SLOVENSKI STANDARD

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Centrifuge - Splošne varnostne zahteve

Centrifuges - Common safety requirements

Zentrifugen - Allgemeine Sicherheitsanforderungen

Centrifugeuses - Prescriptions communes de sécurité

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Centrifuges - Common safety requirements

Centrifugeuses - Prescriptions communes de sécurité

Zentrifugen - Allgemeine Sicherheitsanforderungen

This European Standard was approved by CEN on 6 November 1998 and includes Amendment 1 approved by CEN on 22 February 2009.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Foreword

This document (EN 12547:1999+A1:2009) has been prepared by Technical Committee CEN/TC 313 "Centrifuges - Safety requirements", 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of an identical text or by endorsement, at the latest by September 2009, and conflicting national standards shall be withdrawn at the latest by December 2009.

This document includes Amendment 1, approved by CEN on 2009-02-22.

This document supersedes EN 12547:1999.

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.

Annexes A and C of this European Standard are normative, whereas Annexes B, D, E, ZA and ZB are informative. (A1!

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.

Introduction

The extent to which significant hazards are covered is indicated in clause 1. It is indicated in greater detail in clause 4 and annex A. In addition, machinery should comply as appropriate with EN 292 for general machinery hazards which are not covered by this standard.

It is also intended to ensure that sufficient information is collected, is retained and can be made available, to enable centrifuges to be installed, commissioned, used, maintained and disposed of safely, i.e. that information is made available to users of centrifuges.

Different applications and particular centrifuge designs exist. Annex D includes more details of both of these ranges.

1 Scope

1.1 This European Standard applies to centrifuges aiming at separation of liquid/liquid/solid/solid or at least two of these substances. It gives requirements to minimise the risks caused by the hazards specified in 1.2.

The Standard deals with the significant hazards associated with the operation of centrifuges.

1.2 The Standard gives requirements for minimising the risks caused by the following hazards:

— mechanical hazards common to all types of centrifuges, except those specified in 1.3;

— ergonomical hazards;

— electrical hazards.

The standard also covers requirements for noise measurements.

1.3 Types of centrifuges and hazards excluded

1.3.1 Types of centrifuges excluded:

— centrifuges with a kinetic energy of rotation less than 200 Joule;

— centrifuges designated by their manufacturers for domestic use;

— centrifuges designated by their manufacturers as laboratory centrifuges according to EN 61010-2-020, including Amendment 1;

— centrifuges designated by their manufacturers for forming, i.e. centrifugal hot metal casting machines.

1.3.2 Hazards excluded:

— thermal hazards;

— hazards specific to processing radioactive products;

— hazards specific to microbiological processing - including viral and parasitic hazards;

- hazards from processing corrosive and/or erosive materials;
- hazards from processes involving flammable or explosive substances;
- hazards caused by leakage of hazardous substances;
- hazards caused by unsuitable hygienic design for applications involving food products;
- other application specific hazards which must be dealt with, either according to application specific standards (e.g. [A1) EN 12505 (A1]), or EN 292.

1.4 This standard applies to centrifuges which are manufactured after the date of issue of this standard.

2 Normative references

This European Standard incorporates by dated or undated references, 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 incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 292-1:1991, *Safety of machinery - Basic concepts, general principles for design – Part 1: Basic terminology, methodology*

EN 292-2:1991, *Safety of machinery - Basic concepts, general principles for design – Part 2: Technical principles and specifications, including Amendment 1:1995*

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

EN 418:1992, *Safety of machinery - Emergency stop equipment, functional aspects - Principles for design*

EN 729-2:1994, *Quality requirements for welding - Fusion welding of metallic materials – Part 2: Comprehensive quality requirements*

EN 729-3:1994, *Quality requirements for welding - Fusion welding of metallic materials – Part 3: Standard quality requirements*

EN 894-2:1997, *Ergonomics - Requirements for the design of displays and control actuators. Part 2: Displays.*

prEN 894-3:1992, *Ergonomics - Requirements for the design of displays and control actuators. Part 3: Control actuators.*

EN 953:1997, *Safety of machinery - General requirements for the design and construction of guards (fixed and moveable)*

EN 954-1:1996, *Safety of machinery - Safety related parts of control systems – Part 1: General principles for design*

prEN 1005-2:1993, *Safety of machinery - Human physical performance – Part 2: Manual handling of objects associated to machinery*

