EUROVENT/ CECOMAF

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PRESCRIPTIONS FOR SPARK RESISTANT FAN CONSTRUCTION

Fans for use in potentially explosive atmospheres

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FOREWORD

The Commission of the European Union, General Directorate III, has proposed a new directive on equipment and protective systems intended for use in potentially explosive atmospheres (called ATEX-100-Directive). As soon as this directive comes into force its basic requirements will have to be observed in addition to those of the Directive on Machinery.

In view of this, the European Committee for Standardisation (CEN) is going to develop the European Standard EN 1127-1 « Safety of machinery - Fire and explosions - Part 1 : Explosion prevention and protection » (in draft as pr EN 1127-1).

This EN describes methods for the assessment of hazardous situations arising from explosions and the design and construction measures appropriate for the required safety. It is very general and applicable to any machinery to be used where explosions can occur due to combustible material emanating from the machine or other sources in the presence of air under atmospheric conditions.

Moreover additional standards, e.g. on special prevention and protection measures or on special machinery to meet the requirements of the directives will be needed to support the manufacturer in the application of them. This applies to fans, also.

Fans can produce an effective ignition source by hot surfaces (e.g. from damaged bearings), by mechanically generated sparks as a result of friction, impact or abrasion processes (e.g. as a result of contact between rotor and fixed components) and by discharges of static electricity when using a non-conductive material.

The need and level of protective or preventive construction measures for fans depends on the likelihood of occurrence of a hazardous explosive atmosphere. For classification of hazardous areas (zones) see pr EN 1127-1.Though the risk cannot be eliminated totally, it has to be reduced to a minimum by suitable constructive measures for avoiding ignition sources.

EUROVENT has therefore initiated a discussion on this subject. The fan manufacturers of EUROVENT see a need for a European Standard dealing with construction measures of fan used to handle explosive atmosphere and installed in an area with such an atmosphere.

This EUROVENT Document is a proposal based on a German technical guideline[1] which has been compiled with the collaboration of all parties concerned - manufacturers, users and official authorities in this field. The design measures described are intended to prevent the fan itself as a source of ignition. They apply to the manufacturer of fans.

The experts in EUROVENT are of the opinion that there still remain some critical questions which have to be discussed at a wider level. That concerns for instance the material pairings of fans for rotating and static parts. Many manufacturers have doubts concerning the use of the pairing steel/steel and believe that it has to be restricted or even eliminated. But the use of other pairings is in discussion and doubted, too. Researches in this field are based on different conditions and not sufficient for clear technical statements. Therefore the pairings listed in section 4.1.1.3 of this document have to be considered very carefully. The manufacturer has to make the choice according to his theoretical and practical knowledge taking into account the application conditions for his product as far as they are known to him.

Technical documents of EUROVENT are an information and technical guide for manufacturers, users and other parties and may serve as the basis for the European standardisation process. This EUROVENT Document is intented as a proposal for further discussion in CEN between safety experts and fan manufacturers in order to develop a European Standard meeting the needs of today.

[1]VDMA 24169 Part 1 « Air handling units ; Design-related explosion protection measures for fans; Specifications for fans used to handle flammable gases, vapour or mist-containing atmosphere », December 1983 (English version). Beuth-Verlag, Berlin.

PART 1 - SPECIFICATIONS FOR FANS USED TO HANDLE FLAMMABLE GASES, VAPOUR OR MIST CONTAINING ATMOSPHERE

INTRODUCTION

This EUROVENT Document contains specifications for the design of fans for use in zone 1 and zone 2[2] explosion hazardous locations as a result of the presence of gases, vapours, mist or mixtures thereof. The manufacturer is to be solely responsible for meeting the requirements set down in this document. The requirements detailed in pr EN 1127-1 shall be deemed to have been met in the case of fans if the latter meet the specifications set down in this document.

The design measures described herein are intended to prevent the fan itself acting as a source of ignition. Alternative design measures intended to reduce the effects of an explosion to a safe level are not dealt with here (see pr EN 1127-1).

1 - SCOPE

This document is a fan-specific supplement to pr EN 1127-1 and is to be applied to fans (see section 2, no. 2.1) used to handle explosive atmospheres (gases, vapours, mist or mixtures thereof) of zones 1 and 2 installed in explosion hazardous locations of the same zone or in non-hazardous locations. It does not apply to zone 0.

Fans complying with this document meet the requirements of

Explosion group II A and II B (see EN 50014 [3]) and
Temperature class T1 to T4 (see EN 50014[4])

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[2]For definition and specification of the zones, see prEN 1127-1
[3]Former name : explosion class 1 and 2
[4]Former name : ignition groupe G1 to G4

The precondition for the application of this document is that maximum pressures of 1.1 bar and temperatures between -20°C and +60°C are maintained on the inlet side and in the environment of the fan. In exceptional cases, the inlet temperature may be as high as 135°C, in this event, however, the fan can no longer be used for temperature class T4.

Fans which are suitable for specific explosion hazardous locations may also be used in areas where the occurrence of an explosive atmosphere is less probable.

This document is not to be applied to fans which are safety designed for cooling of explosion-proof motors.

