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Eksplozivne atmosfere - Prepreļ evanje eksplozije in zaģļ ita - 1. del: Osnovni pojmi in metodologija

Explosive atmospheres - Explosion prevention and protection - Part 1: Basic concepts and methodology

Explosionsfähige Atmosphären - Explosionsschutz - Teil 1: Grundlagen und Methodik

Atmospheres explosives - Prévention de l'explosion et protection contre l'explosion - Partie 1 : Notions fondamentales et méthodologie

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Explosive atmospheres - Explosion prevention and protection - Part 1: Basic concepts and methodology

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Explosionsfähige Atmosphären - Explosionsschutz - Teil 1: Grundlagen und Methodik

This European Standard was approved by CEN on 21 October 2007.

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN Management Centre has the same status as the official versions.

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Foreword

This document (EN 1127-1:2007) has been prepared by Technical Committee CEN/TC 305 “Potentially explosive atmospheres – Explosion prevention and protection”, the secretariat of which is held by DIN.

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of an identical text or by endorsement, at the latest by May 2008, and conflicting national standards shall be withdrawn at the latest by May 2008.

This document will supersede EN 1127-1:1997.

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 EU Directives.

For relationship with EU Directives, see informative Annex ZA, ZB and ZC, which are an integral part of this document.

The main changes with respect to the previous edition are technical changes in the definitions (see Clause 3). Furthermore the document has been editorially revised, references have been updated and a bibliography has been added.

This standard is a general guideline for explosion prevention and protection by design and construction of equipment, protective systems and components.

Detailed information on specific equipment, protective systems and components is comprised in appropriate individual standards. The design and construction of explosion prevention and protection measures need safety relevant data of flammable substances and explosive atmospheres. Detailed information is available from appropriate standards.

EN 1127-1 *Explosive atmospheres — Explosion prevention and protection* consists of the following parts:

— *Part 1: Basic concepts and methodology;*

— *Part 2: Basic concepts and methodology for mining.*

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

CEN and CENELEC are producing a set of standards to assist designers, manufacturers and other interested bodies to interpret the essential safety requirements in order to achieve conformity with European Legislation. Within this series of standards CEN has undertaken to draw up a standard to give guidance in the field of explosion prevention and protection, as hazards from explosions are to be considered in accordance with EN ISO 12100-1:2003, 4.8.

The present standard was drawn up on request and by mandate of CEC and EFTA to fulfil

- Directive 2006/42/EC of the European Parliament and the Council of May 17, 2006 on machinery which demands in its Annex I, Clause 1.5.7 that machinery must be designed and constructed in such a way as to avoid any risk of explosion as well as

- Directive 94/9/EC of the European Parliament and the Council of March 23, 1994 on the approximation of the laws of the member states concerning equipment and protective systems intended for use in potentially explosive atmospheres.

In accordance with EN ISO 12100-1 it is a type A standard.

This standard has been prepared to be a harmonized standard in the sense of the appropriate Directives of the EU and associated EFTA regulations.

This standard describes the basic concepts and methodology of explosion prevention and protection.

CEN/TC 305 has a mandate in this area to produce B-type, and C-type standards, which will allow verification of conformity with the essential safety requirements.

Explosions can occur from

a) materials processed or used by the equipment, protective systems and components;

b) materials released by the equipment, protective systems and components;

c) materials in the vicinity of the equipment, protective systems and components;

d) materials of construction of the equipment, protective systems and components.

Since safety depends not only on equipment, protective systems and components but also on the material being handled and its use, this standard includes aspects related to the intended use, i.e. the manufacturer should consider how and for what the equipment, protective systems and components will be used and take this into account during its design and construction. Only in this way can hazards inherent in equipment, protective systems and components be reduced.

NOTE This standard may also serve as a guide for users of equipment, protective systems and components when assessing the risk of explosion in the workplace and selecting the appropriate equipment, protective systems and components.

1 Scope

This European Standard specifies methods for the identification and assessment of hazardous situations leading to explosion and the design and construction measures appropriate for the required safety. This is achieved by:

- hazard identification;
- risk assessment;
- reduction of risk;
- information for use.

The safety of equipment, protective systems and components can be achieved by eliminating of hazards and/or limiting the risk, i.e. by:

a) design without using safeguarding;

b) safeguarding;

c) communication links if necessary to convey information to the user;

d) any other precautions.