EN 1037:1995, *Safety of machinery - Prevention of unexpected start-up*

EN 1050:1996, *Safety of machinery - Principles for risk assessment*

EN 1088:1995, *Safety of machinery - Interlocking devices associated with guards - Principles for design and selection*

EN ISO 3744:1995, *Acoustics - Determination of sound power levels of noise sources using sound pressure - Engineering method in an essentially free-field over a reflecting plane (ISO 3744:1995)*

EN ISO 3746:1995, *Acoustics - Determination of sound power levels of noise sources using sound pressure - Survey method using an enveloping measurement surface over a reflecting plane (ISO 3746:1995)*

EN ISO 4871:1996, *Acoustics - Declaration and verification of noise emission values of machinery and equipment (ISO 4871:1996)*

EN ISO 11203:1995, *Acoustics - Noise emitted by machinery and equipment - Determination of emission sound pressure levels at a work station and at other specified positions from the sound power level (ISO 11203:1995)*

[A1) EN ISO 11688-1:1998, *Acoustics – Recommended practice for the design of low-noise machinery and equipment – Part 1:Planning (ISO/TR 11688-1:1995)* (A1]

EN 50081-2:1994, *Electromagnetic compatibility - Generic emission standard. Part 2: Industrial environment*

EN 50082-2:1995, *Electromagnetic compatibility - Generic immunity standard. Part 2: Industrial environment*

EN 60204-1:1997, *Electrical equipment of machines – Part 1: General requirements*

EN 60529:1991, *Degrees of protection provided by enclosures (IP Code)*

EN 61310-1:1997, *Safety of machinery - Indicating, marking and actuation. Part 1: Requirements for visual, auditory and tactile signals*

ISO 780:1997, *Packaging - Pictorial marking for handling of goods*

ISO 3266:1984, *Eyebolts for general lifting purposes*

[A1) ISO 9296:1988, *Acoustics - Declared noise emission values of computer and business equipment* (A1]

ISO 9614-1:1993, *Acoustics - Determination of sound power levels of noise sources using sound intensity – Part 1: Measurement at discrete points*

ISO 9614-2:1993, *Acoustics - Determination of sound power levels of noise sources using sound intensity – Part 2: Measurement by scanning*

ISO TR 11688-2:1998, *Acoustics - Recommended practice for the design of low-noise machinery and equipment – Part 2: Introduction into physics of low-noise design*

IEC 60364:1992, *Electrical installations of buildings*

3 Terms and definitions

For the purpose of this standard, the following definitions apply:

Further definitions, giving the preferred terminology for all major parts of centrifuges and being a non exhaustive list of types of centrifuges, not necessary for the understanding of this standard, are given in annex D.

3.1 General terms

3.1.1
centrifuge
separation device which has a rotatable chamber in which a mixture of process materials may be subjected to (radial) acceleration

3.1.2
particular centrifuge design
family of centrifuges which may have minor variations in the basic dimensions or speed, but with basically similar specifications and properties of materials of construction

3.2 Parts of a centrifuge

3.2.1
drum
chamber which holds the process material, and is arranged to rotate about its symmetrical axis

3.2.2
hoop
ring secured to the outer periphery of a drum to give extra strength

3.2.3
basket
drum used for filtration purposes

3.2.4
bowl
drum used for the separation of immiscible liquids and/or the sedimentation of solids

3.2.5
rotor
assembled part of the centrifuge which rotates, comprising drum and shaft together with their attachments

3.2.6
casing; housing
enclosure in which at least the drum rotates and which may constrain process materials leaving the drum to particular paths.

The casing may consist of several components

3.2.7
casing cover; lid
part fixed to the casing to provide access, for example for inspection, operation or maintenance

3.2.8
discharge device
device to induce discharge of liquids and/or solids from the centrifuge rotor.