2 - NORMATIVE REFERENCES

pr EN 1127-1 : 1996
Explosive atmospheres - Explosion Prevention and Protection
Part 1 : Basic concepts and methodology

EN 50 014
Electrical Apparatus for Potentially Explosive Atmospheres
Part 1 : General Requirements

pr EN 50 154 : 1993
Electrical Apparatus for Potentially Explosive Atmospheres ; Electrical Installation in potentially explosive atmospheres (other than mines)

EN 60 529 : 1991
Degrees of protection provides by enclosures (IP Code)

ISO 1940 - 1 : 1986
Mechanical vibration - Balance quality requirements of rigid rotors
Part 1 : Determination of permissible residual unbalance

I E C 167-1964 :
Methods of test for the determination of the insulation resistance of solid insulating materials

EN 294 :
Safety of machinery ; safety distances to prevent danger zones being reached by the upper limbs

ISO 5801 1996 Industrial fans
Performance testing using standardised airways

3 - TERMINOLOGY

3.1 Fan

Rotary bladed machine for handling dust/air mixtures with a pressure ratio up to 1.3 the fan discharge pressure being up to 1.3 bar.

3.2 Critical rotational speed

Rotational speed at which the rotor (impeller and shaft of the fan oscillates at its natural flexural frequency under operating conditions.

3.3 Zones for gases/vapours (from prEN 1127-1)

Zone 0 : An area in which a hazardous explosive gas atmosphere is present continuously or for long periods or frequently.
Note : In general these conditions, when they occur, arise inside containers, pipes and vessels etc.

Zone 1 : An area in which a hazardous explosive gas atmosphere is likely to occur in normal operation.
Note : This zone can include, among others :
- the immediate vicinity of zone 0,
- the immediate vicinity of feed openings,
- the immediate vicinity around filling and emptying openings,
- the immediate vicinity around fragile equipment, protective systems, and components made of glass, ceramics and the like,
- the immediate vicinity around inadequately sealed glands, for example on pumps and valves with stuffing-boxes.

Zone 2 : An area in which a hazardous explosive gas atmosphere is not likely to occur in normal operation, and if it does occur it will exist for a short period only.

4 - FANS FOR HANDLING ZONE 1 EXPLOSIVE ATMOSPHERES, INSTALLATION IN ZONE 1, ZONE 2 OR IN NON-HAZARDOUS LOCATIONS

4.1 Requirements which apply independently of installation

The requirements contained in this section apply to fans used to handle zone 1 explosive atmospheres, irrespective of whether the fan is installed in zone 1, zone 2 or in non-hazardous locations. In addition, the requirements in sections 4.2 4.3 or 4.4 apply as regards the respective cases of installation. Section 6 contains a summary chart.

4.1.1 Materials and components

4.1.1.1 The materials must be sufficiently resistant or protected with regard to the ambient atmosphere and the fluid handled.

4.1.1.2 The components used in the rotor and housing must be able to withstand short-term exposure to flames. This requirement is met if the components are exposed to a (propane) bunsen burner flame approx. 150 mm long for 30 seconds without additional air supply and are only partly destroyed without self-sustaining the combustion.

4.1.1.3 With a view to malfunctioning which can be expected to occour during normal operation, potential arreas of contact between rotor and fixed components (with the exception of shaft seals ; see section 4.1.4) must be made of materials in which the risk of ignition through friction and impact sparks is limited. This requirement is met if the following material pairs are used. There are partial reservations concerning some material pairs. This especially applies to the pairs a) and e) (see also introduction). The German mining industry e.g. only allows silumin. (The order in which they are listed is also the order of preference) :

a) plastic combined with plastic
b) material such as c) or d) combined with plastic

c) steel (also galvanised) or cast iron combined with bronze, brass, copper or another hardly oxidisable material with high thermal conductivity (but not light metal)
d) stainless steel combined with stainless steel
e) steel (also galvanised) or cast iron combined with steel

Material combinations such as light metal with light metal and stainless steel or other corrosion-resistant metals with light metal may only be used if rust (even flash rust) cannot occur or is certainly at a minimum at the expected contact points.

Material combinations such as non-corrosion resistant steel with light metal or cast iron with light metal are not suitable due to the increased risk of ignition. Alloys with a low light metal content are, however, admissible if their suitability is certified by the expertise of an approved testing authority.

Note : such certification already exists, for example, for GNi Al Bz F 60 and other alloys with a light metal content not exceeding 15 %.

Base materials which are unsuitable in uncoated form may also be used if coated with suitable metallic surface layers (e.g. bands or foils). The metallic surface layer must be at least 0.5 mm thick.

4.1.1.4 The fans must be of sturdy design and securely mounted in order to prevent deformation or movement which might lead to rubbing or striking of the moving parts[5] .

[5]The fan must be protected against damage during transport

This requirement is generally considered fulfilled for housings, supporting structures, guards, protective devices and other external parts if the deformation resulting from a single impact test at what is held to be the weakest point is so small that the moving parts do not come into contact with the housing. The test should be performed in accordance with EN 50 014 (7 J impact energy, i.e. 1 kg test weight, 0,7 m drop height, using a 25 mm diameter hardened steel hemispherical impact piece).

The test for the strength of the impeller is contained in the test listed in section 4.1.6 paragraph 3.

4.1.2 Increase in temperature

The temperature of the explosive atmosphere must not exceed 80 % of the ignition temperature. The maximum temperature on the discharge side of the fan for the design point is based on the inlet temperature and the temperature increase in the fan due to the change in condition of the atmosphere as a result of friction, throttling and compression [6].

