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Compressors and vacuum pumps - Safety requirements - Part 2: Vacuum pumps

Compresseurs et pompes à vide - Prescriptions de sécurité - Partie 2: Pompes à vide

Kompressoren und Vakuumpumpen - Sicherheitsanforderungen - Teil 2: Vakuumpumpen

This European Standard was approved by CEN on 13 March 1996 and includes Amendment 1 approved by CEN on 6 August 2009.

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COMITÉ EUROPÉEN DE NORMALISATION
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Contents

Foreword

This document (EN 1012-2:1996+A1:2009) 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by publication of an identical text or by endorsement, at the latest by March 2010, and conflicting standards shall be withdrawn at the latest by March 2010.

This document includes Amendment 1, approved by CEN on 2009-08-06.

This document supersedes EN 1012-2:1996.

The start and finish of text introduced or altered by amendment is indicated in the text by tags [A1] ⟨A1⟩.

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

[A1] For relationship with EU Directive(s), see informative Annexes ZA and ZB, which are integral parts of this document. ⟨A1⟩

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 supply".

[A1] Annexes A, ZA and ZB to this draft European Standard are informative. ⟨A1⟩

This standard is divided in two parts:

— EN 1012-1 Compressors

— EN 1012-2 Vacuum Pumps

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, 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 United Kingdom.

[A1] Introduction

This document is a type C standard as stated in EN ISO 12100.

The machinery concerned and the extent to which hazards, hazardous situations and hazardous 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 or 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. ⟨A1⟩

1 Scope

This standard is applicable to all vacuum pumps, vacuum pump combinations and vacuum pumping systems. The standard lists the significant hazards associated with vacuum pumps and specifies safety requirements applicable to the design, installation, operation, maintenance and dismantling of vacuum pumps during their foreseeable life and subsequent disposal.

The scope does not include pumps designed to pump continuously on open systems where the pump inlet pressure is above 75 kPA (750 mbar) absolute, i.e. vacuum cleaners, ventilation fans).

Vacuum pumps intended for use in special applications shall also comply with any specific standards relating to those applications.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when they are incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

〚A1〉 *deleted text* 〈A1〛

EN 294:1992, *Safety of machinery – Safety distances to prevent danger zones being reached by the upper limbs.*

EN 418, *Safety of machinery – Emergency stop equipment – Functional aspects*

EN 563, *Temperatures of touchable surfaces – Ergonomics data to establish temperature limit values for hot surfaces*

EN 953, *Safety of machinery – Guarding of machinery – Fixed and moveable guards.*

EN 1127-1, *Safety of machinery – Fires and explosions – Part 1: Explosion prevention*

〚A1〉 *deleted text* 〈A1〛

EN 50 014, *Electrical apparatus for potentially explosive atmospheres – General requirements*

EN 50 081-2, *Electro-magnetic compatibility – Generic emission – Part 2: Industrial environment*

EN 50 082-2, *Electro-magnetic compatibility – Generic immunity – Part 2: Industrial environment*

EN 61310-1, *Safety of machinery – Indication, marking and actuation – Part 1: Requirements for visual, auditory and tactile signal (IEC 1310-1:1995)*

EN 60204-1:1992, *Electrical equipment of industrial machines – Part 1: General requirements*

EN 60529, *Degrees of protection provided by enclosures*

ENV 1070, *Safety of machinery – Terminology*

〚A1〉 EN ISO 2151, *Acoustics – Noise test code for compressors and vacuum pumps – Engineering method (Grade 2) (ISO 2151:2004)* 〈A1〛

〚A1〉 EN ISO 12100-2:2003, *Safety of machinery – Basic concepts, general principles for design – Part 2: Technical principles (ISO 12100-2:2003)* 〈A1〛

ISO 3266, *Eyebolts for lifting purposes*

ISO 3529, *Vacuum Technology – Vocabulary*

ISO 4126-1, *Safety valves – Part 1: General Requirements*

ISO 4871, *Acoustics – Declaration and verification of noise emission values of machinery and equipment*

ISO 7000, *Graphical symbols for use on equipment – Index and synopsis*

ISO/TR 11688-1, *Acoustics – Recommended practice for the design of low noise machinery and equipment – Part 1: Planning*

IEC 417, *Graphical symbols for use on equipment*

▌A1⟩ IEC 61010-1 ⟨A1▌, *Safety requirements for electrical equipment for measurement, control and laboratory use – Part 1: General requirements*

3 Definitions

For the purposes of this standard the definitions given in ENV 1070 and ISO 3529 apply. Definitions specifically needed for this standard are added below.

3.1
vacuum
an environment where the total pressure is below the prevailing atmospheric level.

NOTE Vacuum is usually measured as the absolute pressure of the residual gas expressed as Pascals (Pa) or millibar (mbar). 1 mbar = 100 Pa.

3.2
vacuum pump
device for creating, improving and/or maintaining a vacuum.

NOTE Terms "vacuum pump" and "pump" have the same meaning throughout this standard.

