

Cellulose ethers

Safe handling and processing - burning behaviour and explosion risk



Content

1.	Introduction.....	2
2.	Legal Basis	3
3.	Approach to the risk assessment.....	5
4.	Zone classification.....	8
5.	Product data, summary and meaning	11
5.1	Dust deposits.....	12
5.2	Dispersed dust	13
6.	Prevalent ignition sources for dusts	15
7.	Selection of equipment and protective systems in accordance with Directive 94/9/EC	17
8.	General dust explosion protection measures.....	18
8.1	Storage and transport.....	18
8.2	Storage in silos.....	19
8.3	Bag dischargers, Big Bag dischargers	19
8.4	Storage in FIBCs	19
8.5	Mixers.....	20
8.6	Separators	20
8.7	Screens	20
8.8	Handling in areas that are at risk from gas explosions	21
8.9	Handling of cellulose ether in the presence of potentially explosive vapour/ or gas/air mixtures.....	21
Annex I	Literature	22
Annex II	Norm allocation for the standardised tests	23



1. Introduction

Many industrially processed powdery materials are combustible and can, under certain conditions if dispersed cause dust explosions. Cellulose ethers (CE) are organic dusts that are combustible and potentially explosive. However, provided that some basic principles of fire- and explosion protection are followed, cellulose ethers can be safely handled.

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It serves to provide basic information on the burning behaviour and explosiveness of CE and the interpretation for a risk assessment to allow for an even safer handling and processing of these products.

To determine these characteristics, commercially available products were used that contain a < 63 µm particle size fraction, although these products also contain significant amounts of coarser fractions. This fine product fraction, however, is representative for the risk assessment of a dust explosion.

The moisture content has got an influence on the burning behaviour and explosiveness. As mentioned above, the commercially available products were tested. The values of the explosion characteristics increase with decreasing water content, shifting towards less favourable values.

Products that are modified during their processing (e.g. mixing, grinding or drying) can significantly deviate from this representative fraction and must be examined separately.

Users must perform their own risk assessment but this can be based upon the principles and data presented here.



2. Legal Basis

The operators of plants and work places with potentially explosive areas, must meet the requirements of the European approximation of the laws of the member states, are called to meet standardised and binding minimum requirements with view to operational explosion protection. This brochure gives examples on how the handling of CE of various product groups can be assessed from an explosion protection point of view and how responsible and practicable solutions to nationally implement the “operator's directive” 1999/92/EC¹ can be found.

Complementing the directive, the Commission set up practical guidelines for established proceedings. The guideline provides further information, especially for small and medium-sized companies, on implementing the requirements of Directive 1999/92/EC.

Table 1 gives an overview of the European legal structure of work- and health protection in potentially explosive areas as well as the regulation for the conditional requirements concerning equipment and protective systems in potentially explosive atmospheres.

¹ Directive 1999/92/EC of the European Parliament and the Council of 16 December 1999 on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres (Official Journal L 23 of 28 January 2000, p. 57)



Table 1: European legal structures concerning works- and health protection as well as product safety

Directive 1999/92/EC² with ATEX guideline (published as memorandum KOM /2003/0515 final [3])	Directive 1994/9/EC³ bringing into circulation and initial operation including the condition of equipment and protective systems intended for use in potentially explosive atmospheres
regulated object work environment (health protection at work in potentially explosive atmospheres)	regulated object products (requirements for machines, plants, ...)
goal protection of workers	goal product safety
approximation minimum regulations to gradually improve the work- and health protection	approximation complete regulatory approximation to remove technical trade barriers
national implementation in the member states in the form of minimum requirements	concretised in harmonised EN standards The national implementation in the member states is realised 1:1

² Minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres

³ Approximation of the laws of the Member States concerning equipment and protective systems intended for use in potentially explosive areas



3. Approach to the risk assessment

A risk assessment must be carried out on the basis of the requirements of Directive 1999/92/EC as well as the appropriate national implementation. Depending on the risk assessments result, it might be necessary to conduct a so-called zone classification and to take the appropriate explosion protection measures.

For the risk assessment, the following criteria play an essential role:

- systems- and process engineering, operational parameters
- material characteristics,
- frequency and duration of the occurrence of potentially explosive atmosphere,
- occurrence of effective ignition sources,
- interaction of the plant components with one another and with the work environment.