If the fan manufacturer is not able to specify a limit for temperature increase, temperature monitoring devices should be fitted which detect when the admissible temperature of the fluid on the discharge side is exceeded and automatically activate emergency functions (e.g. fan shutdown).

4.1.3 Bearings

Suitable roller bearings should be used for the fan shaft bearings. The service life of these bearings should generally be at least 40 000 hours[7]. Exceptions are possible in individual and well-founded cases. If the bearing is situated in zone 1, the surface temperature caused by normal frictional heat during operation and also generated in the event of frequent malfunction must not exceed 80 % of the ignition temperature of the explosive atmosphere.

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[6] If a malfunction in the upstream system may result in an excessive inlet temperature or a considerable deviation from the design point (e.g. through additional throttling) temperature and monitoring devices should be fitted to automatically activate emergency functions in the event that the admissible temperature is exceeded (e.g. shutdown of the fan motor).

[7] Operating instructions should contain details of the necessary maintenance measures (e.g. checking and replacement of bearings).

4.1.4 Shaft seals

At maximum operating speed, sealing elements on shafts must not produce surface temperatures at the friction point exceeding 80 % of the ignition temperature of the explosive mixtures.

Non-contacting seals should be used wherever possible. The risk of ignition in seals due to friction and impact sparks must be largely eliminated ; e.g. by using material pairs as listed in section 4.1.1 as well as combinations with graphite and ceramic seals.

4.1.5 Vibration characteristics

4.1.5.1 The operating speed must differ by at least 20 % from the actual critical speed. During over-critical operation the drive must permit fast passage through the critical rotational speed.

4.1.5.2 The impeller shall be secured against torsion and movement on the shaft and balanced (quality class at least G 6.3 of ISO 1940-1). The fan belt pulleys are also to be balanced (quality class at least G 6.3 of ISO 1940-1).

4.1.5.3 The operative fan must be sufficiently quiet when running. This condition is fulfilled if, when installed.

a) on high-tuned, rigid or heavy bases the effective vibration velocity does not exceed 2.8 mm/s r.m.s
b) on low-tuned bases the effective vibration velocity does not exceed 4.5 mm/s r.m.s.

The vibration velocity shall be measured at the bearings.

4.1.5.4 Measures shall be taken to prevent fans from operating in unstable regions of the characteristic curves (e.g. in the case of axial flow fans in the stall region [8]). The manufacturer must inform the operator of these regions[9].

4.1.6 Gap between impeller and housing

The minimum clearance between rotating components (e.g. impeller) and fixed components (e.g. housing) must be at least 1 % of the maximum possible contact diameter of the finished fan. This clearance shall not be less than 2 mm and need not be greater than 20 mm. Shaft seals are not subject to these provisions.

In order to avoid an inadmissible clearance reduction during operation, the fan must be designed to ensure that the minimum clearance does not decrease by more than 10 % at 1.2 x nominal rotational speed over 24 hours.

Each impeller must be subjected to a trial run at 1.2 x nominal rotational speed for 3 minutes. During this period the diameter must not increase to a degree which results in inadmissible reduction of the clearance.

If it is not possible to maintain the required clearance, the gap may have the usual arithmetical tolerances (no contact during operation at rated speed), provided that at least one of the two friction partners becomes sufficiently soft to interrupt the heat-generating friction process due to material flow. This softening effect must occur before the surface temperature of the material has reached 80 % of the ignition temperature of the explosive atmosphere. If this measure only covers the endangered surface area of rotation and fixed components (e.g. in the case of surface coating) the gap between the fixed metallic component and metallic impeller must comply with the requirements set down in paragraph 1 of this section.

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[8] This can be achieved by ensuring sufficient distance between the operating point and the breakaway limit or by means of suitable monitoring measures.

[9] The specification provided by the manufacturer is based on a uniform inflow to the fan in accordance with ISO 5801. It is therefore important to ensure uniform inlet flow during operation.

4.1.7 Protection against foreign particles

The fan shall to be protected against penetration and suction intake of foreign particles[10]. Suction intake of foreign particles is prevented, for example, by a protective device of IP 20 protection class (see EN 60 529)[11].

The protective devices shall be fitted in such a way that they can be checked for function and condition. They must be made of conductive material and conductively connected to the conductive parts of the system and earthed.

4.1.8 Electrical equipment (internal)

Electrical equipment (e.g. motors) shall be subject to the regulations on electrical systems in explosion hazardous locations.

The ambient temperature to be taken into consideration when classifying the electrical equipment in temperature categories is 40°C. Temperatures other than 40°C are admissible, but the effect of adjacent heat sources must also be taken into account.

The driving motor must not be located in the fluid flow if there is the danger of solid or liquid materials (e.g. colour particles from painting units) carried along in the fluid flow settling on the motor.

4.2 Additional requirements for fans installed in zone 1

4.2.1 Electrostatic charge [12]

The fans must be designed to eliminate the risk of ignition due to electrostatic charges during operation and during malfunctions possible during regular operation. All conductive parts of the fan must be electrostatically earthed.

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[10] If this is not effected by the manufacturer, the manufacturer must inform the operator or the system builder of measures still to be taken. If necessary, intake and discharge openings of the system should be protected against the entry and intake of foreign particles into/by the fan (e.g. by fitting a hood.