3.3
pump inlet
port by which gas to be pumped enters the pump

3.4
pump outlet
outlet or discharge port of a pump

3.5
maximum starting pressure
maximum inlet pressure at which the vacuum pump may be started

3.6
maximum outlet pressure
maximum pressure at the vacuum pump outlet specified by the manufacturer

3.7
throughput of a vacuum pump
quantity of gas flowing through the inlet of the vacuum pump, usually expressed as a pressure quantity product per unit time interval

3.8
pumped media
all the substances which enter the vacuum pump i.e. gases, vapours, liquid mists and entrained solid particles

3.9
pump fluid
fluid essential for the operation of a vacuum pump

3.10
primary pump
pump that has a maximum outlet pressure equal or greater than ambient pressure

3.11
secondary pump
pump which has a maximum starting pressure or a maximum outlet pressure which is less than atmospheric pressure or is only efficient at lower pressures and is intended to operate in conjunction with a primary pump to produce pressures lower than could be achieved by the primary pump alone

3.12
pumping system
pump or a combination of pumps fitted with accessories for the sole purpose of producing a vacuum. The accessories could include pipework, valves, filters, coolers, control devices and any other equipment required to meet performance requirements

3.13
positive displacement pump
vacuum pump in which a volume filled with gas is cyclically isolated from the inlet, the gas being then transferred to an outlet

3.14
vapour pump
vacuum pump in which gases are pumped by molecular collision with and/or entrainment by a high speed directional vapour stream and driven to the pump outlet (e.g. Vapour Diffusion Pumps and Vapour Diffusion Ejector Pumps)

3.15
cryogenic entrapment pump
vacuum pump in which the pumped media is either condensed on a surface refrigerated to a very low temperature (less than 120 K) or is retained by adsorption using a porous medium of large effective area maintained at cryogenic temperature (e.g. Cryopumps and Adsorption Pumps). The term "cryogenic temperature" is used in the text for temperatures less than 120 K.

3.16
getter pump
pumps in which the gas is retained principally by chemical combination with a getter. The getter is usually a metal or metal alloy either in bulk (volume getter pump) or is sublimated (sublimation pump) or is dispersed by cathodic sputtering (sputter ion pump)

3.17
molecular pump
vacuum pumps in which the pumping action is achieved by a high speed rotor imparting momentum to gas molecules causing them to move towards the outlet of the pump (e.g. Molecular Drag Pumps and Turbomolecular Pumps)

3.18
maximum allowable working pressure
maximum operating pressure which the manufacturer specifies

3.19
minimum allowable working pressure
minimum operating pressure which the manufacturer specifies

3.20
baking
process of heating a vacuum system to accelerate, for instance, the removal of unwanted substances from the surfaces within the system and enable a low pressure to be achieved

3.21
methane drain pump
positive displacement pump used for the extraction of methane from mines, landfill sites and environments where the presence of methane is a hazard

4 List of Hazards Specific to Vacuum Pumps

4.1 Mechanical Hazards

		Reference to safety requirement
4.1.1	**Generally applicable**	
a)	Cutting and severing due to contact with moving parts such as drive belts, cooling fans, couplings, shafts and rotors;	5.1.1
b)	Cutting and severing due to sharp edges such as sheet metal parts, crimped tubes and turbine blades;	5.1.1 and 5.1.4
c)	Drawing in to a vacuum system;	5.1.1
d)	Ejection of parts caused by implosion of any part of the pump or pumping system;	5.1.1
e)	Ejection of parts caused by bursting of the vacuum system due to excess pressure caused by:	5.1.1 and 7.3.1
—	the incorrect direction rotation of the vacuum pump,	
—	a blocked or restricted exhaust,	
—	the faulty operation of a gas input to the vacuum system,	
—	mechanical failure of components,	
—	the reverse rotation of a pump when switched off under vacuum;	
f)	Loss of stability when adding or removing accessories;	5.1.1
g)	Loss of stability during transportation;	5.1.1
h)	Loss of stability during lifting due to lack of lifting facilities;	5.1.1

i) Slip, trip or fall resulting from oil leakage; 5.1.1

4.1.2 Applicable to vapour pumps 5.1.2

Ejection of parts due to a pressure rise caused by operating a vapour pump at atmospheric pressure, without cooling and with its inlet and outlet valves closed.

4.1.3 Applicable to cryogenic entrapment pumps 5.1.3

Ejection of parts due to the bursting of a cryogenic entrapment pump caused by:

— release of entrapped pumped medium in a sealed system;

— excessive pressure generated when cold high pressure refrigerant is allowed to warm up in a sealed system;

— excessive pressure generated when a container of refrigerant at high pressure is exposed to fire;

— the cryogenic failure of materials used in its construction.

4.1.4 Applicable to getter pumps 7.3.1

Trapping of fingers when handling strong magnets.

4.1.5 Applicable to Molecular Pumps 5.1.5

a) Ejection of the moving rotor assembly from a turbomolecular pump;

b) Ejection of high energy fragments resulting from disintegration of the high speed rotor of a turbomolecular pump;

c) Loss of stability of a molecular pump caused by the rotor becoming unbalanced or decelerating suddenly.