Such a device can for example be a paring tube which discharges a liquid from a rotating rotor by dipping a fixed tube into the liquid

3.2.9
plough; scraper
device for the removal of centrifuged solids from the rotating drum

3.2.10
critical components
parts of a centrifuge that cause significant hazardous situations to develop when they fail or rupture

3.2.11
special lifting tools
tools tailored to the lifting and other handling requirements of a centrifuge or specific components of the centrifuge

3.3 Operational terms

3.3.1
process material
substances fed to a centrifuge for separation and other purposes, for example washing, purging or drying the load

3.3.2
filling mass
total mass of process materials in the drum at any instant

3.3.3
maximum filling mass
filling mass determined by the limiting features of the centrifuge - for example either drum strength or linear dimensions

3.3.4
cleaning in place (CIP)
cleaning of equipment by impingement or circulation of flowing chemical solutions and water rinses into, onto and over surfaces in equipment or systems without dismantling, using equipment designed and installed for that purpose

3.3.5
kinetic energy of total rotating system
total kinetic energy of the rotor together with the filling mass at operating speed

3.3.6
maximum/minimum (allowable) temperature
maximum allowable or minimum allowable temperature of the process material declared by the manufacturer

3.3.7
normal operation
operating condition of the centrifuge, determined by specification and design, considering feed and wash rates, load, vibration, rotational speeds, etc

3.3.8
operating speed of a centrifuge
rotational speed measured in revolutions per unit time at which the rotor is expected to revolve either continuously or at each part of a multispeed programme

3.3.9
purging
removal of unwanted material from a centrifuge by means of a flushing media

3.3.10
throughput
actual feed rate in the case of centrifuges with a continuous process material flow, or;

the throughput of a centrifuge using a batch or non-continuous process determined from the charge mass per cycle and cycle time

3.3.11
out of balance (unbalance)
unequal distribution of filling mass and/or rotor mass which produces oscillating forces during rotation

3.3.12
service media
liquids, gases etc. used for operating the centrifuge

3.3.13
critical speed
characteristic speed or rotating frequency of the centrifuge at which resonance of the centrifuge system is excited

3.3.14
run down time
period between the time at which the stop command is initiated and the time at which the rotor has stopped completely

3.3.15
dangerous run down time
condition when the run down time is longer than the time needed for a skilled person to remove a guard and to reach dangerous moving parts of the machine

4 List of hazards

The table A.1 in annex A of this standard is a list of possible significant hazards normally associated with the use of a centrifuge. The table is the result of a risk assessment carried out in accordance with EN 1050, for all centrifuges covered by the scope of this standard.

The technical measures in clause 5 and information for use in clause 7 are based on that risk assessment, and deal with the identified hazards by either eliminating them or reducing the effects of the risks they generate.

The designer shall determine which of the hazards in Annex A are applicable to their centrifuge design, paying particular attention to the intended use of the centrifuge including maintenance and cleaning, and of its reasonably foreseeable misuse.

5 Safety requirements and measures

5.1 General

Centrifuges shall be so designed and manufactured as to withstand the loads associated with the specified and reasonably foreseeable operating and maintenance conditions without endangering the safety and health of exposed persons.

This clause gives the requirements and measures for those hazards for which particular action appears necessary, either by elimination or reduction of the risk.

All hazards shall where possible be avoided by design (clause 3 of EN 292-2:1991). Where this is not possible one or several protective measures shall be taken. Any residual hazards shall be indicated by warning labels positioned adjacent to the hazard and included in the instructions for use. Where personnel protective equipment is required this shall be stated in the instructions for use.

If applicable requirements/measures are already contained in other standards, specifically in EN 292-1 and EN 292-2 or in type B1- and B2-standards, references are made to them, or to relevant subclauses.

The following parameters shall be taken into account, if applicable, for the purpose of designing, testing, inspection, operating and servicing centrifuges.

- allowed speed range;
- maximum filling mass;
- maximum and minimum through-put;
- starting, stopping, feeding and discharging sequences (cyclic loading);
- allowable ambient temperature range;
- limits in application (for example related to corrosive, erosive, explosive/flammable and toxic properties of the material to be processed by the centrifuge);
- allowable process material temperature range;
- minimum and maximum casing pressure;
- out of balance or vibration limits (dangerous movement);
- maximum power input;
- requirements and limitations regarding installation and connections (for example foundation, piping, ducting loading);
- corrosion and wear allowance on critical components;
- allowable dimensions on critical components;
- inspection/replacement intervals for safety related parts (see example in 5.7);
- inspection/replacement intervals for critical components.