Measures in accordance with a) (prevention) and b) (protection) against explosions are dealt with in Clause 6, measures according to c) against explosions are dealt with in Clause 7. Measures in accordance with d) are not specified in this European Standard. They are dealt with in EN ISO 12100-1:2003, Clause 5.

The preventive and protective measures described in this European Standard will not provide the required level of safety unless the equipment, protective systems and components are operated within their intended use and are installed and maintained according to the relevant codes of practice or requirements.

This standard specifies general design and construction methods to help designers and manufacturers in achieving explosion safety in the design of equipment, protective systems and components.

This European Standard is applicable to any equipment, protective systems and components intended to be used in potentially explosive atmospheres, under atmospheric conditions. These atmospheres can arise from flammable materials processed, used or released by the equipment, protective systems and components or from materials in the vicinity of the equipment, protective systems and components and/or from the materials of construction of the equipment, protective systems and components.

This European Standard is applicable to equipment, protective systems and components at all stages of its use.

This European Standard is only applicable to equipment group II which is intended for use in other places than underground parts of mines and those parts of surface installations of such mines endangered by firedamp and/or flammable dust.

This European Standard is not applicable to:

i) medical devices intended for use in a medical environment;

ii) equipment, protective systems and components where the explosion hazard results exclusively from the presence of explosive substances or unstable chemical substances;

iii) equipment, protective systems and components where the explosion can occur by reaction of substances with other oxidizers than atmospheric oxygen or by other hazardous reactions or by other than atmospheric conditions;

iv) equipment intended for use in domestic and non-commercial environments where potentially explosive atmospheres may only rarely be created, solely as a result of the accidental leakage of fuel gas;

v) personal protective equipment covered by Directive 89/686/EEC;

vi) seagoing vessels and mobile offshore units together with equipment on board such vessels or units;

vii) means of transport, i.e. vehicles and their trailers intended solely for transporting passengers by air or by road, rail or water networks, as well as means of transport insofar as such means are designed for transporting goods by air, by public road or rail networks or by water. Vehicles intended for use in a potentially explosive atmosphere shall not be excluded;

viii) the design and construction of systems containing desired, controlled combustion processes, unless they can act as ignition sources in potentially explosive atmospheres.

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 13237:2003, *Potentially explosive atmospheres — Terms and definitions for equipment and protective systems intended for use in potentially explosive atmospheres*

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

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 13237:2003 and the following apply.

3.1
hazardous explosive atmosphere
explosive atmosphere which, if it explodes, causes harm

3.2
malfunction
situation when the equipment, protective systems and components do not perform the intended function

NOTE 1 See also EN ISO 12100-1:2003, 5.3 b).

NOTE 2 For the purposes of this standard this can happen due to a variety of reasons, including

a) variation of a property or of a dimension of the processed material or of the workpiece,

b) failure of one (or more) of component parts of the equipment, protective systems and components,

c) external disturbances (e.g. shocks, vibration, electromagnetic fields),

d) design error or deficiency (e.g. software errors),

e) disturbance of the power supply or other services and

f) loss of control by the operator (especially for hand held and mobile machines).

4 Hazard identification

4.1 General

The explosion hazard is related to the materials and substances processed, used or released by equipment, protective systems and components and materials used to construct equipment, protective systems and components. Some of these materials and substances can undergo combustion processes in air. These processes are often accompanied by the release of considerable amounts of heat and can be associated with a pressure build-up and the release of hazardous materials. In contrast to burning in a fire, an explosion is essentially a self-sustained propagation of the reaction zone (flame) through the explosive atmosphere.

Flammable and/or combustible substances shall be considered as materials which can form an explosive atmosphere unless an investigation of their properties has shown that in mixtures with air they are incapable of self-sustained propagation of an explosion.

This potential hazard associated with explosive atmosphere is released when ignited by an effective ignition source.

The safety data listed in 4.2, 4.3 and 4.4 describe safety relevant properties of substances. They can be obtained by laboratory experiments and in a few cases also by calculation methods[1)]. The safety data obtained are used for the identification of the hazard.

It is necessary to bear in mind that such safety data are not physical constants but depend for instance on the techniques used for their measurement. Also, for dusts, tabulated safety data are for guidance only because the values depend on particle size and shape, moisture content and the presence of additives even in trace concentrations. For a specific application, samples of the dust to be present in the equipment should be tested and the data obtained used in the identification of the hazard.

