Safety Guideline SG-C-2-0-1

EXPLOSION PROTECTION MEASURES

Abstract
This Safety Guideline is intended for use with all activities which involve flammable substances and which may give rise to explosive atmospheres and so explosion hazards. It provides practical advice for the implementation of protection measures.

DOCUMENTATION

Reference documents:
[5] Safety Form SF-C-2-0-2, Classification of hazardous areas (EDMS No. 1113456).

Further reading:
- Explosive atmospheres, Explosion protection and prevention, Part 1 – Basic concepts and methodology, EN 1127-1, August 2011.
- CENELEC Report R-044-001 “Guidance and recommendations for the avoidance of hazards due to static electricity”.
- Full flammability test of gases and gas mixtures in air, an industrial training report from CERN, S. Besnard, 1996.

TRACEABILITY

Reference No.: Safety Guideline SG-C-2-0-1
EDMS No.: 1097065 ver. 7

Prepared by: J. Gulley, HSE/SEE
Date: 12/06/2017

Verified by: F. Angerand, HSE/SEE
Date: 12/06/2017

Approved by: E. Cennini, HSE/SEE
Date: 14/06/2017


<table>
<thead>
<tr>
<th>Rev. No.</th>
<th>Date</th>
<th>Description of Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>16/09/2013</td>
<td>Chapter 2.4 – local audible alarm (siren) no longer generated on Alarm Level 2. See Engineering Change Request (EDMS no. 1292095).</td>
</tr>
<tr>
<td>7</td>
<td>14/06/2017</td>
<td>Chapter 6.3 – Details added of the two training courses available. Update of regulatory context.</td>
</tr>
</tbody>
</table>
1 INTRODUCTION

This Safety Guideline is intended for use with all activities which involve flammable substances and which may give rise to explosive atmospheres and so explosion hazards. It provides practical advice for the implementation of protection measures.

A risk assessment must be made, using the Safety Form SF-C-2-0-1, Explosion risk assessment [4], where flammable substances are present or are used at the workplace.

N.B.: This Safety Guideline does not deal with explosive atmospheres formed by combustible dusts. For this specialized subject, external expert advice must always be sought.

2 EXPLOSION PROTECTION MEASURES

2.1 Limiting of concentration

Gases and vapours are only explosive within certain limits of concentration in air: the Lower Flammable Limit or Lower Explosion Limit (LFL or LEL) and the Upper Flammable Limit or Upper Explosion Limit (UFL or UEL). Under certain operating and ambient conditions, it is possible to remain outside these explosion limits.

Example: In a closed container, the concentration above a flammable liquid can be guaranteed to remain below the Lower Explosion Limit (LEL) if the temperature at the surface of the liquid is kept below the flash point (e.g. 5°C below for pure solvents and 15°C below for mixtures).

2.2 Inerting

A hazardous explosive atmosphere can also be prevented by diluting the flammable substance or the atmospheric oxygen inside plant with an inert gas. This is known as "inerting" and is generally only practical for enclosed plant or vessels. The maximum allowed oxygen concentration inside the vessel must be well below the Limiting Oxygen Concentration (LOC), defined as the concentration of oxygen below which combustion is not possible, independent of the concentration of the flammable substance. The LOC varies with pressure and temperature. It is also dependent on the type of inert gas used.

2.3 Ventilation

Ventilation may be natural or artificial (mechanical). Depending on the degree and availability of the ventilation a reduction in the extent and duration of the hazardous area (ATEX zone) can be achieved. For more information refer to Safety Guideline SG-C-2-0-3, Classification of hazardous areas [3], that accompanies the Safety Form C-2-0-2, Classification of hazardous areas [5].

2.4 Flammable gas/vapour detection

Gas or vapour concentrations in the vicinity of equipment or experiments can be monitored, and alarms generated at suitable concentrations. When installing such devices the essential points are as follows:

- The substances likely to be present, leak sources, leak rates and dispersion conditions must be determined.
- The number and location of measuring points must be carefully chosen so that mixtures can be detected as quickly as possible (e.g. in general, for flammable gases or vapours denser than air locate gas detectors at a point below the leak source, for gases or vapours lighter than air locate gas detectors at a point above the leak source).
- The instrument performance must be appropriate for the required use (e.g. response time, alarm level and the cross sensitivity to other gases that might be present).
The following alarm levels for flammable gases should be used, with the associated actions as listed:

**Alarm Level 2 at 10% LEL:**
- local visual alarm (flashing light),
- transmit alarm to the CERN Control Centre (CCC).

**Alarm Level 3 at 20% LEL (in addition to the above):**
- local audible alarm (siren),
- cut off electrical power in the ATEX hazardous area (not protective systems),
- shut off the supply of flammable gas,
- switch on or increase the ventilation speed,
- transmit alarm to the CERN Fire Brigade (SCR).