Apart from normal operation, maintenance works, start-up and shut-down processes, possible operational failures, and predictable defects must be taken into consideration.

In many cases, the risk assessment can be carried out by means of a simple inquiry system (cf. figure 1). For very complex plants, different procedures might also be made use of [3].

As a basic principle, the following questions must always be answered:

Are combustible materials present?

For an explosion to occur combustible materials must be present in the work- or production process. This means, that at least one combustible substance either is used as a raw or auxiliary material, arises as a waste-, intermediate- or final product, or may be generated during ordinary operational failures [chapter 2.2.1 of the guideline [3]].

Note: Cellulose ether dusts are combustible, so that this question must be answered positively if cellulose ethers are handled.

Can sufficient dispersion in air give rise to a potentially explosive atmosphere?

Whether a potentially explosive atmosphere can be generated in the presence of combustible substances depends on the ignitability of the mixture that has been formed with air. A potentially explosive atmosphere is present if the necessary degree of dispersion is attained and if the concentration of the combustible substances in air lies within their explosion limits [chapter 2.2.2 of the guideline [3]].

Note: Dispersed cellulose ether dusts are potentially explosive.



Is the generation of potentially explosive atmosphere possible?

If the generation of **potentially explosive atmosphere is possible**, it is essential to determine the exact location in which it arises in the workplace or plant, so as to be able to limit the risk potential. For this determination, again, the materials' characteristics as well as the system-, process- and environment-specific conditions need to be considered [chapter 2.2.3 of the guideline [3]].

If, in certain areas, a potentially explosive atmosphere can occur in such quantities that special protective measures to guarantee maintenance of health and safety standards for the employees concerned are rendered necessary, the potentially explosive atmosphere is called **hazardous atmosphere**, and the areas in question are classified to be potentially explosive areas [chapter 2.2.4 of the guideline [3]].

Note: Cellulose ether dusts are potentially explosive and can, in a sufficient amount and in combination with an oxidant such as air, generate a hazardous atmosphere. A hazardous atmosphere can be generated e.g. in the interior of systems (e.g. mixer, rotating screen, separator...) but also due to leakages, deposits (e.g. bag dischargers, delivery points, supply systems...).

Is the generation of a hazardous atmosphere securely prevented?

If the generation of a hazardous atmosphere is possible, technical and/or organisational explosion protection measures must be taken. Here, the first attempt should be to avoid the generation of a hazardous atmosphere [chapter 2.2.5 of the guideline [3]].

Note: The generation of hazardous cellulose ether dust/air mixtures can be prevented through preventive explosion protection measures, e.g. inerting with an inert gas such as nitrogen. A correct design and an efficient operation must be cared for, however.

Is the ignition of hazardous atmosphere securely prevented?

