AT LEAST ONE OF THESE ISSA SECTIONS ON THE PREVENTION OF OCCUPATIONAL RISKS CORRESPONDS TO YOUR OWN FIELD OF INTEREST: DO NOT HESITATE TO CONTACT ITS SECRETARIAT

ISSA INTERNATIONAL SECTION
for AGRICULTURE
Bundesverband der landwirtschaftlichen Berufsgenossenschaften (BLB)
Weißensteinstraße 72
34131 KASSEL-WILHELMSHÖHE
Germany

INTERNATIONAL SECTION
of the ISSA for
MACHINE and SYSTEM SAFETY
Berufsgenossenschaft Nahrungsmittel und Gaststätten (BGN)
Dynamostraße 7-11
68165 MANNHEIM
Germany

ISSA INTERNATIONAL SECTION
for the CHEMICAL INDUSTRY
Berufsgenossenschaft der chemischen Industrie (BG Chemie)
Kurfürsten Anlage 62
69115 HEIDELBERG
Germany

ISSA INTERNATIONAL SECTION
for the MINING INDUSTRY
Bergbau-Berufsgenossenschaft (BBG)
Hunscheidtstraße 18
44789 BOCHUM
Germany

ISSA INTERNATIONAL SECTION
for the CONSTRUCTION INDUSTRY
Caisse régionale d´assurance-maladie d´Ile de France (CRAMIF)
17-19, place de l´Argonne
75019 PARIS
France

ISSA INTERNATIONAL SECTION
for RESEARCH
Institut National de Recherche et de Sécurité (INRS)
30, rue Olivier Noyer
75680 PARIS CEDEX 14
France

ISSA INTERNATIONAL SECTION
for ELECTRICITY - GAS - LONG-DISTANCE HEATING - WATER
Berufsgenossenschaft der Feinmechanik und Elektrotechnik (BGFE)
Gustav-Heinemann-Ufer 130
50968 KÖLN
Germany

ISSA INTERNATIONAL SECTION
for EDUCATION and TRAINING
Commission de la Santé et de la Sécurité du Travail du Québec (CSST)
1199, rue De Bleury
MONTREAL, QUEBEC H3C 4E1
Canada

ISSA INTERNATIONAL SECTION
for INFORMATION
Institut pour la prévention, la protection et le bien-être au travail (PREVENT)
88, rue Gachard, Boîte 4
1050 BRUXELLES
Belgium

ISSA INTERNATIONAL SECTION
for HEALTH SERVICES
Berufsgenossenschaft für Gesundheitsdienst und Wohlfahrtspflege (BGW)
Pappelallee 35-37
22089 HAMBURG
Germany

ISSA INTERNATIONAL SECTION
for the IRON AND METAL INDUSTRY
Allgemeine Unfallversicherungsanstalt (AUVA)
Adalbert-Stifter-Straße 65
1200 WIEN
Austria

ISSA Prevention Series No. 2050 (E)

Practical Assistance for the Preparation of an Explosion Protection Document

International Section
Machine and System Safety
of the ISSA

Berufsgenossenschaft
Nahrungsmittel und Gaststätten
Dynamostraße 7-11
68165 Mannheim
Germany

2006
ISBN 92-843-1167-5
ISSN 1015-8022

has more than 350 members (government authorities and public institutions) in more than 150 countries. The headquarters of the ISSA are at the International Labour Organization in Geneva. Its main goal is the promotion and improvement of SOCIAL SECURITY in all parts of the world.

To improve occupational safety and health in industrial plants, the

INTERNATIONAL SECTION
OF THE ISSA FOR MACHINE
AND SYSTEM SAFETY

was established in 1975. It handles matters relating to the safety of machinery plants and systems. It has its chair and secretariat at the Berufsgenossenschaft Nahrungsmittel und Gaststätten, 68165 Mannheim, Germany.

To intensify work safety in plants of the chemical industry, including plastics, explosives, mineral oil and rubber industries, the

INTERNATIONAL SECTION
OF THE ISSA ON THE PREVENTION
OF OCCUPATIONAL RISKS
AND DISEASES IN THE
CHEMICAL INDUSTRY

was set up in 1970. It has its chair and secretariat at the Berufsgenossenschaft der chemischen Industrie, 69115 Heidelberg, Germany.

2006
ISBN 92-843-1167-5
ISSN 1015-8022

Practical Assistance for the Preparation of an Explosion Protection Document

Compendium for industrial practice

Published by

International Section Machine and System Safety
of the International Social Security Association (ISSA)
Dynamostr. 7-11
68165 Mannheim
Germany

Foreword

The **ISSA** (**I**nternational **S**ocial **S**ecurity **A**ssociation) Section for Machine and System Safety has several project groups dealing with specific questions on the safety of equipment, plants, and systems. The members of the working groups are international experts and come not only from universities and research institutes, but also from industry and the acccident prevention groups of insurance organizations. This range of experience ensures that practical solutions are developed for the complex problems that arise on safety issues.

Directive 1999/92/EC (ATEX 137) on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres requires that the employer prepares an explosion protection document for all areas where explosive atmospheres may occur. This document must demonstrate that the explosion risks have been determined and assessed, that the places where explosive atmospheres may occur have been classified and that the safety measures taken have been documented. The following aspects among others must be considered:

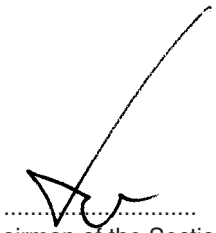
- Areas which could contain explosive atmospheres must be classified into zones
- Existing safety measures must be compared with the explosion risks and where necessary, new measures must be implemented
- The safety measures must be described
- Appropriate technical and organizational measures must be taken

A systematic assessment procedure should be used as it is already the case in many other situations where this Directive does not apply.

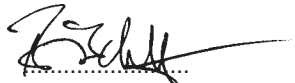
This compendium, which has been compiled in close cooperation with the Chemistry Section of the ISSA, is intended to help employers and/or their nominated responsible persons prepare the explosion protection document. In the future it is intended that examples of an explosion protection document for different industries (e.g. foodstuff branch) and plants (e.g. spray dryer) will be collected based on practical situations. These examples will be produced as a loose-leaf collection which will be published in the ISSA brochure series.