4.2 Electrical Hazards 5.2.1

4.2.1 Generally applicable 5.2.1

— electrical contact direct or indirect,

— electrostatic phenomena,

— external influences on electrical equipment.

4.2.2 Applicable to vapour pumps 5.2.2

High electrical leakage current caused by the absorption of moisture by mineral insulated heater elements.

4.2.3 Applicable to getter pumps 5.2.3

Contact with Extra High Voltage supply to a getter pump due to:

— disconnecting the pump from its power supply before switching off the supply and, if appropriate, without discharging stored energy;

— failure of insulation caused by excessive baking temperatures or mechanical damage.

4.3 Thermal hazards

5.3.1, 5.3.2

a) Burns due to contact with hot surfaces.

b) Burns due to contact with very cold surfaces, cold pumped media or cold refrigerant gas.

c) Scalds due to contact with hot pump fluids or lubricants.

4.4 Hazards generated by noise

5.4.1

Hearing losses caused by high noise level.

4.5 Hazards generated by radiation

5.5.1

Exposure to ionising radiation produced by a getter pump.

4.6 Hazards generated by material and substances processed, used or exhausted by vacuum pumps

4.6.1 Generally applicable

a) Hazards resulting from exhausting of toxic gases or vapours being processed; 5.6.1

b) Hazards resulting from inhalation of concentrations of oil mist from the exhaust of an oil sealed pump; 5.6.1

c) Hazards resulting from any contact during pump maintenance with toxic breakdown/reaction products of lubricants, pump fluids or pumped media; 7.6.2

d) Fire or explosion resulting from processing or exhausting flammable gases and vapours; 5.6.1

e) Fire or explosion resulting from processing or exhausting oxidants; 5.6.1

f) Fire or explosion resulting from processing pyrophoric gases; 5.6.1

g) Fire resulting from the degradation of lubricating oil at high temperatures; 5.6.1

h) Hazard resulting from a violent increase in pressure due to the decomposition of a pumped gas. 5.6.1

4.6.2 Applicable to vapour pumps

5.6.2

Hazards resulting from contact or inhalation of toxic chemical breakdown products of pump fluids exposed to excessive temperature.

4.6.3 Applicable to cryogenic entrapment pumps

5.6.3

Hazards resulting from contact or inhalation of toxic materials released by a cryogenic entrapment pump during warm-up or maintenance.

4.7 Hazards generated by neglecting ergonomic principles in design

a) Neglected use of personal protection equipment; 5.7

b) Human errors resulting from poor positioning of controls and instruments; 5.7

c) Hazards caused by incorrectly connecting a pump to the system to be pumped. 6.3, 7.3.1

4.8 Hazards caused by failure of energy supply, breaking down of parts or other functional disorders

5.8.1

a) Failure of energy supply;

b) Failure or disorder of central control system (unexpected start up);

c) Errors of fitting.

4.9 Hazards caused by missing or incorrectly positioned safety related measures and means

5.9
5.10

a) Hazards that may occur should a pump restart of its own accord after being shut down due to a fault condition;

b) Hazard resulting from error in programming a process sequence;

c) Hazard resulting from a software error;

d) Hazard resulting from a computer component failure.

5 Safety requirements and measures

〚A1〛 Vacuum pumps shall comply with the safety requirements and/or protective measures of this clause. In addition, they shall be designed according to the principles of EN ISO 12100-2:2003 for relevant but not significant hazards, which are not dealt with by this document. 〚A1〛

5.1 Mechanical safety

5.1.1 General requirements

a) Contact with moving parts shall be prevented by the use of guards in accordance with EN 953.

A guard shall be considered adequate if it prevents contact with the moving part using the Test Finger of EN 60 529, (see EN 294).

b) All accessible edges and corners shall be radiused to avoid injury.

c) If final guarding is only achievable on installation to the vacuum system, temporary guards shall be provided (e.g. where the pump mechanism is accessible through the pump inlet, the inlet shall be covered).

d) Evacuated parts shall be strong enough to prevent implosion during the life of the equipment.

Where the risk of such damage cannot be eliminated, implosion guards shall be provided to contain any ejected material.

e) The design shall be such that blockage or restriction due to any accumulation of debris from the pumped media shall not cause a hazard.

Exhaust filters shall have sufficient capacity to allow the pump to operate safely at maximum throughput.

Means shall be provided to ensure that saturation or blockage of the filter element cannot result in the maximum allowable working pressure being exceeded.

Where the process is such that accumulation of debris in the outlet of a pump or pumping system is unavoidable, outlet pressure monitoring devices or a pressure relief valve shall be provided.

f) Vacuum pumping systems shall be designed to be stable. The test for stability is described in clause 8.3.

Consideration shall be given to any accessories that could be added by the user of the equipment.

Where the test requirement cannot be achieved, means shall be provided for adequately securing the system.

g) The means of safe handling shall be provided or specified for vacuum pumps and vacuum pumping systems.

Facilities used may include handles, eyebolts, wheels, lugs or brackets. Eyebolts shall be in accordance with ISO 3266.

h) Steps shall be taken to minimise the possibility of oil leaking from the pump.