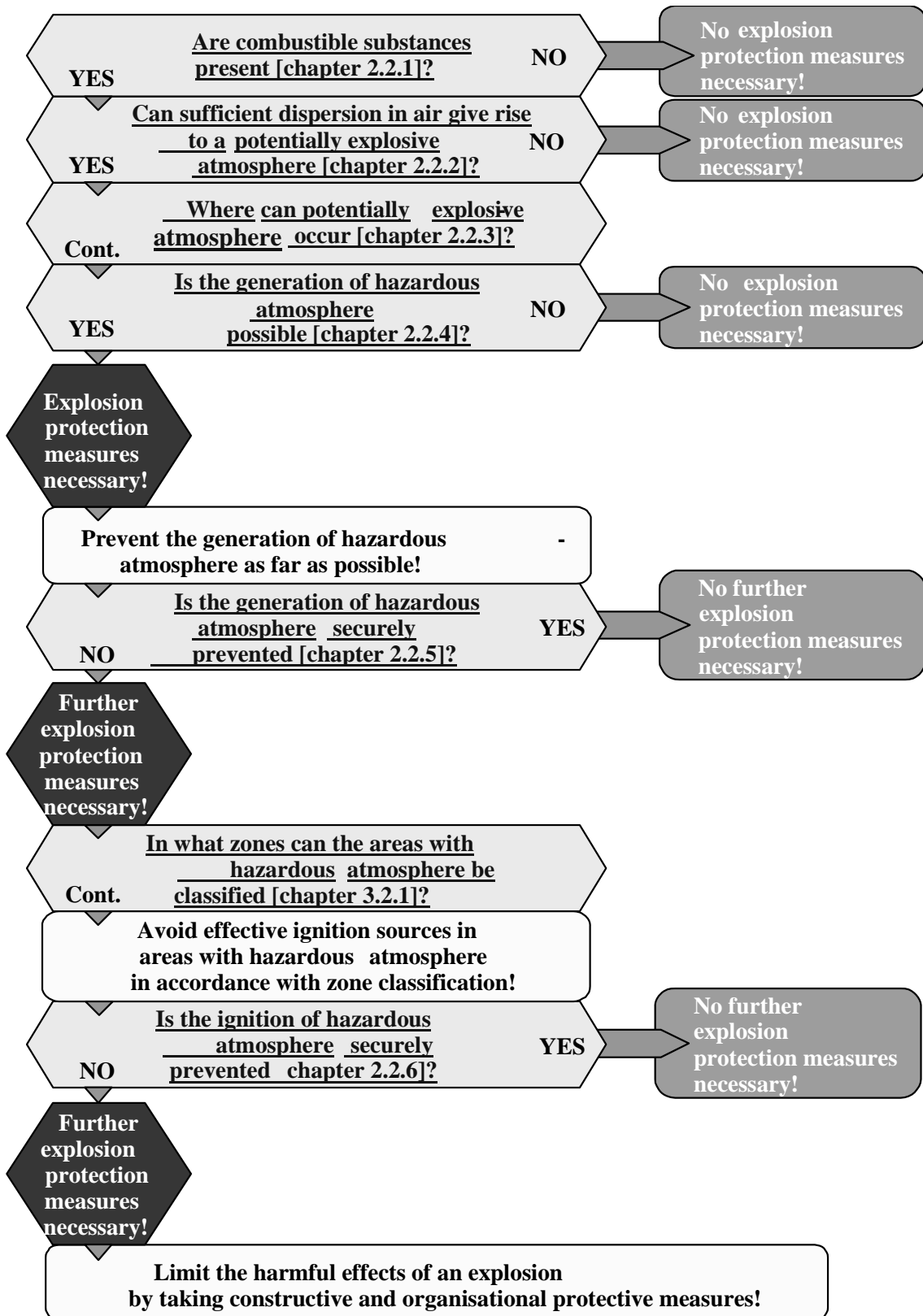
If generation of hazardous atmosphere cannot entirely be ruled out, measures must be taken to avoid effective ignition sources. The more likely the generation of a hazardous atmosphere the safer must be the avoidance of effective ignition sources [chapter 2.2.5 of the guideline [3]].

Note: For instance, hot surfaces caused by bearing failures can be timely detected by dint of a temperature control. The grounding of conductive plant components prevents the occurrence of spark discharges.

When assessing potential explosion risks in workplaces, Figure 1 [3] schematically describes the course of a risk assessment by means of a simple inquiry system.



Figure 1: assessment flowchart to detect and prevent explosion risks [3]



4. Zone classification

A hazardous place is a place in which an explosive atmosphere may occur in such quantities as to require special precautions to protect workers against explosion hazards. Such a quantity is termed a hazardous explosive atmosphere. As a basis for determining the extent of protective measures, any remaining hazardous places must be classified in terms of zones according to the likelihood of occurrence of such atmospheres. That renders necessary measures to protect the employees from explosion risks.

Below is the definition of the different zones for dusts (table 2), by analogy, zones potentially at risk of gas explosions are classified [3].

Zone 20 is a place in which an explosive atmosphere in the form of a cloud of combustible dust in air is present continuously, or for long periods or frequently.

Zone 21 is a place in which an explosive atmosphere in the form of a cloud of combustible dust in air is likely to occur in normal operation occasionally.

Zone 22 is a place in which an explosive atmosphere in the form of a cloud of combustible dust in air is not likely to occur in normal operation but, if it does occur, will persist for a short period only.