**N.B.:** Other alarm levels may be set (e.g. based on the UEL) if deemed necessary by the risk assessment. Careful consideration must be given to alarm levels where two or more gases with different LELs are being used.

(CERN Service for installation, maintenance and calibration of fixed and portable gas detectors: N.M. Broca, tel: 79269, Nicolas.Michel.Broca@cern.ch)

### 2.5 Avoidance of ignition sources

If it is not possible to prevent the formation of a hazardous explosive atmosphere, its ignition must be avoided. The risk assessment should identify places at the workplace where ignition sources may arise in the presence of flammable atmospheres and cause a fire or explosion. The risk assessment should also consider how likely it is that the particular ignition source will ignite the flammable substance. Standard EN 1127-1 distinguishes 13 types of ignition sources:

- **hot surfaces;**
  
  **Attention:** heating systems, electrical equipment, hot pipes...

- **flames and hot gases;**
  
  **Naked flames from welding and smoking must be prevented by organisational measures.**

- **mechanically generated sparks;**
  
  **Attention:** grinding operations.
Choose suitable materials (e.g. for fans), use non-sparking tools.

- electrical apparatus;

  Electric equipment used in hazardous areas must comply with Annex II of Directive 1999/92/EC.

  New electrical equipment must be selected on the basis of the categories described in Directive 2014/34/EU.

  (An electrical inspection of equipment is required before the start of work: mailto: Electrical-Verifications.Service@cern.ch).

- stray electrical currents, cathodic corrosion protection;
- static electricity;

  Always earth conductive objects as well as installations and bond together when necessary (e.g. when transferring flammable liquid from one container to another).

  Where necessary:
  - wear approved anti-static clothing (e.g. conducting footwear and anti-static garment),
  - install flooring with anti-static properties.

- lightning;
- electromagnetic fields in the frequency range from 9 kHz to 300 GHz;
- electromagnetic radiation in the frequency range from 300 GHz to 3 x 106 GHz or wavelength range from 1000 µm to 0.1 µm (optical spectrum);
- ionising radiation;
- ultrasonics;
- adiabatic compression, shock waves, gas flows;
- chemical reactions.

3 MITIGATION MEASURES

When it is not possible to avoid having an explosive atmosphere and sources of ignition present at the same time, measures must be taken to limit the consequences of an explosion. Examples of mitigation measures are:

- **Explosion resistant equipment** – containers, vessels, piping must be constructed to withstand an internal explosion;
- **Explosion relief** – only tested relief devices which comply with Directive 94/9/EC should be used (e.g. bursting discs);

  (CERN contact for testing pressure relief devices: mailto: Valves-Verifications.Service@cern.ch).

  Explosion relief should not be used for toxic substances.
  Pressure must be vented in a safe direction.

- **Explosion suppression systems** – prevent maximum explosion overpressures by injecting extinguishing agents;
- **Preventi on of explosion propagation (explosion decoupling)** – e.g. use of flame arrestors, rapid-action mechanical isolation.
4 PROCESS CONTROL ENGINEERING (PCE)

PCE devices can be used to monitor, control and even switch off potential ignition sources (e.g. hot surfaces) when a safe value is exceeded. The design of such PCE devices and their actions depend on the probability of occurrence of a hazardous explosive atmosphere and the likelihood that the ignition source present will ignite the explosive atmosphere.

Table 1- Use of PCE devices to reduce the probability of effective ignition sources

<table>
<thead>
<tr>
<th>ATEX zone</th>
<th>Occurrence of ignition sources</th>
<th>Requirements for PCE devices</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>Operationally necessary</td>
<td>None</td>
</tr>
<tr>
<td>Zone 2</td>
<td>Operationally necessary</td>
<td>Suitable single device for avoiding ignition sources</td>
</tr>
<tr>
<td></td>
<td>Unlikely in normal operation</td>
<td>None</td>
</tr>
<tr>
<td>Zone 1</td>
<td>Operationally necessary</td>
<td>Two suitable devices for avoiding ignition sources (*)</td>
</tr>
<tr>
<td></td>
<td>Unlikely in normal operation</td>
<td>Suitable single device for avoiding ignition sources</td>
</tr>
<tr>
<td></td>
<td>Unlikely in normal operation or in the event of malfunction</td>
<td>None</td>
</tr>
<tr>
<td>Zone 0</td>
<td>Unlikely in normal operation</td>
<td>Two suitable devices for avoiding ignition sources</td>
</tr>
<tr>
<td></td>
<td>Unlikely in normal operation or in the event of malfunction</td>
<td>Suitable single device for avoiding ignition sources (*)</td>
</tr>
<tr>
<td></td>
<td>Unlikely in normal operation, in the event of rare malfunctions</td>
<td>None</td>
</tr>
</tbody>
</table>

(*) Or an equivalent device tested in accordance with Directive 2014/34/EU.