[11] If necessary, EN 294 is to observed as regards protection against accidental contact.

[12] European Standard for avoidance of ignition hazards arising from static electricity » in preparation by CENELEC

External components which are made of non-conductive materials, e.g. plastics, are sufficiently protected against ignition if :

- the insulation resistance to IEC 167-1964 fig 3 of the material in standard atmosphere 23/50 to EN 50 014 does not exceed 10^9 Ω or
- dangerous build-up is prevented by suitable design of the chargeable components or
- dangerous build-up is prevented by a conductive earthed net on or slightly beneath the surface of the components (mesh surface of the net max. 100 cm^2) or via conductive earthed layers. The thickness of any non-conductive layers above the net or on the conductive layer shall not exceed 2 mm.

If the handled fluid contains dust or mist in a concentration exceeding that of nominal atmospheric contamination, an ignition hazard due to electrostatic charge is to be expected if the internal surfaces including the rotors are made of non-conductive materials. In such cases, these materials may not be used.

Electrostatically conductive belts must be used in belt drives.

4.2.2 Electrical equipment (external)

(see section 4.1.8 paragraph 1 and 2.)

4.2.3 Transmission elements [13]

Transmission elements such as couplings, belt or chain drives are to be designed in accordance with the explosion protection specifications for zone 1 to avoid ignition risk. The manufacturer of the transmission elements is to provide proof of this to the fan manufacturer.

[13] European standard « Safety of machinery - Industrial trucks for potentially explosive atmosphere » in preparation by CEN

4.3 Additional requirements for fans installed in zone 2

4.3.1 Air-tightness of the housing

The housing of the fan including bushings must be of generally air-tight design to prevent explosive mixtures from escaping in hazardous quantities. This is achieved, for example, if a pressure below ambient is present in the area of the shaft bushing during operation.

4.3.2 Electrical equipment (external)

(See section 4.1.8 paragraph 1)
If the motor is installed in zone 2 (e.g. in the case of centrifugal fans), it is sufficient if the motor complies with the special requirements of pr EN 50154.

4.3.3 Transmission elements

Transmission elements such as coupling, belt or chain drives are to be designed in accordance with the explosion protection specifications for zone 2 to avoid ignition risk. The manufacturer of the transmission elements is to provide proof of this to the fan manufacturer.

4.4 Additional requirements for fans installed in non-explosive zones

4.4.1 Air-tightness of the housing

(See section 4.3.1)

5 - FANS FOR HANDLING ZONE 2 EXPLOSIVE ATMOSPHERES, INSTALLATION IN ZONE 2 OR IN NON-HAZARDOUS LOCATIONS

5.1 Requirements which apply independently of installation

The requirements contained in this section apply to fans used to handle zone 2 explosive atmospheres, irrespective of whether the fan is installed in zone 2 or in non-hazardous locations. In addition, section 5.2 applies for installation of the fan in zone 2. Section 6 contains a summary chart.

5.1.1 Materials and components

5.1.1.1 See section 4.1.1.1

5.1.1.2 See section 4.1.1.2

5.1.1.3 The fans must be of solid design and firmly mounted in order to prevent deformation and movement which might lead to contact or grinding of the moving parts. Each impeller must be subjected to a trial run at maximum rotational speed for 3 minutes.

5.1.2 Increase temperature

The increase in temperature of the explosive atmosphere must not exceed the ignition temperature.

The maximum temperature on the discharge side of the fan for the design point is based on the inlet temperature and the temperature increase in the fan due to the change in condition of the atmosphere as a result of friction throttling and compression.

5.1.3 Bearings

Suitable roller bearings should be used as bearings for the fan shaft. The service life of these bearings should generally be at least 40 000 hours. Exceptions are possible in individual and well-founded cases. If the bearing is situated in zone 2 the surface temperature caused by normal friction heat during operation must not exceed the ignition temperature of the explosive atmosphere.

5.1.4 Shaft seals

At maximum operating speed at the friction point, sealing elements on shafts must only produce surface temperatures below the ignition temperature of the explosive mixtures.

5.1.5 Vibration characteristics

5.1.5.1 See section 4.1.5.1

5.1.5.2 See section 4.1.5.2

5.1.5.3 The operative fan must be sufficiently quiet when running. This condition is met if, following installation

a) on high-tuned, rigid or heavy bases the effective vibration velocity does not exceed 4.5 mm/s r.m.s.

b) on low-tuned bases the effective vibration velocity does not exceed 7.1 mm/s r.m.s.

The vibration velocity is measured at the bearings.

5.1.6 Clearance between impeller and housings

The narrowest point of the gap between rotating components (e.g. impeller) and fixed components (e.g. housing) must be at least 0.3 % of the maximum possible contact diameter of the finished fan. This clearance should not be smaller than 1 mm and need not be greater than 20 mm. Shaft seals are not subjected to these provisions.

If it is not possible to keep to the required clearance, the gap may have the arithmetical usual tolerances, (no contact during operation at nominal rotational speed), if at least one of the two friction partners becomes sufficiently soft to interrupt the heat-generating friction process due to material flow. This softening effect must occur before the surface temperature of the material has reached the ignition temperature of the explosive atmosphere. If this measure only covers the endangered surface area of rotating and fixed components (e.g. in the case of surface coating), the gap between the fixed metallic component and metallic impeller must comply with the requirements set down in paragraph 1 of this section.