5.2 Mechanical hazards

5.2.1 Ejection of parts

Three types of ejection of parts can occur:

- debris or major parts of the rotor are ejected due to a rotor rupture;
- parts come loose from the rotor and are ejected;
- stationary parts are ejected.

The manufacturer shall give in the instructions for use details of inspection, operation and maintenance (see clause 7).

5.2.1.1 Rotor rupture

The centrifuge shall be so designed and manufactured that:

a) the casing is capable of containing a ruptured rotor, for example a casing constructed of steel withstanding and containing the energy of the ruptured rotor parts and reducing the energy by friction between the rotor parts and the casing, or by deforming of the rotor parts and/or the casing;

and/or;

b) there is no risk of a rotor rupture.

To support the latter case centrifuge rotors shall be manufactured from suitable materials with verified properties considering the operating environment (e.g. temperature, corrosion and erosion) and steady and/or cyclic loading:

Case 1 - Steady loading

The rotor shall be designed according to procedures specified by the manufacturer. The manufacturer shall ensure a safety margin against general yielding and rupture, taking into account the steady loading due to the rotation of the rotor mass and the maximum filling mass.

The strength of cylindrical baskets or bowls may be determined using the method of analysis specified in annex B provided that the loading, geometry and material of construction satisfies the requirements stated in the annex. For stress analysis of more complex geometry's an elastic-plastic FEM (Finite Element Method) or BEM (Boundary Element Method) calculation is considered to be the most suitable.

If a drive mechanism is employed which would drive the centrifuge at a speed higher than its maximum permissible speed, such as a frequency converter and a hydraulic drive, a speed control and an overspeed prevention device to prevent the rotor from exceeding the maximum permitted speed shall be provided, see 5.7.

Case 2 - Cyclic loading

The rotor shall be designed with a safety margin against fatigue failure.

Stresses which shall be considered in a fatigue evaluation are:

— bending stresses in horizontal rotors caused by the weight of the rotor;

— bending stresses in rotors caused by external forces such as loads from belt drives etc;

— stresses caused by cyclic loading of the centrifuge (for example related to intermittent loading and discharging of process materials);

— stresses caused by unbalanced forces of rotors, in particular in the case of dual rotor systems;

All other cyclic loads acting on the rotor, known by the manufacturer, shall be considered.

The operating load acting on a rotor as a result of the start/stop cycle of a centrifuge shall be considered as a cyclic load. The load and expected number of cycles shall be assessed to determine if this will lead to fatigue failure during the foreseeable life of the centrifuge.

Stress raisers such as sharp edges, perforations, rough surfaces (scores, grinding cracks etc.) and bores shall be avoided in regions subjected to high cyclic stresses.

All peak stresses at perforations or discontinuities shall be considered in the evaluation of the safety margin against fatigue failure.

The difference in the condition of the actual rotor material and the test material shall be considered in the evaluation of the safety margin against fatigue failure. The differences in actual service and test conditions and differences in microstructure, purity, residual stress etc. between the two materials shall be included in the consideration.

The welding of all seams important to the integrity of a rotor shall be carried out in accordance with the requirements in EN 729 2 or EN 729 3.

The reduction of fatigue strength for welded seams subject to cyclic loading shall be considered. The requirements in 4.3 of annex B for welded joints are applicable only for static strength evaluation. Additional requirements may be necessary to account for reduction of corrosion and fatigue resistance.

All welded seams on parts subjected to cyclic loads shall be machined to remove end craters, weld undercuts and arc strikes.

5.2.1.2 Ejection of rotor parts

The risk of any rotor parts coming loose and being ejected (and the possible consequential discharge of high kinetic energy process material; see also 5.2.2) from the centrifuge shall be dealt with by:

a) having a casing capable of containing loosened or broken rotor parts, for example a casing manufactured of steel withstanding and containing the energy of the parts and reducing the energy by friction between the parts and the casing, or by deforming of the parts and/or the casing

and/or by;

b) ensuring that mechanical connections between rotor parts and connections of parts attached to the rotor can withstand all foreseeable loads on the connections with a safety margin considering the operating environment of the connection.

Connections and attached parts subjected to cyclic loading shall have a fatigue life that exceeds the foreseeable service life with a safety margin.

All steady and cyclic loads on mechanical connections between rotor parts, as mentioned in 5.2.1.1, shall be considered.