5.1.2 Requirements for vapour pumps (additional)

The system design shall ensure that no hazard is created if the pump is operated at atmospheric pressure with its inlet and outlet closed.

5.1.3 Requirements for cryogenic entrapment pumps (additional)

a) To prevent explosion of the pump if pumped media is released into a sealed pumping system a suitable pressure relief device shall be incorporated into the pump body.

The pressure relief device shall meet the requirements of ISO 4126-1, but in addition shall be suitable for operation at cryogenic temperatures.

b) To avoid material failure resulting from stress caused by thermal cycling or embrittlement at low temperature, all materials used in construction of the pump shall have suitable mechanical properties for their intended duty.

c) All containers and vessels containing pressurised gas shall be designed and manufactured to an appropriate recognised code of practice.

d) If a fault condition can occur which can cause any part to be subjected to a pressure in excess of its maximum allowable working pressure then suitable pressure relief devices shall be provided.

e) If a disconnection of a cold pump from its refrigerant compressor can create a pressure hazard a facility shall be provided for venting the pressure system to a safe pressure level and instructions provided for its safe use.

5.1.4 Requirements for getter pumps (additional)

Crimp off connections shall be suitably protected and a warning given of the sharp edge.

5.1.5 Requirements for molecular pumps (additional)

The mounting of the rotor shall be strong enough to prevent the rotor being unintentionally released from the pump.

The enclosure of the pump shall be strong enough to retain the fragments of a disintegrating rotor.

A means shall be provided which allows the securing of the pump to a system which is strong enough to withstand a sudden seizure of the rotor.

5.2 Electrical Safety

5.2.1 General requirements

a) Electrical installation

The electrical installation of a vacuum pump shall fulfil the requirements of ▌A1⟩ IEC 61010-1 ⟨A1▐ or EN 60204-1.

Protection devices and switches shall be so designed and connected as to fulfil the requirements of "fail safe".

The over-current protection of the power circuit may be installed outside the vacuum pump enclosure on site. In such a case the Instruction Manual shall state that the user has to make provisions for the installation of the over-current protection of the power circuit.

Where the vacuum pump is not fitted with an electrical disconnecting device, the Instruction Manual shall specify that this device is to be provided by the user.

Wiring harnesses shall:

— Be adequately secured and protected;

— Not be in contact with hot surfaces;

— Have adequate electrical insulation.

For vacuum pumps to be installed in potentially explosive atmospheres the electrical equipment shall comply with EN 50 014.

b) Electrostatic phenomena

The build up of electrostatic charges shall be avoided by earthing all conductive stationary components, if there is a risk to persons or of the possibility for an effective ignition source developing.

c) External influences on electrical equipment

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

— Short circuiting,

— External impacts,

— Variations in the supply voltage,

— Electromagnetic fields (see EN 50 081-2 and EN 50 082-2),

— Earth faults.

5.2.2 Requirements for vapour pumps (additional)

The design for securing the heater shall ensure good thermal contact between the heater element and the pump to prevent excessive element temperature causing degradation of the element insulation.

5.2.3 Requirements for getter pumps (additional)

a) To prevent contact with the high voltage, each pump shall include provision for protective earthing of all normally accessible conductive parts. If earthing is achieved by means of the earth screen of the high tension cable then this must be rated for the maximum fault current and the connection must be such that the unit is earthed before the live connection is made and broken after the live conductor is disconnected.

b) The connections used to connect the supply to the pump shall be designed and rated for the maximum rated open circuit voltage of the pumps power supply.

c) High voltage connections with an operating voltage in excess of 1000 V shall carry the international warning symbol.

The label used shall be able to withstand the high temperatures to which is may be exposed.

d) The maximum temperature to which the pump and its associated high voltage connections and leads can be exposed shall be specified.

5.3 Thermal Safety

5.3.1 General requirement

Where high or low temperature of the processed medium, lubricant or cooling medium can cause a hazard to personnel, the temperature shall be monitored and if the limits are exceeded the vacuum pumps shall be brought to a safe condition.

All parts with an external surface temperature above 70˚C or below -10˚C and which may be accidentally touched by personnel during normal operation of the pump, shall be guarded, insulated or carry an adequate warning. (See EN 563.) Other high-temperature pipework shall be clearly marked in accordance with annex A.

Any piping shall be free to move with changing temperature and hot piping shall not be in contact with wood or flammable material.

Vacuum pumps installed in an area with potentially explosive atmosphere must have limited surface temperatures and other ignition sources shall be avoided. (See EN 50 014 and EN 1127-1).

5.3.2 Requirements for vapour pumps (additional)

a) Contact with hot pump fluids shall be avoided by the provision of suitable facilities for safe draining and the accompanying instructions shall specify the minimum cooling time that shall be allowed before a fluid is drained from the pump.

b) When shortage of fluid, cooling circuit failure or electrical faults can cause hazardous boiler temperatures to be reached, a suitable thermal overload trip shall be provided designed to disconnect the electrical supply from the pump before unsafe temperatures are reached.

c) When excessive temperatures can result in hazardous degradation of diffusion pump fluids a suitable thermal trip shall be provided.