Table 2: Zone classification of hazardous places

Occurrence of explosive atmosphere (pea)	Dusts
continuously, frequently, for long periods	Zone 20
occasionally during normal operation	Zone 21
normally not, or only temporarily	Zone 22



For the zone classification, it must fundamentally be regarded that

- layers, deposits and accumulations of combustible dust must be considered to be causes of the generation of potentially explosive atmosphere.
- normal operation is the plant's condition in which it is operated within its constructional parameters.

The hazardous places to be classified in zones can be described and illustrated graphically in the form of a zone plan. In any case, it should be clearly defined where exactly explosive atmosphere may occur. Here, one must differentiate between:

- the interior of plant components
- and the environment of plant components.

The following operational conditions should be taken into consideration:

- normal operation⁴,
- start-up and shut-down processes,
- servicing (according to DIN 31051: maintenance, inspection, repair)
- operational failures
- process- or product alterations

The extent of protective measures depends on the probability of an occurrence of explosive atmosphere (zone classification). The following table displays the interdependence of zone classification and the operational conditions, in which ignition sources must be safely prevented.

⁴ Normal operation is considered to be the condition in which plants are operated within their constructional parameters.



Table 3: Extent of ignition source prevention

Zone classification	Ignition sources must be safely prevented during:
20	<ul style="list-style-type: none">• undisturbed operation (normal operation)• predictable failures and• rarely occurring operational disturbances
21	<ul style="list-style-type: none">• in undisturbed operation (normal operation) and• predictable failures
22	<ul style="list-style-type: none">• in undisturbed operation (normal operation)



5. Product data, summary and meaning

Below, the results of the tests of the various products, provided by the participating producers of cellulose ethers, are summarised in table form. The data are selected in a way so as to render them representative of the products' respective class and therefore make them universally valid for the fire- and explosion-related assessment of these products.

EXAM tested the cellulose ether safety characteristics in accordance with the standards and directives listed in the annex. For further information we refer to the test report [9].

To also cover the most critical conditions to be expected, the parameters were determined by testing dusts with a particle size of $< 63 \mu\text{m}$. Critical conditions can occur if, during processing, the degree of fineness of the cellulose ethers is altered or if it amounts to accumulation of fines (e. g. in deposits, due to abrasion, in the filter or after a grinding process). It must be taken into consideration that the safety-relevant parameters listed in table 4 are always some determined maximum values or, in parts, the upper value of a classification. This means that individual products of a product group can indeed have deviating lower values. In addition it is possible that there are certain products that have not been tested here and that have even more critical values. For this reason it is recommended to draw on the parameters of the dust actually present in the respective plant to provide a basis for the assessment of explosion protection concepts. Therefore, the values listed in the table can only be considered exploratory.

Table 4: Safety-relevant parameters of cellulose ethers

cellulose ether group	Burning class	Smoulder temperature	Auto-ignition temperature	LEL	p_{max}	K_{St}	MIE*	Ignition temperature
		°C	°C	g/m ³	bar	bar·m·s ⁻¹	mJ	°C
CMC and CMC technical	5	280	170	60	9	<200	>1000	360
EHEC	5	>450	120	30	10	<200	>10	420
HEC	5	280	120	30	10	<200	>10	460
EC	5	390	130	20	8	<200	>3	380
HPC	5	>450	230	30	10	<200	>3	420
HPMC / HEMC / MEHEC	5	>450	170	30	10	<300	>10	400
MC	5	300	170	30	10	<300	>10	380

* measured with inductivity



The abbreviations used for the cellulose ethers assessed are listed in table 5.

Table 5: Definition of Terms

EC	Ethyl cellulose
MC	Methyl cellulose
CMC	Carboxy methyl cellulose
HEC	Hydroxyethyl cellulose
EHEC	Ethyl hydroxyethylcellulose
MEHEC	Methyl ethyl hydroxyethylcellulose
HPMC = MHPC	Hydroxypropyl methyl cellulose
HEMC = MHEC	Hydroxyethyl methyl cellulose
HPC	Hydroxypropyl cellulose

In the following, the test results are explained with view to their interpretation and meaning.