When screwed and/or bolted connections are used for connecting rotor parts subjected to pressure loading from the filling mass, the screws shall be able to carry the sum of the pressure load and other loads on the connection related to the operation of the centrifuge, with a safety margin against rupture of the screws.

All thread type joints subjected to vibration and cyclic loads shall be secured against coming loose by pretensioning. The tightening torque for all critical joints requiring pretensioning shall be specified by the manufacturer.

The design for screwed and/or bolted joints requiring pretensioning shall be such that there is no risk of loss of pretensioning due to settling in the joint and indentation below screw heads and nuts.

The design of screwed and/or bolted connections should follow approved standards.

If it is not possible to secure a joint by pretensioning, it shall be secured against coming loose by a safe positive locking device, or by a method with an equal safety margin.

The possibility of corrosion and erosion on the parts in the connection shall be considered at the design of mechanical connections.

The manufacturer shall specify precautions and inspection/replacement criteria for the parts of the connections between rotor parts subjected to corrosion and/or erosion.

5.2.1.3 Ejection of stationary parts

The risk of stationary parts or debris of such parts being ejected from the centrifuge as a consequence of heavy out of balance or vibration, ejection of rotor parts or a rotor rupture, or as a consequence of those stationary parts failing and/or loosening and being accelerated by the rotor and ejected (and the possible consequential discharge of high kinetic energy process material; see also 5.2.2) shall be dealt with by:

a) having a casing capable of containing loosened and accelerated stationary parts, for example a casing manufactured of steel withstanding and containing the energy of those parts and reducing the energy by friction between those parts and the casing or by deforming of those parts and/or the casing

and/or by;

b) employing specified and well controllable methods for fastening critical stationary components and ensuring that any critical part and its attachments subjected to high or low frequency cyclic loading have a fatigue life exceeding the specified or foreseeable service life with a sufficient margin.

A centrifuge which operates at more than one speed, and which incorporates a discharge device which is inadequate for operation within a certain speed range, shall be provided with an interlocking device to prevent the plough or other discharge device from leaving the parked position, until a safe rotational speed is achieved.

The manufacturer shall specify the maximum allowable operating out of balance or vibration level and, if necessary, how the centrifuge shall be accelerated or decelerated through any critical speed.

Centrifuges shall be designed and manufactured in such a way as to safely withstand, for a short duration of time, an excess out of balance or vibration level determined by the manufacturer, during start-up, operation (duration at least 1 h) and run-down. If a particular centrifuge design cannot be operated safely with such an excess out of balance or vibration level, means for detecting and preventing these conditions shall be provided.

It may be necessary to keep the bowl filled, and/or maintain a flow, during the stopping period of a centrifuge, in order to avoid hazards due to vibration or unbalance conditions.

Centrifuges charged manually and/or operated with frequent starts and stops and centrifuges which can be affected dangerously by out of balance forces shall be equipped with a decelerating device. The decelerating device shall be so designed that the time taken to pass through any critical speed will be so short that the vibration energy will not develop hazardous movement. Examples of such decelerating devices are mechanical brakes, water brakes, hydraulic brakes, pneumatic brakes, electrical motor brakes and magnetic brakes.

5.2.2 Ejection of high kinetic energy process material or service media

Centrifuges shall be so designed and installed that neither solids, liquids, gases nor fumes can escape under normal and predictable circumstances if such an escape can cause impact hazards.

An example where the risk of such impact hazard has to be considered is for the solids outlet at centrifuges where the solids leave the drum at the periphery. Depending on the design of the drum the solids may leave the outlet at a velocity close to the peripheral velocity of the drum. There are several ways to dissipate the kinetic energy. One way is to use a cyclone where the solids can rotate until their velocity is reduced. Another way is to design the drum casing in such a way that the velocity is reduced in a similar way by rotation inside the casing. A third way is to use a closed receiving system strong enough to handle the high velocity.

If a centrifuge is equipped with covers or hatches that need to be removed for cleaning or service when the centrifuge is at a standstill, but can cause a hazard by escape of material if they are removed when the centrifuge is running, then those covers or hatches shall be designed according to the requirements in 5.2.6. Examples of such openings are for cleaning and inspection at the top of a solids outlet cyclone and openings in the bowl cover for cleaning and inspection of the nozzles of a nozzle centrifuge.