5.4 Noise

Design considerations shall be given to noise reduction, taking into account ISO/TR 11688-1. Design shall be such that continuous full load operation is possible at the maximum specified ambient temperature, with protective means in place.

5.5 Radiation

The equivalent dose rate of unintended and stray radiation at 50 mm from the outer surface of a getter pump shall not exceed 5 μSv/h.

5.6 Materials and substances processed, used or exhausted by vacuum pumps

Where vacuum pumps and pumping systems are supplied for processes where the pumped media and/or pump fluid could generate hazards, special actions are required to remove the risks associated with the hazards.

5.6.1 General requirements

a) Harmful leakage of air into the system, or toxic gases leaking into the atmosphere shall be prevented by the design. The system shall be tested for leak tightness according to clause 8.4.

b) Harmful entry of any fluid or solid particles into the pump shall be prevented by the fitting of adequate traps or separators.

c) Fire, due to processing flammable substances, shall be avoided by:

— The design and choice of materials to minimise sources of ignition;

— Preventing the build-up of electrostatic charges by the choice of material and suitable earthing;

— Preventing the ingress of foreign particles which could ignite when coming into contact with the rotating shaft.

Where water is used as the sealing medium, a flow meter shall be fitted that shall trip the prime mover if the water flow is reduced to a hazardous level.

To avoid the escape of flammable gases, the pumping system shall be tested to an appropriate degree of leak tightness in accordance with 8.4.

If appropriate, the means shall be provided for diluting any flammable substance with an inert gas.

d) Fire or explosion due to processing oxidants shall be avoided by:

— Cleaning all parts of the pump and the system before assembly to remove all traces of organic materials;

— The careful choice of materials used in the construction of the pumping system;

— The careful choice of fluid for lubricating, sealing or pumping;

— Providing, if appropriate, for the dilution of the pumped gases with a monitored inert gas;

e) Fire or explosion due to processing pyrophoric gases shall be avoided by:

— Providing for the dilution of the pumped gases with a monitored inert gas;

— Leakage of air into the system shall be prevented by the design and tested for leak tightness in accordance with 8.4;

— Leakage of the pyrophoric gases into the atmosphere shall be prevented by the design and the system shall be tested for leak tightness in accordance with 8.4;

f) If there is a risk of decomposition of the gas or of an explosion, the system shall be designed to resist the resulting pressure. This shall be verified by a static overpressure test in accordance with 8.2.

5.6.2 Requirements for vapour pumps (additional)

If a hazardous pump fluid is used (e.g. mercury) precautions must be taken to prevent migration of the fluid into the exhaust system, or other parts of the vacuum system by provision of suitable traps. Appropriate precautions to be taken during maintenance shall be specified.

To prevent hazardous chemical breakdown of the pump fluid or sealing materials due to excess temperature, precautions shall be taken to prevent excess temperatures. (See 5.3.2.c).

Steps shall be taken to prevent high inlet and outlet pressures causing oxidation of the pump fluid.

Fluids shall be selected to suit the application, the working temperature and pressure.

5.6.3 Requirements for cryogenic entrapment pumps (additional)

a) To avoid possible ignition of accumulated flammable pumped media, hot filament or electrical discharge devices must be prevented from switching on unless the system pressure is below 10^{-1} mbar.

b) To prevent contact with hazardous pumped media the accompanying instructions must warn of the need to provide safe ducting of exhausted gases and warn of the need to take adequate precautions appropriate to the substances involved during pump maintenance.

c) The design and use of the pump must take into consideration the possible accumulation of hazardous gases such as hydrogen.

5.7 Ergonomic principles in machine design

Start and stop devices shall be easy to operate and shall be clearly marked in accordance with EN 418, or IEC 417 (see Annex A).

Manual controls and other devices frequently used shall be arranged to be easily reached and operated with excessive effort.

Instruments shall be located so as to be easily visible from the operator's position from which the controls related to those instruments are operated.

Whenever possible, controls and instruments shall be designed and arranged to assist the operator to understand their function and hence avoid operator's error.

The vacuum pump shall be designed and constructed to permit safe handling of fluids during filling, purging, venting, recovery and draining.

5.8 Failure of energy supply, breaking down of machinery parts and other functional disorders

5.8.1 General requirements

a) In the case of loss of the main or auxiliary energy supply the pump or pumping system shall be brought to a safe condition;

b) The pump or pumping system design shall be such that failure of the energy supply shall not result in a hazardous situation at the time of failure or when the energy supply is reinstated.

This shall apply to the complete system and include lubrication feed, water supply, valve position or any part of the control circuit that could pose a hazard.

5.8.2 Breaking down of machinery parts

The materials used in the construction of vacuum pumps and pumping systems shall be adequate for the intended use with particular regard to durability, the phenomena of fatigue, ageing (incl. embrittlement), corrosion, abrasion, chemical reaction, heat and electrostatic effects.

Materials used shall not endanger the health and safety of personnel.