5.1.7 Protection against foreign particles

The fan is to be protected against penetration and suction intake of foreign particles.
The protective devices should be fitted in such a way that they can be checked for function and condition.

5.1.8 Electrical equipment (internal)

See section 4.1.8 paragraphes 1 and 3.
The electrical equipment must comply with the requirements pr EN 50 154.

5.2 Additional requirements for fans installed in zone 2

5.2.1 Electrical equipment (external)

See section 4.1.8 paragraph 1.
The electrical equipment must comply with the requirements pr EN 50 154.

5.2.2 Transmission elements

See section 4.3.3.

6 - SUMMARY

TABLE 1 SHOWS A SUMMARY OF THE SECTION NUMBERS APPLICABLE TO THE VARIOUS ZONES COMBINATIONS

Table 1 : allocation of requirements according to sections 4 and 5 on the different zone combinations

Section	Zone combinations				
	Zone 1 int. Zone 1 ext.	**Zone 1 int. Zone 2 ext.**	**Zone 1 int. --- 1 ext.**	**Zone 2 int. Zone 2 ext.**	**Zone 2 int. --- 2 ext.**
Materials and components	4.1.1	4.1.1	4.1.1	5.1.1	5.1.1
Temperature increase	4.1.2	4.1.2	4.1.2	5.1.2	5.1.2
Bearings	4.1.3	4.1.3	4.1.3	5.1.3	5.1.3
Shaft seals	4.1.4	4.1.4	4.1.4	5.1.4	5.1.4
Oscillation characteristics	4.1.5	4.1.5	4.1.5	5.1.5	5.1.5
Gap between impeller and housing	4.1.6	4.1.6	4.1.6	5.1.6	5.1.6
Protection against foreign particles	4.1.7	4.1.7	4.1.7	5.1.7	5.1.7
Air-tightness of the housing	-	4.3.1	4.4.1-4.3.1	-	-
Electrostatic charge	4.2.1	-	-	-	-
Electrical equipment	4.1.8+4.2.2	4.1.8+4.3.2	4.1.8	5.1.8+5.2.1	5.1.8
Transmission elements	4.2.3	4.3.3	-	5.2.2-4.3.3	-

PART 2 - SPECIFICATIONS FOR FANS USED TO HANDLE ATMOSPHERE CONTAINING INFLAMMABLE DUST

INTRODUCTION

This EUROVENT Document contains specifications for the design of fans to be used in zone II[1] locations where there is an explosion hazard because of the presence of dusts. The manufacturer shall bear sole responsibility for meeting the requirements specified in this document. The requirements according pr EN 1127-1 shall be deemed to have been met if a fan complies with the specifications in this document.

The purpose of the design measures described here is to prevent the fan itself acting as a source of ignition. Other design measures intended to reduce the effects of an explosion to a safe level are not addressed here (see pr EN 1127-1).

If there is a proposal to use a fan in a zone II locations the possibility of preventing the occurrence of explosive dust/air mixtures by modifying the process technology or of eliminating the risk of ignition by operating the fan under pure air conditions should first be examined.

1 - SCOPE

This document applies to fans (see section 2, no. 2.1) used to move inflammable dust-laden air either from zone II locations to non-hazardous locations or within zone II locations. These fans may be installed in zone II or in non-hazardous locations. The requirements of Part 1 shall be met if the explosive dust/air mixture additionally contains inflammable gases or vapour (so-called hybrid mixture).

[1] For definition and specification of the zones, see the explosion protection specifications

This document is applicable only on condition that a maximum pressure of 1.1 bar and a temperature between -20°C and +60°C is maintained on the intake side and in the environment of the fan. If different conditions prevail, additional measures may be required.

Note : This EUROVENT Document shall analogously apply to fans which are designed only for cooling of dust explosion-proof motors (zone 11).

2 - TERMINOLOGY

2.1 Zone for dusts (from prEN 1127-1)

Zone II : An area in which a hazardous explosive atmosphere formed by a dust cloud in air is likely to occur during normal operation. Layers of combustible dust will in general be present.

Note : This zone can include, among others, areas in the immediate vicinity of e.g. powder filling and emptying points and areas where dust layers occur and are likely in normal operation to give rise to an explosive concentration of combustible dust in mixture with air.

3 - FANS FOR MOVING DUST/AIR MIXTURES FROM ZONE II TO NON-HAZARDOUS LOCATIONS OR WITHIN ZONE II, INSTALLED IN NON-HAZARDOUS LOCATIONS OR IN ZONE II

3.1 Requirements for fans installed in non-hazardous locations

The requirements in this section apply to fans used to mode dust/air mixtures from zone II to non-hazardous locations or within zone II when the fan is installed in a non-hazardous location. The additional requirements in section 3.2 apply if the fan is installed in zone II.

3.1.1 Materials and components

3.1.1.1 The materials must be sufficiently resistant or protected with regard to the ambient atmosphere and the fluid handled [2]

3.1.1.2 The components used in the rotor and housing must be able to withstand short-term exposure to flames. This requirement is met if the components are exposed to a (propane) bunsen burner flame approx. 150 mm long for 30 seconds without additional air supply and are only partly destroyed without self-sustaining the combustion.