In this way the Section Machine and System Safety is making a significant contribution not only to maintaining but also to further improving a common status of technical knowledge among industrial countries. The members of the Section actively participate in EC technical committees. With its understanding and international experience of the wide range of important explosion prevention and protection measures the Section also can offer support and advice to developing countries.

International Section Machine and System Safety



Chairman of the Section
(N. Weis)



General Secretary
(Dr H.-J. Bischoff)

Commission members and authors

Chairman

Berufsgenossenschaft
Nahrungsmittel und Gaststätten,
Dr Frank Hauert (D)

In cooperation with

Allgemeine Unfallversicherungsanstalt (AUVA), Vienna (A)
AZO GmbH, Osterburken (D)
Berufsgenossenschaftliches Institut für Arbeitsschutz (BGIA),
Sankt Augustin (D)
Berufsgenossenschaft der chemischen Industrie, Heidelberg (D)
Berufsgenossenschaft Nahrungsmittel und Gaststätten (BGN), Mannheim (D)
Ciba Specialty Chemicals Inc., Basel (CH)
ESCIS (Expert Commission for Safety in the Swiss Chemical Industry), Lucerne (CH)
FireEx Consultant GmbH, Giebenach (CH)
FSA (Research Center for Applied System Safety
and Industrial Medicine), Mannheim (D)
ISMA (Int. Bureau for Safety and Risk Management), Kontich (B)
ISPESL (Istituto Superiore per la Prevenzione e la Sicurezza del Lavoro), Rome (I)
Suva (Swiss National Accident Insurance Fund), Lucerne (CH)

Authors

Dr A. Arnold, Mannheim (D)
Dipl.-Ing. H. Beck, Sankt Augustin (D)
Dr B. Dyrba, Heidelberg (D)
Dr F. Hauert, Mannheim (D)
Dipl.-Ing. N. Jaeger, Basel (CH)
Ing. K. Kopia, Vienna (A)
Dr G. van Laar, Kontich (B)
Dipl.-Ing. G. Nied, Osterburken (D)
Dr R. J. Ott, Lucerne (CH)
Ing. F. Pera, Rome (I)
Prof. Dr-Ing. S. Radandt, Mannheim (D)
Dipl.-Ing. R. Siwek, Giebenach (CH)
Dr B. Strocka, Hamburg (D)

Layout and graphic design

Dr R. J. Ott, Lucerne (CH)
Dipl.-Designer D. Settele (Mannheim) (D)

Contents

1 Introduction 11

2 Structure and layout 13
2.1 Description of the plant or process 13
2.2 Risk assessment 13
2.3 Technical measures 14
2.4 Organizational measures 14
2.5 Annexes 15

3 Area classification 17
3.1 Zone definitions 17
3.2 Explanatory notes on the terms used in the zone definitions 18
3.3 Basic zoning considerations 19
3.4 Practical examples 19
3.4.1 Floor over a silo complex 19
3.4.2 Pneumatic conveying system 21
3.4.3 Filling station for pneumatic conveying system 21
3.4.4 Wagon discharging into a chute 22
3.4.5 Filling of a silo truck via a conveying system 23
3.4.6 Hydrogen storage 23
3.4.7 Gas supply station 24
3.4.8 Storage for flammable liquids 24
3.4.9 Petrol tank farm 25
3.4.10 Filling of liquefied flammable gas bottles 26
3.4.11 Paint spraying booth 26
3.4.12 Charging of combustible powders into highly flammable solvents ... 27
3.4.13 Charging of combustible powder into a reactor containing flammable solvent under inert gas 27
3.4.14 Solvent drum storage area and dispensing station 28
3.4.15 Fermentation tank of a sewage treatment plant 29
3.4.16 Area classification drawing for an external storage tank containing highly flammable liquid 30

4 Requirements for equipment and protective systems 32
4.1 Existing equipment 33

5 Terms and definitions 35

6 Literature 38

7 Picture credits 41

8 ISSA publications on explosion protection 43

1 Introduction

In Europe, explosion protection in work places is governed by the European Directive 1999/92/EC (ATEX 137) [1].
This requires that the employer carries out an assessment of the risks from a possible explosion and that appropriate measures are taken to ensure the safety of the employees. The Directive applies irrespective of the number of employees or the likelihood of an incident.
The results of the risk assessment as well as the resulting safety measures must be recorded by the employer in an explosion protection document.

The employer has to record in the explosion protection document

- that the explosion hazards have been identified and evaluated,
- the places where explosion hazards are likely to occur (hazard area classification and zones),
- the measures taken to avoid explosion hazards or to protect against the consequences of an explosion,
- which work equipment has been selected for use in hazardous places and how it has been selected,

  and
- which organizational measures are required.

An explosion protection document has to be prepared for every plant and process and it must be revised when changes are made to the workplace or process so as to take into account the altered conditions. The explosion protection document should be prepared before commissioning new installations. It should include:

- the risk assessment, including the safety measures which are to be used
- the area classification and specification of the resulting zones
- a description of training procedures
- a description of maintenance measures
- a description of the coordination of safety measures.

The explosion protection document describes the measures that have been implemented to ensure the employees´ protection against explosions at work

2 Structure and layout

The explosion protection document does not need to be a completely separate report. It can use risk assessments of explosion hazards which have already been carried out and documented for other purposes and can make cross reference to other existing reports.
In carrying out the risk assessment existing “good engineering practice” can be used provided this is described in the explosion protection document.
It is recommended that the explosion protection document includes sections describing the plant or process, the risk assessment and the technical and organizational safety measures which have been implemented. Details or cross references to documents describing safety procedures such as “permit to work” procedure should be included in annexes.