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

Lubricating oils, grease and pump fluids shall be capable of withstanding the extremes of pressure and temperature to be encountered.

Seals or gaskets shall be made from materials which are capable of withstanding the extremes of pressure and temperature to be encountered.

5.9 Safety related measures and means

a) After a stop caused by the safety devices, restart shall only be possible by an intentional operation of a manual control;

b) When a keyboard is used as the interface with the operator, it shall not be possible for an incorrect command to result in a hazardous situation;

c) Safety shall not be dependent on the correct operation of software. Hardware, in the form of interlocks or other safety devices must be provided to ensure safe operation in the event of software failure. Similarly, safety shall not be dependent on the correct operation of computer hardware.

5.10 Emergency stops

An emergency stop shall be provided when a hazardous situation can develop which needs to be averted by a manual action.

Emergency stop devices shall be in accordance with EN 418 and EN 61310-1 (see Annex A).

However if an analysis shows that the normal stop device complies functionally with emergency stop requirements, this is acceptable and the stop device shall be marked accordingly.

6 Marking, signs and warnings

6.1 Generally applicable

Marking, signs and warnings shall be permanently attached and clearly visible.

6.2 Data plate

〉A1〈 Vacuum pumps shall be marked visibly, legibly and indelibly with the following minimum particulars:

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

— designation of the machinery;

— mandatory marking;[1]

— designation of series or type;

— serial number, if any;

— the year of construction, that is the year in which the manufacturing process is completed; 〉A1〈

— rotational shaft speed, in reciprocal minutes, min^{-1}, (if appropriate).

6.3 Additional requirements

The following additional information shall be marked:

a) On pumps driven by rotational shaft:

— Direction of rotation,

— Pump inlet and outlet, if they can be confused,

— Maximum and minimum fluid levels, if it affects safety,

— Cooling inlet and outlet (if appropriate),

— The pump fluid to be used, if other fluids can cause a hazard.

b) On vapour pumps:

— The quantity of pump fluid required,

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[1] 〉A1〈 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. 〉A1〈

— The direction of air flow or fan rotation on air cooled pumps,

— Hot surface warning labels as appropriate.

c) On cryogenic entrapment pumps:

— A label shall be provided adjacent to the pressure relief valve warning that the valve shall not be obstructed and that precautions for safe ducting shall be taken, if hazardous substances have been pumped;

— A label warning that the pressure system must be vented to a safe pressure before disconnecting a cold pump or dismantling the system;

— A label to recommend the operator to read the Instruction Manual.

d) On getter pumps:

— Maximum rated voltage (on the data plate),

— High voltage warning symbol,

— Magnetic field warning symbol.

6.4 A vacuum pumping system shall be marked with additional information on vacuum systems.

— ▌A1⟩ the business name and full address of the manufacturer and, where applicable, his authorised representative;

— designation of the machinery;

— mandatory marking;[2]

— designation of series or type;

— serial number, if any;

— the year of construction, that is the year in which the manufacturing process is completed; ⟨A1▐

— the nominal voltage, frequency and current.

7 Information for use

7.1 General

Every vacuum pump, vacuum pump combination and vacuum pumping system shall be supplied with written instructions. These instructions must provide the user with all the information needed for the safe and efficient installation, storage, use, maintenance and disposal of the equipment throughout its intended life.

[2] ▌A1⟩ 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. ⟨A1▐

7.2 Transport and Storage

User instructions shall clearly state any information needed for the safe movement, transportation and storage of the equipment including:

— Weight,

— Provisions provided for lifting,

— Transit fixtures,

— Storage limitations,

— Storage condition.

7.3 Installation

7.3.1 User instructions shall clearly state all the information needed to install the equipment, including:

— Instructions for fixing the pump in its operating position when appropriate;

— Description of pump inlet and outlet;

— A specification of cooling requirements;

— A warning of the need to check for correct pump rotation on installation and after maintenance, with instructions on how to check rotation safely;

— A statement of the maximum safe outlet pressure of the pump and a warning not to operate the pump with the outlet blocked or restricted;

— A statement of the maximum safe outlet pressure of the pump and a warning not to operate the pump with the outlet blocked or restricted;

— A statement of the maximum throughput of the pump and a warning of the need to ensure that any exhaust system and relief valves are capable of passing this throughput without causing the maximum pump outlet pressure to be exceeded;

— A statement of the maximum gas pressure that can be connected to any gas inlets with instructions for safe connection and disconnection;

— A warning of the need to ensure safe ducting of the pump exhaust if oil mist or hazardous substances are present;

— A statement of the working fluids with which the pump is intended to be used;

— A warning not to use specific known diffusion pump fluids for which the pump is unsuitable and which would render it unsafe, (e.g. mercury);

— A warning not to restrict the air flow on air cooled pumps and a specification for clearance around the air intake or minimum flow of air;

— A statement for installing cryogenic pumps of the correct charge pressure of the refrigerant and a warning that all apparatus used for charging must be adequately rated and that the correct charge pressure must not be exceeded. All necessary instructions for safe charging must be given;

— A statement for installing getter pumps giving the maximum rated voltage, maximum operating current and maximum baking temperature;

— A statement for installing getter pumps on the safe handling of magnets;

— A warning, if appropriate, of the need to protect any electrical circuits from dripping water resulting from condensation on cold surfaces.