5.1 Dust deposits

When assessing a dust's combustibility, it is tested whether and to what degree a fire that has been initiated through external ignition can spread in the deposited dust. The combustibility is assessed in accordance with the classification marked with the numbers BZ 1 to BZ 6 as listed in table 6.

Table 6: Burning Behaviour

No propagation of a fire	No ignition	BZ 1
	Brief ignition and rapid extinction	BZ 2
	Localized burning or smouldering without propagation	BZ 3
Propagation of a fire	Propagation of a smouldering fire	BZ 4
	Propagation of an open fire	BZ 5
	Very hefty, deflagration-like burn-off	BZ 6



- The burning class of all cellulose ethers is 5, which means that a fire can spread with open flame after its ignition, e. g. caused by a welding bead or cigarette ember.
- The glowing temperature is between 280 °C and > 450 °C and is product-type dependent. This temperature leads to a smouldering fire if there is a thin dust layer (5 mm) on a hot surface.
- Decomposition gases generated in the glowing process are generally combustible.
- All cellulose ethers tend to auto-ignite at increased temperature. The auto-ignition temperature depends on the stored amount and on the storage temperature. The values listed in the table refer to a sample volume of 400 ml. In this case, the auto-ignition temperature is between 120 °C and 230 °C and is product-type dependent. The listed value can be consulted for the assessment of the respective deposits and caking, e.g. in drying processes. Should there be larger deposits, or should it be about storing larger amounts e.g. in FIBCs or silos, the auto-ignition temperature can be noticeably lower. Generally, it is recommended to store the products below 60 °C.

5.2 Dispersed dust

The dust explosion parameters

- p_{max} is the maximal occurring explosion overpressure. For cellulose ethers, this value is between 8 and 10 bar.
- The K_{st} -value indicates the maximum rate of pressure rise scaled to 1 m³ volume. For the explosion-related design of constructive explosion protection measures, substances are classified in dust explosion classes.
- Cellulose ethers are St 1- or St 2-products

The interrelationship between K_{st} -value and dust explosion classes is shown in the following table:

Table 7: Interrelationship between K_{st} -value and dust explosion class

Dust explosion class	K_{st} -value in / bar·m·s ⁻¹
St 1	> 0 to 200
St 2	> 200 to 300
St 3	> 300

The **lower explosion limit (LEL)** defines the lower limit of a span of a dust/air mixture in which a dust explosion can occur. The LEL values of cellulose ether are product-type dependent and are in between 20 g/m³ and 60 g/m³. These values are important when assessing whether in a certain area, the



concentration of cellulose ethers in air is within the explosion limits. The dust concentration can be heavily modified by dispersal of deposits or depositing of dispersed dust.

Explosions in adjacent work areas can also disperse dust deposits and ignite them (so-called secondary explosions).

The **minimum ignition energy (MIE)** defines the ignition sensitivity of products to sparks (electrostatic, mechanical etc.). Products are classified depending on this value. Depending on the product, cellulose ethers are either little (> 1000 mJ), normally (≤ 1000 mJ, > 10 mJ) or specifically ignition-sensitive (3 mJ – 10 mJ).

The MIE can be determined both without and with inductivity. The cellulose ethers listed in table 4 were divided into material-specific groups. Within these groups, the dusts' minimum ignition energies were determined in the modified Hartmann apparatus according to DIN EN 13821, "Potentially explosive atmospheres – Explosion Protection – Determination of the minimum ignition energy of dust/air mixtures". For many dusts it is true that the interconnection of an inductivity in the discharge circuit results in a lower MIE. The MIE determined with inductivity can be consulted for the assessment of the ignition risk due to spark discharges in the electrical circuit.

If also the dust/air mixtures' ignition temperature is known, the ignition risk due to mechanically produced sparks can be assessed as well.

The MIE determined without interconnected inductivity particularly serves for the assessment of the ignition risk due to electrostatic discharges. If the determined minimum ignition energy is less than 10 mJ, another test series without inductivity in the main discharge circuit is conducted. The thus shortened duration of sparks is more similar to electrostatic discharging processes.

The **ignition temperature** for dispersed dust defines the temperature at which dispersed dust ignites on a hot surface. Depending on the product group, the ignition temperature of cellulose ethers is in between 360 ° C and 460 ° C.