2.1 Description of the plant or process

The following items have to be described:

- designation of the workplace (building, room, plant)
- person responsible for the site (normally the employer)
- description of the plant and process steps
- list with quantities of flammable materials used
- list of their flammable/explosion characteristics
- overview of design and operating data used to specify plant and equipment
- information on installation and emergency plans

2.2 Risk assessment

The risk assessment has to address the following questions:

- Can explosive atmospheres occur around the plant or installation being assessed or inside the equipment?
- What quantity of explosive atmosphere could be present or occur as a result of the local and operating conditions and where could it occur?
- Are the quantities of explosive atmosphere which could as a result of the local and operating conditions occur potentially dangerous? A classification into zones is only necessary if this is the case (see section 3, p. 17).
- What effective ignition sources are present?

2.3 Technical measures

The explosion prevention protection measures which have been implemented as well as any process control measures which are necessary for safety should be documented.

Explosion prevention measures

The measures to prevent an explosion can include:

- Measures to avoid the formation of an explosive atmosphere (e.g. substitution) or to limit its extent (e.g. ventilation, closed systems, inerting).
- Measures to avoid effective ignition sources (e.g. procedures to exclude flames, discharges of static electricity and hot surfaces or to select appropriate electrical and mechanical equipment).

Explosion protection measures

Measures which can limit the effects of an explosion to an acceptable level include explosion venting, explosion-resistant design, explosion suppression where necessary in combination with explosion isolation (decoupling) measures.

2.4 Organizational measures

Training of employees

Employees should be informed and instructed at regular intervals on:

- working procedures
- hazards which may occur
- areas where explosive atmospheres may arise (see section 3, p. 17)
- explosion protection measures
- use of personal protective equipment
- use of mobile equipment (“permit to work”/“hot work” procedures)
- emergency measures

This training should be documented.

Coordination

The employer who is responsible for the site should coordinate the implementation of the safety measures and document the procedures used. He is responsible for:

- giving instructions to contractors
- instructing the staff of contractors
- coordinating the interaction of his own staff with the staff of external companies
- issuing work permits (e.g. hot work permit)
- controlling the working environment while the work is being performed

Testing, inspection

Workplaces in hazardous areas including plant, equipment and tools as well as the measures used for explosion prevention and protection should be tested as follows:

- prior to first use
- on a regular basis
- after maintenance work

Such testing and inspection must be carried out by persons who are competent in the field of explosion protection as a result of their experience or professional training.

Maintenance

The maintenance work (inspection, maintenance, repair) carried out both by site personnel and by contractors during normal and special operations should be documented.

2.5 Annexes

Details or cross references to other safety relevant documentation should be included in annexes. These may include:

- area classification report (method, type of zones, extent)
- cleaning and house keeping procedures and schedules
- test certificates for equipment
- work instructions
- training records and documentation
- permit to work procedures (hot work, etc.)
- drawings (building layout, installation plans, ventilation plans, escape routes etc.)
- EC certificate of conformity for the equipment used (where appropriate)
- operating instructions for use of the installed equipment
- fire protection procedures (emergency plans)

3 Area classification

3.1 Zone definitions[1)]

This procedure classifies places in which hazardous explosive atmospheres may occur into zones depending on the frequency and duration with which the explosive atmosphere occurs.
If the quantity of explosive atmosphere is so small that special precautions are not required then it is not considered hazardous and is not classified in terms of zones.

Gases, vapours or mists

Zone 0

A place in which an *explosive atmosphere*[2)] consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is present continuously or *for long periods* or *frequently*.

Zone 1

A place in which an *explosive atmosphere* consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is likely to occur in *normal operation occasionally*.

Zone 2

A place in which an *explosive atmosphere* consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is *not likely to occur* in *normal operation* but, if it does occur, will persist *for a short period only*.

Dusts

Zone 20

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

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

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*.

[1)] The zone definitions are taken from the European Directive 99/92/EC [1].
[2)] The terms in italics are explained in more detail in section 3.2, p. 18.

3.2 Explanatory notes on the terms used in the zone definitions

Normal operation

Means situations when an installation is used within its design parameters. Start-up, shut-down, sampling and cleaning operations are also considered as *normal operations*. Malfunctions which cause a shut-down or require repairs are not part of *normal operation*.

Explosive atmosphere

An *explosive atmosphere* is a mixture with air of flammable substances in the form of gases, vapours, mists or dusts in which, after ignition has occurred, combustion spreads to the entire unburned mixture. An *explosive atmosphere* only exists if the lower explosion limit (LEL) is exceeded and the upper explosion limit (UEL) is not reached. The LEL and UEL are substance-specific characteristics[1)], which are experimentally determined. For dusts the UEL is normally not determined.

Hazardous explosive atmosphere

An *explosive atmosphere* which may occur in such quantities as to require special precautions to protect the health and safety of the workers concerned is considered to be *hazardous*.
An *explosive atmosphere* which is not expected to occur in such quantities as to require special precautions is considered as *non-hazardous* and does not result in a zone.

Dust layers

Layers, deposits and heaps of combustible dust must be taken into account in the same manner as any other source which can form an explosive atmosphere (*cloud*).
Good housekeeping, i.e. the removal of dust deposits, is an important safety measure in implementing explosion prevention measures and is advantageous when considering the area classification [9].

Likelihood or probability

Which zone occurs depends on the duration and frequency of occurrence of the explosive atmosphere. The explosive atmosphere occurs with a certain likelihood or probability which is expressed as follows:

A: frequently or *for long periods:* the occurrence related to the effective operating time (e.g. in Germany > 50 %)

B: *not likely to occur* in normal operation or *for a short period only:* few times per year for say half an hour

C: *occasionally:* the occurrence and frequency between A and B

The explanations of these terms are given as starting points only and should not be considered as absolute values.

[1)] See ISSA brochure "Determination of the fire and explosion characteristics of dusts", ISSA No. 2018 (E)

3.3 Basic zoning considerations

Zone 0 and Zone 20 are only found in the inside of vessels, pipes, apparatus etc.