7.3.2 If the equipment is designed for use with hazardous gases or vapours, clear warnings shall be given of all the additional precautions needed for safe operation and of the importance of observing the safety recommendations of the supplier of the gas.

7.4 Product description

User instructions shall describe the equipment, stating:

— Name and address of manufacturer;

— The important features (e.g. leak rate, information appearing on the data plate),

— Protective devices,

— The environment in which the equipment is intended to be used,

— Intended use,

〚A1〛 *deleted text* 〈A1〉

— 〚A1〛 Declared noise level (see 8.1). 〈A1〉

7.5 Use

7.5.1 User instructions shall clearly describe all the information required to operate the equipment safely, including:

— Description and function of the controls,

— Emergency stop procedure (if applicable),

— How not to operate the equipment.

7.5.2 User instructions shall warn of any possible hazard associated with operating the equipment and with the process(es) for which it was intended, including:

a) For all equipment:

   — Warnings relating to the exhausting of pumped gases and vapours;

   — A warning against exposing any part of the human body to vacuum;

b) For vapour pumps (additional):

   — A warning that if specified maximum inlet and backing pressures are exceeded, pump fluid will migrate to other parts of the vacuum system. Instructions shall be provided for appropriate primary pumping and valving;

— Any warnings and safe handling instructions for the operation of cryocooled baffles incorporated into the pump;

c) For cryogenic entrapment pumps (additional)

— A warning that the refrigeration system shall be vented to a safe pressure before disconnecting a cold pump from its compressor or dismantling the pump together with instructions on how to vent the system safely;

— A warning not to restrict the pump's pressure relief valve and instructions for safe ducting of the valve throughput if hazardous materials have been pumped;

— A statement not to fit any device to the pump which could ignite flammable pumped media during pump warm up;

— A statement that bodily contact with surfaces at cryogenic temperatures shall be avoided and the circumstances when this risk exists;

— A statement of the additional risks associated with accumulation of hazardous gases;

d) For getter pumps (additional):

— A warning of the need to ensure protective earthing of the pump body;

— Instructions for safe baking of the pump including the marking or shielding of the hot surface;

— A specification for the maximum baking temperature of all parts of the pump assembly (e.g. those parts which must not be baked);

— The maximum operating temperature if different from the maximum baking temperature shall also be specified.

7.6 Maintenance

7.6.1 User instructions shall state clearly all the actions necessary to maintaining the safety of the equipment for its intended life, including:

— List of consumable items/spare parts,

— [A1] The specifications of the spare parts to be used, when these affect the health and safety of operators, [A1]

— How to fit consumable items/spares,

— Recommended maintenance interval,

— Instructions for the inspection and maintenance of safety devices where this is necessary to ensure their reliable operation,

— How to verify the leak tightness of the pump, if applicable.

7.6.2 User instructions shall warn of any possible hazard associated with maintaining the equipment, including:

a) For all equipment:

— The accompanying instructions shall warn of the need to take precautions appropriate to the hazardous materials that may remain in the pump;

— A warning of the possibility of harmful substances caused by the breakdown of pump lubricants or pumping fluid, remaining in the pump;

— Instructions for the safe handling and safe disposal of spent lubricants and other waste materials shall be given;

— All data necessary for the safe handling, use and disposal of the pump fluids;

— Instructions shall be given for the safe maintenance of any filters and a warning of the need to take precautions appropriate to the pumped media when changing and disposing of the filter elements. The intended purpose for which the filter is suitable must be stated.

b) For vapour pumps (additional):

— Instructions for cleaning the pump and statement of the solvents to be used and if appropriate the types to be avoided;

— Instructions for checking the level of pump fluid;

— Instructions for safe draining of the pump fluid including a warning on the minimum cooling time to be allowed before draining.

8 Verification

8.1 Noise measurement

[A1] Verification of noise emission values shall be made in accordance with the dual-number declaration in ISO 4871. [A1]

The measured noise emission values shall be determined in accordance with [A1] EN ISO 2151 [A1].

8.2 Pressure test

A vacuum pump or any part of a pumping system which is intended to contain a possible explosion or a rapid pressure rise due to the decomposition of the pumped media, shall at the design be proven to withstand an absolute pressure of 11 bar.

The period of application of the pressure shall be at least one minute. Distortion of the outer case and leakage may take place, but it must not rupture or be damaged in any other way.

8.3 Mechanical stability testing

A vacuum pump or vacuum pumping system shall be considered stable if, when tilted at an angle of 10° in any direction, the system does not fall over.

8.4 Testing for leak tightness

The degree of leak tightness required shall be consistent with the system, the process and the nature of the gases being pumped.

The method used shall be capable of detecting the leak rate required and shall be calibrated to national standards. Methods used may include:

— Measuring pressure rise after isolating or switching off the pump,

— Pressurising the pump or vacuum system with an inert gas, to between 1,0 bar and 2,0 bar absolute,

— Enveloping the pump or vacuum system with a suitable search gas e.g. helium and using a mass spectrometer to measure the amount of gas leaking into the system.