3.1.1.3 It must be ensured that compliance with the explosion protection requirements mentioned below is not affected by wear when abrasive dusts are handled.
Possible design-related measures include the protection of components exposed to wear by cladding [3] .

The following surfaces are for example exposed to wear :
- the impeller blade surfaces in contact with dust
- the impeller backplate surfaces in contact with dust
- the connecting parts between hub and impeller backplate in contact with dust
- the inlet box to the impeller
- the housing sideplates

3.1.1.4 In view of the fact that malfunctions can be expected to occur during regular operation, potential areas of contact between rotor and fixed components (with the exception of shaft seals ; see section 3.1.4) shall be made of materials with a very limited risk of ignition through friction and impact sparks. This requirement is met if the following combinations of materials are used (the order of listing is also the order of preference) :

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[2] For details see e.g. the Dechema materials chart
[3] This requirement can also be met by setting up a maintenance schedule (e.g. early replacement of parts

a) plastic combined with plastic
b) material listed under c) or d) combined with plastic
c) steel (also galvanised) or cast iron combined with bronze, brass, copper or another hardly oxidisable material with righ thermal conductivity (but not light metal)
d) stainless steel combined with stainless steel
e) steel (also galvanised) or cast iron combined with steel.

Material combinations such as light metal with another light metal and stainless steel or another corrosion-resistant metal with a light metal may only be used if rust (even flash rust) cannot occur or is certainly at a minimum at the expected contact points.

Material combinations such as non-corrosion resistant steel with a light metal or cast iron with a light metal are not suitable due to the increased risk of ignition. Alloys with a low light metal content are, however, admissible if certified as suitable by an approved testing authority (e.g. Bundesanstalt für Materialfurschung und -prüfung (BAM) Berlin).

Note : Such certification already exists, for example, for GNiAlBzF60 and other alloys with a light metal content not exceeding 15 %. Base materials which are unsuitable in uncoated form may also be used if a suitable metallic surface coating is applied (e.g. bands or foils coating). The metallic surface must be at least 0.5 mm thick.

3.1.1.5 The fans must be of sturdy design and securely mounted in order to prevent deformation or movement which might lead to rubbing or striking [4] of moving parts.

This requirement is generally considered fulfilled for housings, supporting structures, guards, protective devices and other external parts if in a single impact test the deformation at the weakest point is so slight that the moving parts do not come into contact with the housing. The test should be performed in accordance with EN 50 014 (7 J impact energy, i.e. 1 kg test weight, 0.7 m drop height, using a 25 mm diameter hardened steel hemispherical impact piece).

Impeller strength testing is included in the test listed in section 3.1.6 paragraph 3.

[4] The fan must be protected against damage during transport

3.1.2 Increase in temperature

The maximum admissible surface temperature of all components in contact with dust/air mixtures must not exceed 2/3 of the ignition temperature in °C of the dust/air mixtures. The temperature of surfaces which come into contact with the fluid handled must not exceed the smoulder temperature of the relevant dust less 75°C where hazardous deposition of smouldable dust is not effectively prevented. Ignition temperature and smoulder temperature are measured according to VDI 2263, sheet 1[5] . A maximum surface temperature is not known in each particular case [6].

The maximum temperature on the discharge side of the fan for the design point is based on the intake temperature and the temperature increase in the fan due to the changed state condition of the fluid as a result of friction, throttling and compression [7] .

If the fan manufacturer is not able to specify a limit for temperature increase, temperature monitoring devices should be fitted to detect any rise above the admissible limit in the temperature of the fluid on the discharge side and automatically activate emergency functions (e.g. fan shutdown).

3.1.3 Bearings

The bearings should be positioned outside the fluid handled. Suitable roller bearings or friction bearings should be used for the fan shaft bearings. The nominal service life of these bearings should be at least 40 000 hours in accordance with ISO 281 Part 1[8] . The rotational speed limit of the bearings must not be exceeded under the selected lubrication conditions. A nominal service life of at least 20 000 hours must be guaranteed for the bearings of the fan motor.

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[5] Smoulder and ignition temperatures of a large number of dusts are given in the safety information sheets « sicherheitstechnische Informations- und Arbeitsblätter » 140 260 to 140 279 published in the BIA-Handbook. Erich Schmidt Verlag, Bielefeld

[6] The maximum surface temperature specified apply to deposited layers of dust <5 mm. The corresponding ignition temperatures fal extremely with thicker layers (see also 3.1.11). The specified maximum surface temperatures do not apply if dust decomposition reactions could produce inflammable gaseous decomposition products

[7] If a malfunction in the upstream system could result in an excessive intake temperature or a considerable variation from the design point (e.g. through additional throttling) monitoring devices should be fitted to activate emergency functions automatically if the admissible temperature is exceeded (e.g. shutdown of the fan motor)

[8] Operating instructions should contain details of the necessary maintenance measures (e.g. checking and replacement of bearings).

3.1.4 Shaft seals

At maximum operating speed at the friction point, the surface temperatures of sealing elements on shafts must not exceed the levels specified in section 3.1.2. The risk of ignition in seals due to friction and impact sparks must be largely eliminated, e.g. by using material combinations as listed in section 3.1.1.4.

