibition: Do not open the cock before the air hose is attached	Background: white Circular band: red Symbol: black	
A.6 	Warning: Compressor unit may start without warning	Background: yellow Triangular band: black Symbol: black	ISO 7000:2004 – 0017

A.7 	Warning: risk of high temperature	Background: yellow Triangular band: black Symbol: black	IEC 60417-5041
A.8 	Warning: Maintenance work in progress	Background: yellow Triangular band: black Symbol: black	
A.9 	Warning: Exhaust of hot or harmful gases in normal working area	Background: yellow Triangular band: black Symbol: black	

A.10 	Warning: Risk of low temperature	Background: yellow Triangular band: black Symbol: black	EN 61310-1:1995
A.11 	Start device		IEC 60417-5007
A.12 	Stop device		IEC 60417-5008
A.13 	Start and stop device		IEC 60417-5010
A.14 	Emergency stop device	Red-coloured (mushroom-type push button on a yellow background)	IEC 60417:2002 - 5638
A.15 	Direction of rotation	Symbol: black	ISO 7000:2004 – 0004

A.16 	Fuel fill	Symbol: black	ISO 7000:2004 – 0245
A.17 	Oil fill	Symbol: black	ISO 7000:2004 – 0248
A.18 	Engine coolant	Symbol: black	ISO 7000:2004 – 1377
A.19 	Lifting point	Symbol: black	ISO 7000:2004 – 1368
A.20 	Lashing point (Tie down)		ISO 7000:2004 – 2069

Annex ZA
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 2006/42/EC Safety of machinery

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association to provide a means of conforming to Essential Requirements of the New Approach Directive 2006/42/EC, Safety of machinery.

Once this standard is cited in the Official Journal of the European Union under that Directive and has been implemented as a national standard in at least one Member State, compliance with the normative clauses of this standard confers, within the limits of the scope of this standard, a presumption of conformity with the relevant Essential Requirements of that Directive and associated EFTA regulations.

WARNING — Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this standard.

Bibliography

CEN standards

[1] EN 286-1, *Simple unfired pressure vessels designed to contain air or nitrogen — Part 1: Pressure vessels for general purposes*

[2] EN 349, *Safety of machinery — Minimum gaps to avoid crushing of parts of the human body*

[3] EN 614-1, *Safety of machinery — Ergonomic design principles — Part 1: Terminology and general principles*

[4] prEN 1012-3, *Compressors and vacuum pumps — Safety requirements — Part 3: Process compressors*

[5] EN 1088, *Safety of machinery — Interlocking devices associated with guards — Principles for design and selection*

[6] EN 1127-1, *Explosive atmospheres — Explosion prevention and protection — Part 1: Basic concepts and methodology*

[7] EN 13309, *Construction machinery — Electromagnetic compatibility of machines with internal power supply*

[8] EN 13463-1, *Non-electrical equipment for use in potentially explosive atmospheres — Part 1: Basic method and requirements*

[9] EN 13861, *Safety of machinery — Guidance for the application of ergonomics standards in the design of machinery*

CENELEC standards

[10] EN 60079-0, *Explosive atmospheres — Part 0: Equipment — General requirements*

[11] EN 61000-6-2, *Electromagnetic compatibility (EMC) — Part 6-2: Generic standards — Immunity for industrial environments*

[12] EN 61000-6-4, *Electromagnetic compatibility (EMC) — Part 6-4: Generic standards — Emission standard for industrial environments*

[13] EN 61310-1-1:1995, *Safety of machinery — Indication, marking and actuation — Part 1: Requirements for visual, acoustic and tactile signals*

[14] EN 61310-3, *Safety of machinery — Indication, marking and actuation — Part 3: Requirements for the location and operation of actuators*

CEN/ISO standards

[15] EN ISO 11688-2, *Acoustics — Recommended practice for the design of low-noise machinery and equipment — Part 2: Introduction to the physics of low-noise design (ISO/TR 11688-2:1998)*

[16] EN ISO 4871, *Acoustics — Declaration and verification of noise emission values of machinery and equipment (ISO 4871:1996)*

ISO standards

[17] ISO 1217, *Displacement compressors — Acceptance tests*

[18] ISO 3864:1984, *Safety colours and safety signs*

[19] ISO 6405-1:1991, *Earth-moving machinery — Symbols for operator controls and other displays — Part 1: Common symbols*

[20] ISO 7000:2004, *Graphical symbols for use on equipment — Index and synopsis*

EC Directives

[21] Directive 2000/14/EC of the European Parliament and of the Council of 8 May 2000 on the approximation of the laws of the Member States relating to the noise emission in the environment by equipment for use outdoors, OJ L 162, 3.7.2000, p. 1–78

[22] Directive 2004/108/EC of the European Parliament and of the Council, of 15 December 2004 on the approximation of the laws of the Member States relating to electromagnetic compatibility and repealing Directive 89/336/EEC, OJ L 390, 31.12.2004, p. 24–37

The following directives are applicable safety aspects of road transport for portable compressors towed on highways:

[23] Council directive 71/320/EEC of 26 July 1971 on the approximation of the laws of the Member States relating to the braking devices of certain categories of motor vehicles and of their trailers (Consolidation text OJ ref: 01971L0320-20070101 − EN −01.01.2007 − 011.001)

[24] Council Directive 76/756/EEC of 27 July 1976 on the approximation of the laws of the Member States relating to the installation of lighting and light-signalling devices on motor vehicles and their trailers (Consolidation text OJ ref: 01976L0756-20070709 − EN− 09.07.2007 − 008.001)

[25] Commission directive 85/647/EEC of 23 December 1985 adapting to technical progress Council Directive 71/320/EEC on the approximation of the laws of the Member States relating to the braking devices of certain categories of motor vehicles and their trailers

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