Zone 1 can include, among others:

- places in the close vicinity of Zone 0
- places in the close vicinity of filling and emptying openings
- places in the close vicinity of fragile equipment and components made of glass, ceramics and similar materials
- places in the close vicinity of stuffing boxes, e.g. on pumps and because stuffing boxes are not permanently sealed[1)]

Zone 2 can include, among others, places in the vicinity of Zone 0 or 1.

Zone 21 can include, among others, places in the immediate vicinity of powder sampling or charging/discharging stations. This also applies to places where dust layers occur and are likely in normal operation to give rise to an explosive concentration of combustible dust in mixture with air [7].

Zone 22 can also include places in the vicinity of equipment containing dust from which dust can escape in non-explosive concentrations and form dust deposits over a longer period of time. These could be dispersed to create hazardous dust/air mixtures for a short time period [7].

3.4 Practical examples

3.4.1 Floor over a silo complex

Figure 1 shows the floor over a silo complex which is cleaned so frequently that no hazardous dust deposits are formed. The yellow check marks can be clearly seen on the floor. Therefore this is classified as a non-hazardous area and no zone is specified.

[1)] In continental Europe, particularly Germany, Switzerland and Austria, the terms "auf Dauer technisch dicht" and "technisch dicht" are used to describe the degree of sealing in equipment, pipes and fittings.
"Auf Dauer technisch dicht" can be translated as *permanently sealed* or *leak free*. Equipment is *permanently sealed* when its design and technical construction is such that it always remains leak free (for example, completely welded or screwed fittings) or when it can be guaranteed to always remain leak free due to control or maintenance measures.
„Technisch dicht" can be translated as *technically sealed*. Equipment is classed as *technically sealed* when appropriate leak tests or controls, for example with foamy liquid or a leak-tester, do not show any leaks but where small leaks can not be completely ruled out.

Figure 1: Example of "good housekeeping" of the floor over a silo complex. Check marks are clearly visible, therefore non-hazardous area (no zone)

The housekeeping must be such that the check marks on the floor are always visible.

Figure 2 shows an example of Zone 22. Dust deposits are present which may at any time be dispersed such that the LEL is exceeded.

Figure 2: Example of poor cleaning of the floor over a silo complex. Check marks are not visible anymore, therefore Zone 22

3.4.2 Pneumatic conveying system

In a pneumatic conveying system with continuous bulk material transport the upper explosion limit (UEL) is normally exceeded (Figure 3). However start-up and shut-down conditions must also be considered when the dust concentration will be lower and will enter the explosive region. During this time an explosive atmosphere will be present. The inside of the system is therefore classified as Zone 21 or 22 depending on the frequency of the start-up or shut-down procedure.
When a sack is emptied through a funnel into a pneumatic conveying system, the LEL is exceeded occasionally in the area of the funnel and inside of the pneumatic conveying system; therefore Zone 21 is specified here.

Figure 3: Pneumatic conveying plant

3.4.3 Filling station for pneumatic conveying system

Figure 4 shows how dust deposits can be formed when a product is continuously fed to the inlet of a pneumatic conveying system. As the housekeeping is in this case insufficient to prevent the formation of dust deposits which could be swirled up into an explosive dust cloud, the area around the inlet is classified as Zone 22 (typically for a radius of 2 m around the filling station).
The production of a hazardous dust layer can be avoided if regular and efficient cleaning is carried out (e.g. during each shift or immediately after the dust deposit is formed). The area around the filling station can then be considered as non-hazardous i.e. no zone.

Figure 4: Inlet of a pneumatic conveying system

3.4.4 Wagon discharging into a chute

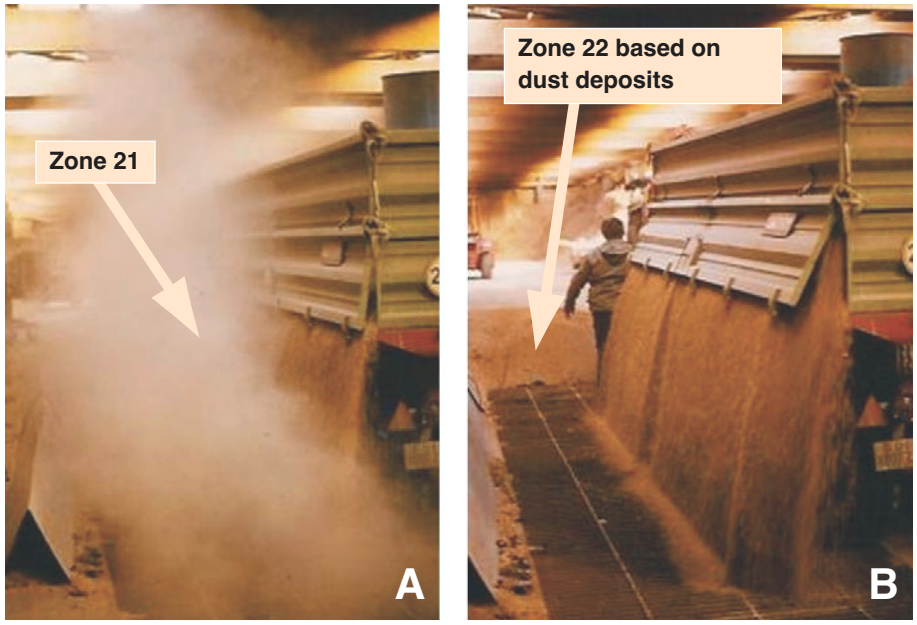


Figure 5: Discharge of corn from a truck

Figure 5 A / B shows the emptying of corn from a truck. Because no dust extraction system is present a Zone 21 is designated in the area between the truck and the top of the bunker (Figure 5 A).
The area in the vicinity of the grid over the bunker is classified as Zone 22 due to the dust deposits (Figure 5 B).

3.4.5 Filling of a silo truck via a conveying system

When a silo truck is filled with corn seed using an open conveyor belt as shown in Figure 6, the lower explosion limit is not exceeded except in the close vicinity of the discharge point. A zone is not allocated to the area beyond the discharge point provided that the area is cleaned each shift (elimination of dust deposits).

Zone 21 is allocated to the area directly at the discharge point.