6. Prevalent ignition sources for dusts

In practice, various effective ignition sources can occur. The most common ignition sources are listed below.

- Hot surfaces
- Flames and hot gases
- Mechanically produced sparks
- Electrical equipment
- Static electricity
- Lightening
- Exothermal reactions (including glowing particle nests and auto-ignition temperatures)

Further information on the individual ignition sources can be drawn from the guideline [3] or from EN 1127-1.

For example, dispersed cellulose ethers can be ignited on contact with **hot surfaces**, if a surface's temperature does not securely fall below the ignition temperature of the potentially explosive atmosphere. If the temperature of a hot surface is not securely below the smoulder temperature a dust deposit can be ignited, too. The temperatures of all surfaces may not exceed 2/3 of the ignition temperature in °C. In the case of surfaces, on which hazardous deposits of smouldering dust cannot be effectively prevented, the surface temperature may not exceed the smouldering temperature of the respective dust reduced by 75 K. This safety margin between the maximum possible surface temperature and the ignition temperature of the potentially explosive atmosphere should be provided for. The safety margin to be maintained is laid down in EN 1127-1.

Smoking, fire and open light are strictly prohibited in potentially explosive areas and must be prevented by organisational measures.

Ignition-effective **electrostatic discharges** can be generated during processes of pouring, stirring, and spraying of liquids, or of rubbing, milling, and mixing of solids. High charges are also generated during gas- and vapour flows with finely distributed fluids. Experts should be consulted when assessing electrostatic ignition sources.

Some devices, e. g. mixers, mills, ventilators, mechanical conveying devices, are subject to such heavy mechanical loads that, at least during operational failures, mechanical sparks or friction-conditioned hot surfaces must be expected at least in the event of operational failures. However, as long as the relative speeds are < 1 m/s, the occurrence of sparks that are ignition-effective for dusts does not necessarily need to be expected. If drive capacities are increased (e. g. cone-screw mixer), hot surfaces might evolve in the event of failures at bearings or shaft ducts that are capable of igniting dusts, even if relative speeds are low. Here, each individual case should be considered separately.



As a matter of principle it is recommended to store the devices in question outside potentially explosive areas wherever possible.

Auto-heating and auto-ignition can occur every time cellulose ether is handled too hot. To avoid these ignition sources, it is necessary to adhere to safe product temperatures.



7. Selection of equipment and protective systems in accordance with Directive 94/9/EC

In areas in which a hazardous atmosphere can occur, equipment⁵ and protective systems must be selected in compliance with the categories according to Directive 94/9/EC, unless provided for otherwise in the explosion protection document and accounted for in an adequate risk assessment. In addition to that, for the safe operation of equipment in potentially explosive areas, further criteria such as temperature class, type of ignition protection, explosion group, etc. must be allowed for. These criteria depend on the burning- and explosion characteristics of the dusts used [3].

Table 8: Equipment categories for use in areas that are at risk from dust explosions

National implementation of Directive 1999/92/EC	Directive 94/9/EC
Zone 20	Category 1 D
Zone 21	at least category 2 D
Zone 22	at least category 3 D

Equipment of category 1 must provide sufficient security even in the event of rare failures.

Equipment of category 2 must provide sufficient security in the event of frequently operational disturbances.

Equipment of category 3 must provide sufficient security during normal operation through prevention or control of the ignition sources occurring under normal operating conditions.

⁵ **Equipment** includes machines, devices, stationary or mobile installations, control- and furnishing parts as well as alarm- and prevention systems that, either individually or in combination, are intended for the generation, transmission, saving, measurement, regulation and transformation of energies as well as for the processing of materials, and that can give rise to an explosion with their own potential ignition source.

Examples: mills, centrifuges, stirrers, lifting tools, elevators, presses, lamps.