4.2 Combustion properties

Since in this context it is not the material itself that represents the potential hazard but its contact or mixing with the air, the properties of the mixture of the flammable substance with air shall be determined. These properties give information about a substance's burning behaviour and whether it could give rise to fire or explosions. Relevant data are e.g.

a) flash point;

b) explosion limits (LEL, UEL);

c) limiting oxygen concentration (LOC).

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1) Appropriate standards have been or are being developed by CEN and CENELEC, see also Bibliography.

4.3 Ignition requirements

The ignition properties of the explosive atmosphere shall be determined. Relevant data are, e.g.:

a) minimum ignition energy;

b) ignition temperature of an explosive atmosphere;

c) minimum ignition temperature of a dust layer.

4.4 Explosion behaviour

The behaviour of the explosive atmosphere after ignition shall be characterized by data such as:

a) maximum explosion pressure (p_{max});

b) maximum rate of explosion pressure rise ($(\mathrm{d}p/\mathrm{d}t)_{max}$);

c) maximum experimental safe gap (MESG).

5 Elements of risk assessment

5.1 General

This risk assessment shall always be carried out for each individual situation in accordance with EN ISO 14121-1. Risk assessment includes the following elements for which the standard gives guidance:

a) hazard identification. The safety data in accordance with Clause 4 assist in the identification of hazards by demonstrating whether substances are flammable and indicate their ease of ignition;

b) determine whether an explosive atmosphere is likely to occur and the amount involved (in accordance with 5.2);

c) determine the presence and likelihood of ignition sources that are capable of igniting the explosive atmosphere (in accordance with 5.3);

d) determine the possible effects of an explosion (in accordance with 5.4);

e) evaluate the risk;

f) consider measures for the reduction of risks (in accordance with Clause 6).

A comprehensive approach shall be taken, especially for complicated equipment, protective systems and components, plants comprising individual units and, above all, for extended plants. This risk assessment shall take into account the ignition and explosion hazard from:

i) the equipment, protective systems and components themselves;

ii) the interaction between the equipment, protective systems and components and the substances being handled;

iii) the particular industrial process performed in the equipment, protective systems and components;

iv) interactions of individual processes in different parts of the equipment, protective systems and components;

v) the surroundings of the equipment, protective systems and components and possible interaction with neighbouring processes.

5.2 Determining the amount and likelihood of an occurrence of an explosive atmosphere

5.2.1 General

The occurrence of a hazardous explosive atmosphere depends on the following:

a) the presence of a flammable substance;

b) degree of dispersion of the flammable substance (e.g. gases, vapours, mists, dusts);

c) concentration of the flammable substance in air within the explosion range;

d) amount of explosive atmosphere sufficient to cause injury or damage by ignition.

In assessment of the likelihood of occurrence of a hazardous explosive atmosphere, possible formation of the explosive atmosphere through chemical reactions, pyrolysis and biological processes from the materials present shall be taken into account.

If it is impossible to estimate the likelihood of occurrence of a hazardous explosive atmosphere, the assumption shall be made that such an atmosphere is always present, except when a reliable monitoring device of the concentration of the flammable substance in the atmosphere is present.

NOTE For practical purposes it is convenient to classify in zones the interior of equipment, protective systems and components and its surroundings on the basis of the likelihood of a hazardous explosive atmosphere (see 6.3).

5.2.2 Degree of dispersion of flammable substances

By their very nature, gases and vapours have a degree of dispersion high enough to produce an explosive atmosphere. For mists and dusts the occurrence of an explosive atmosphere can be assumed if the droplet or particle size falls below 1 mm.

NOTE Numerous mists, aerosols and types of dusts that occur in actual practice have particle sizes between 0,001 mm and 0,1 mm.

5.2.3 Concentration of flammable substances

An explosion is possible when the concentration of the dispersed flammable substance in the air achieves a minimum value (lower explosion limit). An explosion will not occur when the concentration exceeds a maximum value (upper explosion limit).

NOTE Some chemically unstable substances, e.g. acetylene and ethylene oxide, can undergo exothermic reactions even in the absence of oxygen and have an upper explosion limit of 100 %.

The explosion limits vary with pressure and temperature. As a rule, the concentration range between the explosion limits increases with increasing pressure and temperature. In the case of mixtures with oxygen, the upper explosion limits are far higher than for mixtures with air.