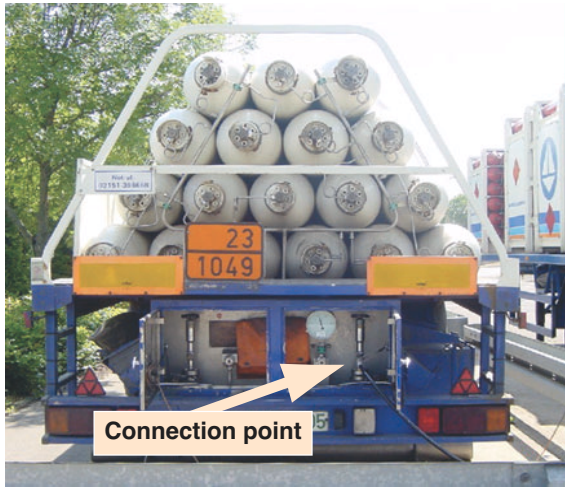
This and the previous (Figure 5) area classification example only apply to the handling of corn seed or other products with similar characteristics i.e. dust content, likelihood of forming dust clouds etc.

Figure 6: Filling of a silo truck with corn seed

3.4.6 Hydrogen storage

Figure 7 shows an outdoor hydrogen (H_2) discharge station. The gas supplier is responsible for connecting and disconnecting the H_2 trailer. The occurrence of an explosive atmosphere is limited because the equipment has been set up outdoors (natural ventilation) and because the density of the hydrogen gas is much lower than air. The correct positioning of the trailer is ensured by technical measures. The formation of an explosive atmosphere is therefore only expected in the case of a leak. The area around the discharge point extending to a height of 3 m above the connections is classified as Zone 2.

Figure 7:
Connection point of a H_2 trailer



3.4.7 Gas supply station

Figure 8:
Storage cabinet for gas cylinders

The metal cabinet (without forced ventilation) set up outdoors contains compressed hydrogen, helium and nitrogen gas cylinders supplying a production laboratory (Figure 8).
To ensure safe handling of the compressed gas cylinders for hydrogen the distribution point was set up in the outdoor area of the production plant.
The hydrogen gas cylinders are changed regularly so that the occurrence of an explosive atmosphere is expected occasionally. As the cabinet has no forced ventilation, the inside is classified as Zone 1 and a Zone 2 is specified for the area 1 m above the cabinet.

3.4.8 Storage for flammable liquids

Figure 9 shows a storage area for flammable liquids where a leak from the metal drums is not likely to occur.

In addition an effective ventilation system has been installed and therefore the storage area is classified as non-hazardous i.e. no zone. In the absence of the ventilation system the area would be classified as Zone 2.

Figure 9:
Storage for flammable liquids with forced ventilation

3.4.9 Petrol tank farm

The petrol storage tanks are all equipped with gas return pipes and with over- and under pressure relief valves on the tank roof (Figure 10). The product transfer pipe and the gas return pipes with their connection points are flanged and located within the retention basin of the tank farm. Since the occurrence of an explosive atmosphere on the tank roof, around the tank walls and inside the retention basin is to be expected rarely and only for a short period of time, these areas are classified as Zone 2. Climatic variations (pressure changes) with the resulting ingress of air could produce an explosive atmosphere inside the tanks over a longer period of time. Therefore the inside of the tanks is classified as Zone 0.

Figure 10:
Tank farm for storage of petrol

3.4.10 Filling of liquefied flammable gas bottles

Figure 11:
Carousel for filling liquefied gas bottles

Gas bottles are filled up with liquefied flammable gas (e.g. propane, butane) on a carousel (Figure 11).
During connection and disconnection of the filling arms to the bottles a small quantity of liquefied gas escapes, forming an explosive gas atmosphere. Local extraction is provided however, as no gas sensors are installed and since propane and butane are heavier than air, the lower part of the filling area up to a height of 1 m over the highest possible gas discharge position on the carousel is classified as Zone 1.

3.4.11 Paint spraying booth

Figure 12:
Paint spraying booth with forced ventilation

In a paint spraying booth work pieces are coated with an highly flammable lacquer paint (Figure 12). The spraying booth is equipped with forced ventilation which is interlocked with the paint spraying unit. The effectiveness of the ventilation is controlled by means of a flow detector in the exhaust air. The average flow rate of fresh air over the work pieces is 0.2 - 0.4 m/s. This provides 100 - 200 changes of air per hour within the paint spraying booth. Thus any explosive atmosphere which is formed is prevented from spreading and is rapidly diluted such that the formation of a hazardous explosive atmosphere can be excluded. For these reasons the inside of the booth is classified as non-hazardous i.e. no zone.

3.4.12 Charging of combustible powders into highly flammable solvents

Figure 13:
Blending unit with manual charging of powder

In a paint factory flammable liquids are charged into a blender and afterwards a combustible powder (the colour pigment) is charged from paper bags into the blender through the manhole (Figure 13). The inside of the blender is classified as a Zone 0. While charging the colour pigments into the blender, additionally a Zone 21 (hybrid mixture[1)]) is generated. As can be seen in Figure 13, the blender is provided with an effective ventilation (though without interlock). Therefore the immediate vicinity[2)] of the charging area is classified as Zone 1 and due to possible dust accumulations as Zone 22.

3.4.13 Charging of a combustible powder into a reactor containing flammable liquid under inert gas

Figure 14:
Charging of combustible powder into an inerted reactor

In a chemical production unit a combustible powder is discharged from bags through a charging system (charging hopper, screw feeder, charging pipe) into an inerted reactor containing a flammable solvent (Figure 14). Powder is charged into the hopper and passes from there through a screw feeder via a ball valve into the reactor. As the inerting procedure is only manually controlled and additionally

[1)] In hybrid mixtures the individual dust, gas or vapor concentration may be below their lower explosive limits (LEL) and on their own would not be explosive, however together they can form an explosive hybrid mixture.
[2)] The immediate vicinity of the charging area which should be classified depends on the rate of release of the flammable material and the efficiency of the extraction system.

since air will be introduced into the reactor during the charging of the powder, the inside of the reactor including the charging pipe up to the ball valve is classified as Zone 1. The inside of the reactor is also classified as a Zone 21 due to the dust cloud formed during charging of the combustible powder.