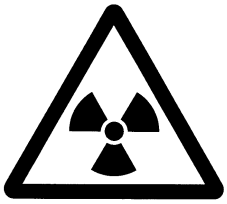
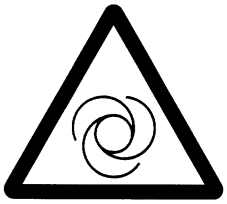
8.5 Structure of verification

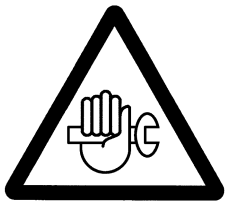
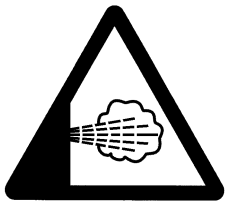
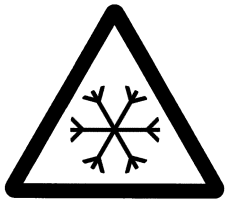
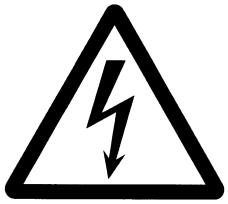
Safety requirement	Visual check	Function check	Measurement	Reference to clauses of this standard or to other standards
5.1 Guards	X		X	EN 60529 EN 953
5.1 Ejection of parts		X	X	8.2
5.1 Stability		X	X	8.3
5.2 Electrical safety		X	X	EN 50014 EN 50081-2 EN 50082-2 EN 60204-1 [A1] IEC 61010-1 [A1]
5.3 Thermal safety	X		X	EN 563 EN 1127-1 EN 50014
5.4 Noise			X	[A1] EN ISO 2151 [A1]
5.5 Radiation for getter pumps			X	
5.6 Leakage			X	8.4
5.6 Fire and explosion			X	8.2 8.4
5.7 Ergonomics	X	X		EN 61310-1
5.8.1 Energy supply	X	X		
5.8.2 Breaking down	X	X		
5 Errors of fitting	X	X		ISO 4126-1
5.1.3 Pressure relief devices	X	X	X	EN 418 EN 61310-1
5.10 Emergency stop	X	X		

Annex A
(normative)

Labels, signs and warnings

Symbol	Referent	Colours	Corresponding standard and registration number
A.1 	Mandatory: Read the Instruction Manual	Background: blue Symbol: white	
A.2 	Mandatory action: Hearing protection must be worn	Background: blue Symbol: white	ISO 3864 EN 61310-1
A.3 	Prohibition: Do not start	Background: white Circular band: red Symbol: black	

Symbol	Referent	Colours	Corresponding standard and registration number
A.4 	Warning: Risk for radiation	Background: yellow Triangular band: black Symbol: black	EN 61310-1
A.5 	Warning: Risk for electro-magnetic field	Background: yellow Triangular band: black Symbol: black	EN 61310-1
A.6 	Warning: Unit is remotely controlled and may start without warning	Background: yellow Triangular band: black Symbol: black	ISO 7000- 0017
A.7 	Warning: Risk of high temperature	Background: yellow Triangular band: black Symbol: black	IEC 417 - 5041

Symbol	Referent	Colours	Corresponding standard and registration number
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 for low temperature	Background: yellow Triangular band: black Symbol: black	EN 61310-1
A.11 	Warning: Risk of electric shock	Background: yellow Triangular band: black Symbol: black	EN 61310-1 ISO 3864

Symbol	Referent	Colours	Corresponding standard and registration number
A.12 	Start device		417 – IEC – 5007
A.13 	Stop device		417 – IEC – 5008
A.14 	Start and stop device		417 – IEC – 5010
A.15 	Emergency stop device	Red-coloured (mushroom-type push button mounted on a yellow background)	EN 418
A.16 	Combined stop and emergency stop device	Red-coloured Symbol: white (mushroom-type push button mounted on a yellow background)	EN 418 417 – IEC – 5008
A.17 	Direction of rotation	Symbol: black	ISO 7000 – 004

Symbol	Referent	Colours	Corresponding standard and registration number
A.18 	Fuel fill	Symbol: black	ISO 7000 – 0245
A.19 	Oil fill	Symbol: black	ISO 7000 – 0248
A.20 	Coolant fill	Symbol: black	ISO 7000 – 0244
A.21 	Lifting point	Symbol: black	ISO 7000 – 1368

Annex ZA
(informative)

⟨A1⟩ Relationship between this European Standard and the Essential Requirements of EU Directive 98/37/EC

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association to provide one means of conforming to Essential Requirements of the New Approach Directive 98/37/EC on machinery amended by the New Approach Directive 98/79/EC.

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 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. ⟨A1⟩

Annex ZB
(informative)

A1 Relationship between this European Standard and the Essential Requirements of EU Directive 2006/42/EC

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 on 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 clauses of this standard confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding 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. A1