If the surface temperature of a combustible liquid exceeds the lower explosion point, an explosive atmosphere can be formed (see 6.2.2.2). Aerosols and mists of combustible liquids can form an explosive atmosphere at temperatures below the lower explosion point.

The explosion limits for dusts do not have the same significance as those for gases and vapours. Dust clouds are usually inhomogeneous. The dust concentration can fluctuate greatly due to dust depositing and dispersion into the atmosphere. Consideration shall always be given to the possible formation of explosive atmospheres when deposits of combustible dust are present.

5.2.4 Amount of explosive atmosphere

The assessment whether an explosive atmosphere is present in a hazardous amount depends on the possible effects of the explosion (see 5.4).

5.3 Determining the presence of effective ignition sources

5.3.1 General

The ignition capability of the ignition source shall be compared with the ignition properties of the flammable substance (see 4.3).

The likelihood of occurrence of the effective ignition sources shall be assessed, taking into account those that can be introduced e.g. by maintenance and cleaning activities.

NOTE Protective measures can be used to make the ignition source non-effective (see 6.4).

If the likelihood of occurrence of an effective ignition source cannot be estimated, the assumption shall be made that the source of ignition is present at all times.

The ignition sources should be classified according to the likelihood of their occurrence in the following manner:

a) sources of ignition which can occur continuously or frequently;

b) sources of ignition which can occur in rare situations;

c) sources of ignition which can occur in very rare situations.

In terms of the equipment, protective systems and components used this classification shall be considered equivalent to:

d) sources of ignition which can occur during normal operation;

e) sources of ignition which can occur solely as a result of malfunctions;

f) sources of ignition which can occur solely as a result of rare malfunctions.

The different ignition sources are considered in 5.3.2 to 5.3.14.

5.3.2 Hot surfaces

If an explosive atmosphere comes into contact with a heated surface ignition can occur. Not only can a hot surface itself act as an ignition source, but a dust layer or a combustible solid in contact with a hot surface and ignited by the hot surface can also act as an ignition source for an explosive atmosphere.

The capability of a heated surface to cause ignition depends on the type and concentration of the particular substance in the mixture with air. This capability becomes greater with increasing temperature and increasing surface area. Moreover, the temperature that triggers ignition depends on the size and shape of the heated body, on the concentration gradient in the vicinity of the surface and, to a certain extent, also on the surface material. Thus, for example, an explosive gas or vapour atmosphere inside fairly large heated spaces (approximately 1 l or more) can be ignited by surface temperatures lower than those measured in accordance with EN 14522 or by other equivalent methods. On the other hand, in the case of heated bodies with convex rather than concave surfaces, a higher surface temperature is necessary for ignition; the minimum ignition temperature increases, for example, with spheres or pipes as the diameter decreases. When an explosive atmosphere flows past heated surfaces, a higher surface temperature could be necessary for ignition owing to the brief contact time.

If the explosive atmosphere remains in contact with the hot surface for a relatively long time, preliminary reactions can occur, e.g. cool flames, so that more easily ignitable decomposition products are formed, which promote the ignition of the original atmospheres.

In addition to easily recognizable hot surfaces such as radiators, drying cabinets, heating coils and others, mechanical and machining processes can also lead to hazardous temperatures. These processes also include equipment, protective systems and components which convert mechanical energy into heat, i.e. all kinds of friction clutches and mechanically operating brakes (e.g. on vehicles and centrifuges). Furthermore, all moving parts in bearings, shaft passages, glands etc. can become sources of ignition if they are not sufficiently lubricated. In tight housings of moving parts, the ingress of foreign bodies or shifting of the axis can also lead to friction which, in turn, can lead to high surface temperatures, in some cases quite rapidly.

Consideration shall also be given to temperature increases due to chemical reactions (e.g. with lubricants and cleaning solvents).

For ignition hazards in welding and cutting work, see 5.3.3.

For protective measures against ignition hazards from hot surfaces, see 6.4.2.

5.3.3 Flames and hot gases (including hot particles)

Flames are associated with combustion reactions at temperatures of more than 1 000 °C. Hot gases are produced as reaction products and, in the case of dusty and/or sooty flames, glowing solid particles are also produced. Flames, their hot reaction products or otherwise highly heated gases can ignite an explosive atmosphere. Flames, even very small ones, are among the most effective sources of ignition.