Since the solvent pipes are only connected with simple flanges (having a plain raised face without special sealing requirements), the complete production area in the region of the reactor, shown here, is classified as Zone 2. The inside of the powder charging system is classified as a Zone 21 due to occasional filling of the hopper with combustible powder. The charging station is fitted with an extraction system which prevents the formation of high dust concentrations in the work area. Thus only the immediate area around the charging station is classified as Zone 22.

3.4.14 Solvent drum storage area and dispensing station

Drums, filled with highly flammable solvents (e.g. Acetone, Nitro-thinners, Toluene) are stored on racks outside the production building (Figure 15). The solvents are dispensed using taps screwed onto the drums. This operation is carried out several times per day. Explosive atmospheres occur therefore occasionally in the close vicinity of the flammable drum storage area is classified as Zone 1.

Figure 15: Flammable drum storage area with dispensing station

3.4.15 Fermentation tank of a sewage treatment plant

“Biogas” (mainly Methane) is produced inside the fermentation tank by anaerobic oxidation. The tank is fitted with a pressure compensation valve which maintains a slight overpressure. Air cannot be sucked back into the tank and therefore there is no explosive atmosphere present during this stage of the process.

When the tank is filled with sewage for the first time, it is first completely filled with water and then the sewage is pumped into the tank. This displaces the water and ensures that no air is present in the tank at the start of the fermentation process. The atmosphere in the tank will therefore contain only the “biogas”. If it is certain that no ingress of air into the tank can occur, then the inside can be classified as non-hazardous. However, when the ingress of air cannot be definitely excluded, then the inside must be classified on the basis of the likelihood and duration that an explosive atmosphere will be present.

Outside the tank an explosive atmosphere could be formed above the tank roof due to leakage from valves, flanges and other equipment which are installed in this area. This region, which should extend several meters above the highest leakage point is therefore classified as Zone 2.

Figure 16: Two fermentation tanks with integrated gasometers[1)]

[1)] The “biogas” is stored in a gasometer with floating roof above the sewage tank.

3.4.16 Area classification drawing for an external storage tank containing highly flammable liquid

Figure 17 shows an area classification drawing of zones for a storage tank filled with a highly flammable liquid (e.g. petrol). The tank is fitted with a pressure compensation valve which relieves to the open. An explosive atmosphere can therefore occasionally be produced in the vicinity of this valve and a region with a diameter of 3 m is classified as Zone 1. As the flammable liquid vapours are heavier than air, an explosive atmosphere could be formed for a short period around the tank. A Zone 2 is therefore specified for this region which should extend for approximately 3 m along the ground. As the flammable atmosphere could accumulate in the pit, this is classified as Zone 1. Inside the tank an explosive atmosphere is present continuously and the complete inside of the storage tank is classified as Zone 0.

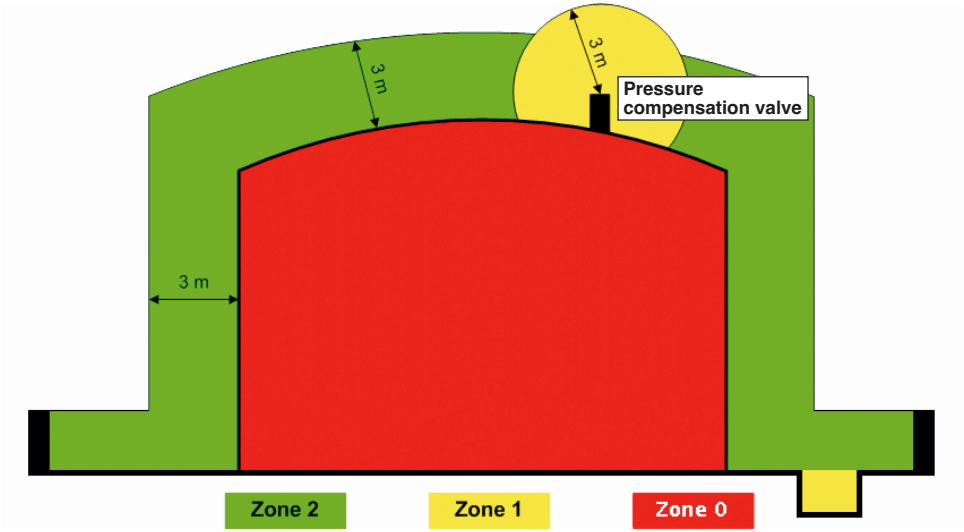


Figure 17: Area classification drawing for an external storage tank with a fixed roof containing highly flammable liquid [10]

4 Requirements for equipment and protective systems

In general, equipment, components and protective systems for use in potentially explosive atmospheres should comply with the essential safety and health requirements of the European Directive 94/9/EC (ATEX 95) [2]. (Equipment which does not have its own source of ignition is excluded from this directive.)
In accordance with this directive, equipment and protective systems are classified into different categories. The categories reflect the safety requirements for use in the specific zones.

Which equipment can be used in which zone is shown in the following table [2], [5].

Equipment category	Use in zone	Equipment marking[1)]	Required documentation
1 G	0, 1, 2	CE 9999 Ex II 1 G	EC type-examination certificate, certificate of conformity of the manufacturer, instructions for use
2 G	1, 2	CE 9999 Ex II 2 G	electrical equipment: EC type-examination certificate, certificate of conformity of the manufacturer, instructions for use
2 G	1, 2	CE Ex II 2 G	non-electrical equipment: certificate of conformity of the manufacturer, instructions for use
3 G	2	CE Ex II 3 G	certificate of conformity of the manufacturer, instructions for use
1 D	20, 21, 22	CE 9999 Ex II 1 D	EC type-examination certificate, certificate of conformity of the manufacturer, instructions for use
2 D	21, 22	CE 9999 Ex II 2 D	electrical equipment: EC type-examination certificate, certificate of conformity of the manufacturer, instructions for use
2 D	21, 22	CE Ex II 2 D	non-electrical equipment: certificate of conformity of the manufacturer, instructions for use
3 D	22	CE Ex II 3 D	certificate of conformity of the manufacturer, instructions for use

[1)] 9999 - identification number of the notified test body

Category 1 equipment fulfils the highest requirements. Only equipment this category together with electrical equipment of category 2 and protective systems have to undergo an EC type-examination.
All equipment, however, must be accompanied by an EC certificate of conformity from the manufacturer. Prior to putting the equipment into operation, the operator has to make sure that the “intended use” specified by the manufacturer is applicable to his particular situation.