8. General dust explosion protection measures

Generally, spaces in which cellulose ethers are processed should meet certain requirements:

- The surface of floors should be easy to clean. Horizontal surfaces, on which dust can accumulate (cables, air ducts, etc.) should be minimised and, if possible, be easy to clean.
- The dust areas should be marked with a clear smoking ban.
- Walls should be designed to exclude dust deposits as much as possible.
- Porous wall coatings, e. g. for the sake of acoustic insulation, are not recommended since dust can accumulate there.
- Openings in inserted ceilings should be tightly sealed to prevent dust from entering the clearance.
- Doors and windows should be installed so that they are flush with the wall in the room's interior.
- Contrast colours facilitate the detection of dust deposits.
- All conductive plant components must be grounded in an electrostatic sense (bleeder $< 10^6 \Omega$). [8]
- All plant components must be designed as dust-proof as possible to minimise the release and deposition of dust in the environment.
- Dust must not be dispersed during the cleaning process. For example, this can be realised when using the adequate industrial vacuum cleaners that are certified for the respective zone.
- Blowing off the dust by means of pressurised air must not be used as a cleaning method in any case.

8.1 Storage and transport

The release of dust is effectively prevented if cellulose ethers are stored in sealed, dust-proof bags, FIBC or drums. The packaging must be tested for its suitability for explosion protection. Paper bags, e. g., may have an aluminium coating to form a vapour barrier in their interior. In this case, the packaging must be grounded.

If there are chargeable parts, hazardous electrostatic discharges of non-conductive parts (so-called propagating brush discharges) must be prevented. [8]

In the case of mechanical conveying systems, it is particularly important that neither electrostatic and mechanical sparks nor hot surfaces can occur [7].

In the case of pneumatic conveying systems, the ventilator must be installed on the clean-air side. Ventilators in the product flow often constitute an ignition source if they are not chosen as per the requirements for the respective category according to Directive 94/9/EC in correspondence with the zone classification. A favourable guidance of the lines must be attended to (avoidance of drops and



dead zones, sufficient conveying speed). Should spiral tubes be used, the spirals must be earthed at both ends. Only dissipative materials should be used.

8.2 Storage in silos

If larger amounts of cellulose ether are stored in silos, it must be tested within the scope of the risk assessment whether it is possible to completely prevent effective ignition sources. If applicable, also the occurrence of glowing particle nests, repose-angle discharges⁶ or the auto-ignition must be regarded as possible ignition sources. Normally, inerting measures or measures of constructive explosion protection (e. g. explosion-pressure venting, explosion suppression, isolation measures) should be taken in addition to the prevention of possible ignition sources.

8.3 Bag dischargers, Big Bag dischargers

Wherever bags are emptied, the release of dust into the environment is to be reduced by means of aspiration at the point of emergence. Dust-proof connections to empty the FIBCs prevent the operational release of the dusts. Enclosures of the dischargers that are as dust-proof as possible avoid the release of dust into other plant sections.

8.4 Storage in FIBCs

FIBC of type B (breakdown voltage < 4 kV) or of type C (dissipative) are appropriate to store cellulose ethers or other potentially explosive products. It must be regarded that type C needs to be grounded. Otherwise it could constitute an effective ignition source. Type B may only be used if no extremely ignition-sensitive dusts (≤ 3 mJ) are handled. When solvent-damp dusts are handled, or when burning gases (hybrid mixtures) are present, type B is not appropriate, either. FIBCs of class B may not be used in areas at risk of gas explosions (zones 0/1/2) [8].

⁶ If high-piled bulk material is filled into silos or big containers with diameters > 3 m, areas are produced within this fill that have a very high density. It also leads to strong electrical fields in the heap's top part, so that bulk-discharges occur. The maximum energy of the bulk energy to be expected can be calculated. Particularly hazardous are situations in which the ignition energies of bulk-discharges are produced through coarse particles and, simultaneously, fines of bulk material (e. g. due to abrasion) with very low ignition energies are present. Bulk-discharges can ignite ignition-sensitive dust/air mixtures



8.5 Mixers

Generally, one must differentiate between slowly-running and fast-running mixers.

Slowly-running mixers

If a mixer's relative speed is < 1 m/s, ignition-effective, mechanical rubbing- or grinding sparks that are ignition-effective for dusts do not necessarily need to be expected. As far as slowly-running with higher drive capacities (e.g. cone mixers) are concerned, hot surfaces might evolve in the event of failures at bearings or shaft ducts that are capable of igniting dusts, even if relative speeds are low. Here, each individual case should be considered separately.