5 WORK EQUIPMENT

Work equipment and all installation materials must be suitable for their use in a defined ATEX zone. The work equipment must be so assembled, installed and operated that it cannot cause an explosion.

6 ORGANISATIONAL MEASURES

Organisational measures must be taken where technical measures alone cannot ensure and maintain fire and explosion protection. Arrangements must be made for inspection, servicing and repair to ensure that technical measures remain operational.

6.1 Operating instructions

These are binding instructions issued in writing. They should describe what explosion hazards exist and where, what mobile equipment may be used and whether special personal protective equipment must be worn. They must be written in a CERN official language.

6.2 Worker competence

A sufficient number of workers should be available with the relevant experience and training to perform the tasks assigned to them, including a good knowledge of one of the official languages.
6.3 Training of workers

Workers must receive training which explains how the explosion hazard arises and where it is present at the workplace. They must be told what personal protective equipment they must wear and the meaning of any marking of hazardous areas. Any applicable operating instructions must be covered in the training.

There are two relevant training courses available in the CERN Training Catalogue:

"Habilitation ATEX Niveau 1 / Explosive Atmosphere level 1" - Course code 077900.
This level 1 course is aimed at workers, who in the course of their duties need to install equipment or carry out maintenance or other works in a declared ATEX zone/hazardous area where there is a risk of explosion. It covers the identification of ATEX Zones, the types of equipment which can be used and the rules to respect when working in an ATEX Zone.

"Habilitation ATEX Niveau 2 / Explosive Atmosphere level 2" - Course code 077910.
This level 2 course is aimed at personnel with responsibilities for the management, design, installation and/or maintenance of facilities having the potential to generate explosive atmospheres. At CERN it is obligatory for Flammable Gas Safety Officers (FGSOs) to follow this course and any other person who is responsible for carrying out the classification of hazardous areas in their departments.

For further information or for specific training requests, please contact the Safety Training Team safety.training@cern.ch.

6.4 Authorisation of works

Before any work that is liable to cause an explosion (e.g. “hot” work as described in the Fire Protection Code, E) is performed outside of normally authorized areas (workshops etc.) it must be authorised using IMPACT. Special provisions may be required if the work will be carried out in or near to a defined hazardous area.

6.5 Maintenance

Maintenance work comprises repair, servicing and inspection.

During servicing, items of equipment or plant which could cause an explosion if inadvertently switched on during the work must be mechanically and/or electrically isolated as appropriate.

As a general rule, work involving a risk of ignition must not be carried out inside an ATEX Zone 0 or Zone 1 without first ensuring that the zone will be free of hazardous explosive atmospheres for the duration of the work. Except in exceptional circumstances, when other appropriate and adequate precautions have been taken, the items of equipment on which work is to be carried out must as necessary be emptied, depressurised, cleaned, purged and must be free of flammable substances.

Work involving a risk of ignition may be carried out inside an ATEX Zone 2 provided that compensatory measures are put in place (e.g. suitable protective clothing, permanent measurement of the flammable gas concentration with immediate stoppage of the work at a concentration of ≥ 25% LEL).
6.6 Authorization

The first use, or use following a change in the risk of a workplace containing hazardous areas shall be subject to authorization by the HSE Unit. Some of the changes that might result in a change in the risk are as follows:

- introducing new equipment;
- use of a different gas or gas mixtures;
- changes to the type or extent of the ATEX zone.

Authorization shall be granted if the overall explosion safety has been verified by the HSE Unit or by an external person whose competence in the field of explosion protection is recognized by the HSE Unit.

The effectiveness of the explosion protection measures taken must then be checked at regular intervals by the organic unit concerned.

6.7 Marking of hazardous areas

Such marking is required at the points of entry to rooms or areas in which a hazardous explosive atmosphere may arise. In practice a physical barrier should be created around an ATEX zone (e.g. a caged area for experimental test zones) where the marking can be displayed. As a minimum, for temporary installations, a plastic chain may be used to delimit an area. Equipment which is fully protected by mitigation measures need not be marked. If the ATEX zone is not the whole area concerned, but only part of it, that part may be marked by yellow/black diagonal stripes (e.g. painted on the floor).

Other details may be added to the warning sign (e.g. indicating the type of flammable substance and zone) as well as placing other warning signs, such as forbidding smoking.