3.1.5 Vibration characteristics

3.1.5.1 The operating speed must differ by at least 20 % from the actual critical speed. In over-critical operation the drive unit must permit fast passage through the critical rotational speed.

3.1.5.2 The impeller shallt be secured against torsion and movement on the shaft and balanced (quality grade at least G 6.3 of ISO 1940-1). The fan belt pulleys or coupling halves are also to be balanced (quality grade at least G 6.3 of ISO 1940-1).

3.1.5.3 The operative fan must be sufficiently quiet in operation. This requirement is met if when installed

a) on a high-tuned rigid or heavy base the effective vibration velocity does not exceed 2.8 mm/s r.m.s.

b) on a low-tuned base the effective vibration velocity does not exceed 4.5 mm/s r.m.s.

The vibration velocity shall be measured at the bearings.

3.1.5.4 Measures shall be taken to prevent fans from operating in unstable regions of the characteristic curve (e.g. in the case of axial-flow fans in the stall region[9]). The manufacturer must inform the operator of these regions[10] .

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[9] This can be achieved by ensuring sufficient distance between the operating point and the breakaway limit or by means of suitable monitoring measures.

[10] The specifications provided by the manufacturer is based on a uniform inflow to the fan in accordance with DIN 24 163 Part 1. It is therefore important to ensure uniform inlet flow during operation.

3.1.6 Clearance between impeller and housing

The minimum clearance between rotating components (e.g. impeller) and fixed components (e.g. housing) must be at least 1 % of the maximum possible contact diameter of the finished fan. This clearance shall not be less than 2 mm and need not be greater than 20 mm. Shaft seals are not subject to these provisions.

In order to avoid an inadmissible clearance reduction during operation, the fan must be designed to ensure that the minimum clearance does not decrease by more than 10 % at 1.2 x nominal rotational speed over 24 hours.

Each impeller must be subjected to a trial run at 1.2 x max. Rotational speed for 3 minutes. During this period the diameter must not increase to a degree which results in an inadmissible reduction of the clearance.

Note : where it is not possible to carry out the tests according to paragraph 2 and 3 of this section (e.g. with direct-driven fans), the following requirements may apply as an alternative : the impeller shall be designed such that at 1.1 nominal rotational speed no more than 90 % of the admissible stress of the material used is utilised. Each impeller must be subjected to a trial run lasting 1 h at maximum operating speed. The position of the minimum clearance shall be marked on the impeller and housing and the clearance dimension measured prior to the trial run. The position and size of the minimum clearance width must remain unchanged after the trial run.

If the required clearance cannot be maintained, the clearance may have the usual arithmerical tolerances (no contact during operation at rated speed), provided that least one of the two friction partners becomes soft enough to interrupt the heat-generating friction process due to material flow. This softening effect must occur before the surface temperature of the material has reached the maximum temperature as specified in section 3.1.2. If the measure only covers the endangered surface area rotating and fixed components (e.g. in the case of surface coating), the gap between the fixed metallic component and metallic impeller must comply with the requirements set down in paragraph 1 of this section.

The clearance shall be checked on site after assembly and before the system is commissioned. The results measured shall be recorded.

3.1.7 Protection against foreign particles

The fan shall be protected against penetration and suction intake of foreign particles[11] . The protective devices shall be fitted in such a way that they can be ckecked for function and condition. They must be made of conductive material and conductively connected to the conductive parts of the system and earthed.

3.1.8 Electrical equipment (internal)

Electrical equipment shall be subject to the regulations on electrical systems in explosion hazardous locations (« Elex V »).

The drive motor must not be located in the fluid flow if there is the danger of particles baking or settling on the motor and generating inadmissible surface temperatures (see section 3.1.2.)

3.1.9 Electrostatic charge

The fans must be designed to eliminate the risk of ignition due to electrostatic charges during operation and during malfunctions possible in regular operation. All parts of the fan must be electrostatically earthed see « Static Electricity » guidlines ZH 1/200).

Sparks with sufficient energy and brush-like surface discharge are deemed capable of igniting dust/air mixtures. Brush-like surface discharge can occur when the combination of a conductive material and a non-conductive material is used, or the latter is in contact with the fluid handled and rests on the conductive material as a layer less than 8 mm thick. The preventive measures against discharge of this type can be found in the « Static Electricity » guidlines (ZH 1/200).

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[11] If this is not done by the manufacturer, the manufacturer must inform the operator or the system builder of measure still to be taken. If necessary, inlets and outlets of the system should be protected against the entry and intake of foreign particles into/by the fan (e.g. fitting a hood).

3.1.10 Air-tightness of the housing

The housing of the fan including bushings must be of generally air-tight design to prevent inflammable dusts from escaping in hazardous quantities. This is achieved for example, if a pressure below ambient is present in the area of the shaft bushing during operation.

3.1.11 Dust deposits

The impeller and housing shall be of streamlined design to prevent dust from baking on or settling. This means that the operating conditions must be matched as closely as possible (flow rate and pressure difference). The selection of an appropriate shape of blade is particulary important.

Suitable facilities (e.g. easily accessible inspection covers) must be provided so that inspection and cleaning operations can be easily carried out. Dust deposits on impellers can be monitored continuously by vibration sensors if necessary.