Other classification criteria must also be taken into account, e.g. temperature class, ignition protection type, explosion group.

If equipment of the appropriate category cannot be used (for example none is available), other equipment for example of a lower category or unclassified may be used provided an additional risk assessment has been carried out to demonstrate its suitability. The results of this risk assessment and any additional measures which must be implemented must also be recorded in the explosion protection document.

4.1 Existing equipment

Equipment which was selected and installed on the basis of previous national or international regulations and guidance can continue to be used provided it complied with the previous requirements. The reasons why it was selected and is safe for its use should be documented. If necessary a risk assessment should be carried out to justify the continued use of the equipment.

Equipment which has been placed on the market before 1 July 2003 does not require marking according to Directive 94/9/EC [2].

The requirement that employers prepare a risk assessment was already specified in the framework Directive 89/391/EEC [3] on the safety and health of workers at work.

5 Terms and definitions

The important terms and definitions related to explosion protection are summarised below.

Effective ignition source [1)]

Potential ignition source which will ignite the explosive atmosphere unless specific safety measures to avoid this are taken. The probability of becoming effective depends on the equipment category (they may arise in normal operation, expected malfunction, rare malfunction).
➯ EN 13463-1 [8]

Note: Not every ignition source can ignite all explosive atmospheres. This depends, amongst others, on the energy of the ignition source and the characteristics of the explosive atmopshere.

Employee (worker)

Any person employed by an employer, including trainees and apprentices but excluding domestic servants.
➯ Directive 89/391/EEC [3]

Employer

Any natural or legal person who has an employment relationship with the worker and has responsibility for the undertaking and/or establishment.
➯ Directive 89/391/EEC [3]

[1)] In the revised EN13463-1 that will be published in autumn 2006 the definition *effective ignition source* will be replaced by three new definitions. At the present state they are defined as:

Possible ignition source
Any ignition source listed in EN 1127-1

Note: Not all possible ignition sources will occur in a piece of equipment.

Equipment related ignition source
Any possible ignition source, which is generated by a piece of equipment regardless of its ignition capability

Note: These are sometimes called „relevant ignition sources“, however this can lead to misunderstanding as to whether the ignition source is relevant in terms of it being present, in terms of its ignition capability or in terms of whether it is generated by the equipment or not.

Potential ignition source
Equipment related ignition source which has the capability to ignite an explosive atmosphere (i.e. to become an effective ignition source)

Note: The probability of becoming effective determines the equipment category (they may arise in normal operation, expected malfunction, rare malfunction).

Equipment

Equipment means machines, apparatus, fixed or mobile devices, control components and instrumentation thereof and detection or prevention systems which, separately or jointly, are intended for the generation, transfer, storage, measurement, control and conversion of energy and/or the processing of material and which are capable of causing an explosion through their own potential sources of ignition.
➫ Directive 94/9/EC [2], EN 13463-1 [8]

Equipment category

Within an equipment group a category is the classification according to the required level of protection and marked accordingly.
➫ Directive 94/9/EC [2], EN 13463-1 [8], EN 13237 [11]

Explosion

Abrupt oxidation or decomposition reaction producing an increase in temperature, pressure or in both simultaneously.
➫ EN 1127-1 [7], EN 13237 [11]

Explosion range

Range of the concentration of a flammable substance in air within which an explosion can occur.
➫ EN 1127-1 [7], EN 13237 [11]

Explosive atmosphere

Mixture with air, under atmospheric conditions, of flammable substances in the form of gases, vapours, mists or dusts in which, after ignition has occurred, combustion spreads to the entire unburned mixture.
➫ Directive 1999/92/EC [1], EN 13237 [11]

Flammable substance

Substance in the form of gas, vapour, liquid, solid or mixtures of these, able to undergo an exothermic reaction with air when ignited.
➫ EN 13237 [11]

Note: Each combustible dust can be explosive.

Hazardous Area Classification (classification of hazardous places)

Classification of hazardous places are classified in terms of zones on the basis of the frequency and duration of the occurrence of an explosive atmosphere.
➫ Directive 1999/92/EC [1]

Hazardous explosive atmosphere

An explosive atmosphere which, if it explodes, causes damage.
➫ EN 1127-1 [7]

Hazardous place (due to explosive atmospheres)

A place in which an explosive atmosphere may occur in such quantities as to require special precautions to protect the health and safety of the workers concerned is deemed to be hazardous.
A place in which an explosive atmosphere is not expected to occur in such quantities as to require special precautions is deemed to be non-hazardous.
➫ Directive 1999/92/EC [1]

Intended use

The use of equipment, protective systems and devices in accordance with the equipment group and category and with all the information supplied by the manufacturer which is required for the safe functioning of equipment, protective systems and devices.
➫ Directive 94/9/EC [2], EN 1127-1 [7], ATEX guidelines [5]

Lower explosion limit

Lower limit of the explosion range.
➫ EN 13237 [11]

Upper explosion limit

Upper limit of the explosion range.
➫ EN 13237 [11]

Use of work equipment

Any activity involving work equipment such as starting or stopping the equipment, its use, transport, repair, modification, maintenance and servicing, including, in particular, cleaning.
➫ Directive 89/655/EEC [4]

Work equipment

Any machine, apparatus, tool or installation used at work, e.g. kneading machine, spatula, knife, pen, measuring device.
➫ Directive 89/655/EEC [4]