If an explosive atmosphere is present inside as well as outside an equipment, protective system, or component or in adjacent parts of the installation and if ignition occurs in one of these places, the flame can spread to the other places through openings such as ventilation ducts. The prevention of flame propagation calls for specially designed protective measures (see 6.5.5).

Welding beads that occur when welding or cutting is carried out are sparks with a very large surface and therefore they are among the most effective sources of ignition.

For protective measures against ignition hazards due to flames and hot gases, see 6.4.3.

5.3.4 Mechanically generated sparks

As a result of friction, impact or abrasion processes such as grinding, particles can become separated from solid materials and become hot owing to the energy used in the separation process. If these particles consist of oxidizable substances, for example iron or steel, they can undergo an oxidation process, thus reaching even higher temperatures. These particles (sparks) can ignite combustible gases and vapours and certain dust/air-mixtures (especially metal dust/air mixtures). In deposited dust, smouldering can be caused by the sparks and this can be a source of ignition for an explosive atmosphere.

The ingress of foreign materials to equipment, protective systems and components, e.g. stones or tramp metals, as a cause of sparking shall be considered.

Rubbing friction, even between similar ferrous metals and between certain ceramics, can generate hot spots and sparks similar to grinding sparks. These can cause ignition of explosive atmospheres.

Impacts involving rust and light metals (e.g. aluminium and magnesium) and their alloys can initiate a thermite reaction which can cause ignition of explosive atmospheres.

The light metals titanium and zirconium can also form incendive sparks under impact or friction against any sufficiently hard material, even in the absence of rust.

For ignition hazards in welding and cutting work, see 5.3.3.

For protective measures against ignition hazards due to mechanically generated sparks, see 6.4.4.

5.3.5 Electrical apparatus

In the case of electrical apparatus, electric sparks and hot surfaces (see 5.3.2) can occur as sources of ignition. Electric sparks can be generated, e.g.:

a) when electric circuits are opened and closed;

b) by loose connections;

c) by stray currents (see 5.3.6).

It is pointed out explicitly that an extra low voltage (ELV, e.g. less than 50 V) is designed for personal protection against electric shock and is not a measure aimed at explosion protection. However, voltages lower than this can still produce sufficient energy to ignite an explosive atmosphere.

For protective measures against ignition hazards due to electrical apparatus, see 6.4.5.

5.3.6 Stray electric currents, cathodic corrosion protection

Stray currents can flow in electrically conductive systems or parts of systems as:

a) return currents in power generating systems - especially in the vicinity of electric railways and large welding systems - when, for example, conductive electrical system components such as rails and cable sheathing laid underground lower the resistance of this return current path;

b) a result of a short-circuit or of a short-circuit to earth owing to faults in the electrical installations;

c) a result of magnetic induction (e.g. near electrical installations with high currents or radio frequencies, see also 5.3.9); and

d) a result of lightning (see 5.3.8).

If parts of a system able to carry stray currents are disconnected, connected or bridged - even in the case of slight potential differences - an explosive atmosphere can be ignited as a result of electric sparks and/or arcs. Moreover, ignition can also occur due to the heating up of these current paths (see 5.3.2).

When impressed current cathodic corrosion protection is used, the above-mentioned ignition risks are also possible. However, if sacrificial anodes are used, ignition risks due to electric sparks are unlikely, unless the anodes are aluminium or magnesium.

For protective measures against ignition hazards due to stray electric currents and cathodic corrosion protection, see 6.4.6.

5.3.7 Static electricity

Incendive discharges of static electricity can occur under certain conditions (see CLC/TR 50404). The discharge of charged, insulated conductive parts can easily lead to incendive sparks. With charged parts made of non-conductive materials, and these include most plastics as well as some other materials, brush discharges and, in special cases, during fast separation processes (e.g. films moving over rollers, drive belts), or by combination of conductive and non-conductive materials) propagating brush discharges are also possible. Cone discharges from bulk material and cloud discharges can also occur.

Brush discharges can ignite almost all explosive gas and vapour atmospheres. According to the present state of knowledge, the ignition of explosive dust/air atmospheres with extremely low minimum ignition energy by brush discharges cannot be excluded. Sparks, propagating brush discharges, cone discharges and cloud discharges can ignite all types of explosive atmospheres, depending on their discharge energy.