3.2 Additional requirements for fans installed in zone II

The requirements in section 3.1 and the additional requirements in this section apply to fans moving dust/air mixtures from zone II locations to non-hazardous locations or within zone II, when the fan is installed in zone II.

3.2.1 Bearings

The bearings SHALL be monitored that the maximum admissible surface temperature (see section 3.1.2) not exceeded. This need not be done if precautions are taken to prevent hazardeous dust deposits accumulating on the bearings (e.g. by covering, fairings or regular cleaning).

3.2.2 Electrical equipment (external)

Section 3.1.8 paragraph 1 applies to external electrical equipment

3.2.3 Electrostatic charge

Electrostatically conductive belts shall be used in belt drives (see « Static Electrically » guidlines ZH 1/200)

3.2.4 Transmission elements

To prevent ignitions, transmission elements such as couplings, belts or chain drives are to be designed with respect to

- material combinations as specified in 3.1.1.4
- increases in temperature according to 3.1.2
- electrostatic charge according to 3.1.9

LITERATURE

(1) DIN EN 292 Teil 1 und 2, Sicherheit von Maschinen, Beuth Verlag 1991.

(2) Vorschlag für eine Richtlinie des Rates zur Angleichung der Rechtsvorschriften der Mitgliedstaaten für Geräte und Schutzsysteme zur bestimmungsgemäßen Verwendung in explosionsgefährdeten Bereichen (92/C46/02), KOM (91) 516 endg. - Syn 375, Amtsblatt der Europäischen Gemeinschaften Nr. C 46/19.

(3) Safety requirements for mine ventilation machinery, electrically operated fans for use underground, prEN 1872..

(4) Bartknecht, Ignition-effectiveness of mechanical sparks and hot surfaces in airborne dusts and mixtures of flammable gases with air. 1987, Bericht an das Bundesministerium für Forschung und Technologie.

(5) Hauptverband der gewerblichen Berufsgenossenschaften (1989) 'Richtlinien für die Vermeidung von Zündgefahren infolge elektrostatischer Aufladung'. Zentralstelle für Unfallverhütung,
Lindenstr 78-800, D-5805 Sankt Augustin 2.

(6) IACS, Internationale Association of Classification Societies, Ltd, F29.
Non-sparking Fans, Rev. 1983, London

(7) Kranchenko V.S. Bondarya V.A. et al. (1976) Vzryvobezopasnost'elektricheskikh razryadov i friktsionnykh iskr Moscow, HSE Trans. No. 8346 (Explosion Safety of Electrical Discharges and Frictional Sparks).

(8) Zalesskii P.S., et al (1978) 'Elektrizatsiya ventilyatorov mesthogo provetrivaniya i sposoby ee snizheniya' Ugol' Ukrainy Vol. 22, No 3 Marche pp. 37-38 HSE Trans. No. 817 (Electrostatic charging of local ventilation fans and methods for its reduction).

(9) Powell F. (1969) 'Ignition of Gases and Vapors' Industrial and Engineering Chemistry;
vol 61, No. 12 Dec. Pp 29-37.

(10) Pollak und Mohr (1988), 'Untersuchungen zum Zündrisiko bei Reibungsvorgängen an Ventilatoren' Glückauf-Forschungshefte 49 (1988) Nr.5.

(11) BSI, Report to the members of CEN/TC 196/WG4, mine ventilation machinery, of 1. June 1990.

(12) British Standards Institution (1973) 'Copper alloy ingots and copper alloy castings'
British Standard 1400, London, BSI 40 pages

(13) Carver, J. (1976) 'Report on Explosion at Houghton Main Colliery Yorkshire' HMSO London, 26 pages

(14) HSE (1978), 'A review of auxiliary and booster fan ventilation practice in mines' a report by the National Comittee to examine all aspects of the ventilation of narrow drivages, London HMSO 41 pages.

(15) Rae, D. (1964). The role of quartz in the ignition of methane by the friction of rocks' SMRE Research Report No. 223, Aug. 50 pages

(16) Schuber, E. And Graumann, K. (1977) 'Safe secondary ventilation in headings' Paper E6 17th International Conference of Mining Safety Research Oct. Varna, Bulgaria.

(17) US Bureau of Mines, Report of investigations, No. 5753 (1961), No. 5971 (1962), No. 6516 (1964), No. 6597 (1965), No. 7132 (1968), No. 7208 (1968).

(18) Dittmar, Paul, Absatz 3e, Reib- und Schlagfunken als Zündquelle in Handbuch der Raumexplosionen, Herausgeber Heinz Helmut Freytag, Verlag Chemie GmbH, Weinheim/Bergstraβe, 1965.

(19) VDMA 24 169, Bauliche Explosionsschutzmaβnahmen an Ventilatoren, Teil 1 und 2, Beuth Verlag, 1983.

(20) VDMA 24 179, Absauganlagen für Holzstaub und Späne, Teil 2? Beuth Verlag 1988.

(21) Maschinensicherheit, Brände und Explosionen, Teil 1, Entwurf DIN EN 1127, Beuth Verlag, September 1993.

(22) Dr. Dyrba, Berufsgenossenschaft der chemischen Industrie, Private Mitteilungen.

(23) H. Beck, BIA, Berufsgenossenschaftliches Institut für Arbeitssicherheit, Private Mitteilungen.

(24) Witt, H. (1994) Explosionsschutz bei Ventilationen

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