Worker

See employee
➫ Directive 89/391/EEC [3]

6 Literature

European directives and guidelines

[1] Directive 1999/92/EC of the European Parliament and of the Council of 16 December 1999 on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres (15th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC) (OJ L 23, 28/01/2000 P. 57), last amended on 7 June 2000 (OJ L 134, 07/06/2000 p. 36)

[2] Directive 94/9/EC of the European Parliament and the Council of 23 March 1994 on the approximation of the laws of the Member States concerning equipment and protective systems intended for use in potentially explosive atmospheres (OJ L 100, 19/04/1994 P. 1), last amended on 26 January 2000 (OJ L 21, 26/01/2000 p. 42)

[3] Directive 89/391/EEC of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work (OJ L 183, 29/06/1989 p. 1)

[4] Directive 89/655/EEC of the Council of 30 November 1989 concerning the minimum safety and health requirements for the use of work equipment by workers at work (second individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC) (OJ L 393, 30/12/1989 p. 13)

[5] ATEX guidelines. Guidelines on the application of Council Directive 94/9/EC of 23 March 1994 on the approximation of the laws of the Member States concerning equipment and protective systems intended for use in potentially explosive atmospheres, July 2005 (published by the European Commission, 2005)[1)]

[6] Non-binding guide of good practice for implementing Directive 1999/92/EC (published by the European Commission, 2003)

[1)] http://europa.eu.int/comm/enterprise/atex/guide

Standards

[7] EN 1127-1, Explosive atmospheres - Explosion prevention and protection - Part 1: Basic concepts and methodology, October 1997

[8] EN 13463-1, Non-electrical equipment for potentially explosive atmospheres - Part 1: Basic method and requirements, November 2001

[9] EN 61241-10, 2005-04, Electrical apparatus for use in the presence of combustible dust - Part 10: Classification of areas where combustible dusts are or may be present (IEC 61241-10:2004)

[10] EN 60079-10, 2003-08, Electrical apparatus for explosive gas atmospheres - Part 10: Classification of hazardous areas (IEC 60079-10:2002)

[11] EN 13237, 2003-06, Potentially explosive atmospheres - Terms and definitions for equipment and protective systems intended for use in potentially explosive atmospheres

7 Picture credits

Acima AG a Rohm and Haas Company, 9470 Buchs SG, Switzerland

ARA Region Lyss, 3250 Lyss, Switzerland

AZO GmbH, 74706 Osterburken, Germany

Ciba Spezialitätenchemie AG, 4002 Basel, Switzerland

Clariant (Schweiz) AG, 4132 Muttenz, Switzerland

Esso Schweiz GmbH, 8021 Zurich, Switzerland

NEUHOF HAFENGESELLSCHAFT mbH, 21107 Hamburg, Germany

Osterwalder Tanklager AG, 9013 St. Gallen, Switzerland

SICPA-AARBERG S. A. Prilly, 3282 Bargen, Switzerland

8 ISSA publications on explosion protection

ISSA Section for Machine and System Safety
'Dust Explosions' Working Group

Dust Explosion Prevention and Protection for Machines and Equipment

- Basic Principles (Engl./Ger.) (2004)
- Examples (Engl./Ger./Fr.) (1990)

Explosion Suppression (Engl./Ger./Fr.) (1990)

Determination of the Combustion and Explosion Characteristics of Dusts (Engl./Ger.) (1995)

Explosion Protection Document (Engl./Ger./It.) (2006)

Explosion Isolation (Engl./Ger.) (in preparation)

Address for orders: ISSA Machine and System Safety Section
Dynamostrasse 7-11
68165 MANNHEIM
GERMANY

ISSA Section for the Chemical Industry
'Explosion Protection' Working Group

Safety of Liquid Gas (Propane and Butane) (Engl./Ger./Fr./It./Span.) (1992)

Static Electricity - Ignition hazards and protection measures (Engl./Ger./Fr./It.) (1996)

Protection against explosions due to mixtures of flammable gases, vapors, or mists with air (Engl./Ger./It.) (2002)

Dust Explosions (Engl./Ger./It.) (2003)

Dust Explosion Incidents: Their Causes, Effects and Prevention (Engl./Ger.) (2005)

Ignition Sources (Engl./Ger.) (in preparation)

Address for orders: ISSA Chemistry Section
Kurfürsten Anlage 62
69115 HEIDELBERG
GERMANY

Notes

THE ISSA AND THE PREVENTION OF OCCUPATIONAL ACCIDENTS AND DISEASES

The ISSA Special Commission on Prevention brings together occupational safety specialists from all over the world. It promotes international cooperation in this field and undertakes special studies on subjects such as the role of the press, radio and television in occupational safety and integral strategies for the workplace, road traffic and the home. It also coordinates the activities of eight international sections for the prevention of occupational risks, which are active in various industries and in agriculture and which have their secretariats in different countries. Three further sections are concerned with information technology in the field of occupational safety, with relevant research and with education and training for the prevention of occupational accidents and diseases.

The activities of the international sections of the ISSA comprise:

- the international exchange of information between bodies concerned with the prevention of occupational risks
- the organization of meetings of committees and working groups, round-table discussions and colloquia at international level
- the performance of surveys and studies
- the promotion of research
- the publication of relevant information.

Further information relating to these activities and the general work of the ISSA in the field of occupational safety can be found in the leaflet ‘Safety for Everyone’. It is available in English, German, French and Spanish from the office of the general secretariat in Geneva.

MEMBERSHIP OF THE INTERNATIONAL SECTIONS

Each international section of the ISSA has three categories of members:

- Full Member

  Full members and associate members of the ISSA, Geneva, and other nonprofit organizations can apply for membership as a Full Member.
- Associate Member

  Other organizations and companies can become Associate Members of a section if they have specialized knowledge of the area for which the section is responsible.
- Corresponding Member

  Individual experts can become Corresponding Members of a section.

Further information and application forms are available directly from the secretariats of the individual sections.