Fast-running mixers

Fast-running mixers must be examined for the possibility of mechanical sparks or friction-conditioned hot surfaces. This may be the case if the mixing tool can rub against the enclosure and/or if the intrusion of foreign substances cannot be excluded. The possibility of overheating in the areas of bearings or shaft ducts must be assessed. If effective ignition sources cannot be securely excluded, such mixers must be operated under inert conditions or must be protected through constructive explosion protection measures.

8.6 Separators

If potentially explosive dusts are handled in filtering separators such as bag filters or pocket filters, a hazardous atmosphere often occurs operationally. Furthermore, the highest load of fines can be found in these apparatuses. Due to their hazard potential, these apparatuses are often protected by means of constructive explosion protection measures such as explosion pressure venting or explosion suppression. In addition, an explosion's propagation into plant components up- or downstream of the filter must be prevented. Therefore, explosion-related isolation measures must be taken (e. g. pressure-shock resistant and flameproof rotary valves as product dischargers, isolation on the raw-air side, e. g. by means of a gate valve or an extinguishing-agent barrier, isolation on the clean-air side, e. g. by means of an explosion protection valve).

When combustible dusts are discharged, isolating filter fabrics must not interrupt the grounding of those parts of the dust separator that are made from conductive or dissipative material.

8.7 Screens

In the case of vibrating- or reciprocating screens, especially the grounding of the screening machine including the screens must be attended to. If rotating screening machines are used, it might also be



necessary to take into consideration mechanical sparks, friction-conditioned hot surfaces and the entry of foreign substances due to the increased mechanical stress.

8.8 Handling in areas that are at risk from gas explosions

If systems, equipment, procedures, etc. for the processing of cellulose ether are used in areas that are at risk from gas explosions, further technical and/or organisational protective measures are necessary. The minimum ignition energy of combustible gases significantly lies below that of the cellulose ethers and therefore determines the additionally necessary protective measures.

The appropriate systems and devices for use in areas at risk from gas explosions should be selected in consideration of application area, substance class, and zone classification, specific characteristics of the gases, vapours, exhalations (e.g. explosion group, temperature class) and of the ambient conditions.

8.9 Handling of cellulose ether in the presence of potentially explosive vapour/ or gas/air mixtures

Hybrid mixtures (e. g. dusts with remains of solvents) can already be potentially explosive if the concentration of the gases, vapours or dusts on its own is below its lower explosion limit. If potentially explosive vapour/air- or gas/air-mixtures cannot be completely excluded, additional technical and organisational measures must be taken. The ignition-sensitivity of vapour/ or gas/air mixtures often is a lot higher than that of pure cellulose ether/air mixtures, so that the above-mentioned measures normally do not suffice if combustible gases or vapours are present.



Annex I Literature

- [1] Explosion protection directive 94/9/EC (Directive on the approximation of the laws of the Member States concerning equipment and protective systems intended for use in potentially explosive atmospheres) ("ATEX100a/95") of 23 March 1994; last amended on 26 January 2000
- [2] Directive 1999/92/EC of the European Parliament and the Council of 16. December 1999 on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres.
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- [8] CLC/TR 50404: Electrostatics; Code of practice for the avoidance of hazards due to static electricity. Technical Report of CENELEC, June 2003
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- [10] TRBS 2153: Vermeidung von Zündgefahren infolge elektrostatischer Aufladungen, 19.01.2007



Annex II Norm allocation for the standardised tests

Table 9: Norm allocation for the standardised tests to determine the safety-relevant parameters of dusts

Characteristic Variable	Test Basis
Particle Size Distribution, Sieve Analysis	VDI 2031
Burning Behaviour and smouldering gases	VDI 2263-1
Smoulder Temperature	DIN EN 50281-2-1
Minimum Ignition Energy	DIN EN 13821
Ignition Temperature (raised dust and layer)	DIN EN 50281-2-1h
Maximum Explosion Pressure	DIN EN 14034-1
Maximum Rate Of Explosion Pressure Rise and/or K_{St} -value	DIN EN 14034-2 (Draft)
Lower Explosion Limit	DIN EN 14034-3
Auto-Ignition temperature-hot storage test (Auto-ignition temperature)	VDI 2263-1



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