FLAMEPROOF EQUIPMENT IN HAZARDOUS LOCATIONS

By

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SA Explosion Prevention

1 Introduction
In general the principles of explosion prevention revolves around the so-called fire triangle.
This principle requires three elements to be present for an explosion to occur.
These elements are:

- A flammable substance
- Oxygen
- An ignition source

Flammable substance may be gases, vapours and dusts.
Oxygen is present in normal air (20.9%)
Ignition sources are:
- arcs (electrical)
- sparks (mechanical)
- hot surfaces
Flameproofing does not rely on the principles of the fire triangle. It does allow an explosion to occur, however it limits the extend of the explosion to the inside of the enclosure.

2 Requirements of Flameproof Equipment
All flameproof equipment requires an enclosure.
This enclosure has three major requirements:

- It must be strong enough to withstand an internal chemical(gas) explosion.
- It must have well defined flamepaths.
- The external surface temperature must be limited.

2.1 Strength of the enclosure
The enclosure must be strong enough to withstand an internal gas (chemical) explosion.
Flameproof enclosures are not designed to withstand electrical explosions. Clearances and insulation levels must consequently be complied with.
There is no restriction on the thickness of the enclosure from a strength point of view.
The enclosure does not need to be made from metal. Some flameproof enclosures may be made from plastic material (limitation on internal volume). However, certain light alloys are not permitted.
Fasteners play an important role in the strength of flameproof enclosures.
Adequacy of strength is determined by explosion tests and overpressure test.

2.2 Flamepaths
The purpose of the flamepath is to cool the hot escaping exploding gas in order not to ignite the surrounding explosive atmosphere.
Well defined flamepaths consists of a length and a gap.
The following types of flamepaths (joints) are popular:
   Flanged
   Spigot
   Cylindrical
   Threaded
   Cemented joints

The lengths and gaps of flamepaths depend on the specific gas it is to be used in. Gases are grouped together in four different groups, i.e., Groups I, IIA, IIB and IIC.

The grouping for flamepaths is done according to the maximum experimental safe gap. For a specific flamepath length, the gap will decrease as one moves from Group I to Group IIA to IIB and to IIC. For a specific gas, the flamepath (length and gap) will also vary depending on the volume of the enclosure. However, for a specific gas and a fixed volume, the flamepath length can be increased or decreased by decreasing or increasing the gap. The gap requirements can be found in Tables 1 and 2 of SANS IEC 60079-1.

Extract from Table 1 and 2 of SANS IEC 60079-1

<table>
<thead>
<tr>
<th>Type of joint</th>
<th>Width of joint (mm)</th>
<th>Minimum gap (mm) for volume &gt;2000cc</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Gr I</td>
</tr>
<tr>
<td>Flanged</td>
<td>&gt;25</td>
<td>0,5</td>
</tr>
<tr>
<td>Cylindrical *</td>
<td>&gt;12,5</td>
<td>0,6</td>
</tr>
<tr>
<td>Cylindrical *</td>
<td>&gt;40</td>
<td>0,8</td>
</tr>
</tbody>
</table>

* The gaps for cylindrical joints are diametral gaps (not radial gaps!)

From the above table one can see that if a gap is suitable for Gr IIC, then it will be suitable for Gr IIB and for Gr IIA and for Gr I. However, a flamepath that is suitable for Gr I will not be suitable for Gr IIA, or IIB and definitely not for Gr IIC.

For volumes greater than 500 cc, flanged joints are not allowed for enclosures to be used in acetylene. The finishing on flamepaths shall be better than 6,3 µm. Flamepaths may not be painted, but it shall be protected against corrosion by the application of oil or a thin grease.

Flamepaths may be interrupted by holes (for fasteners) or by grooves (for O-rings), or by a chamfer (in the case of spigot joints), however strict rules exist for such interruptions which may drastically affect the flamepath length.

Threaded joints have the following requirement:
   Pitch ≥ 0,7 mm
   Depth of engagement ≥ 5 mm for V < 100 cc
                           ≥ 8 mm for V > 100 cc
   Number of threads engaged ≥ 8 for cable glands
                           ≥ 5 in all other cases.

The adequacy of flamepaths is determined by explosion (flame transmission) tests.

### 2.3 Surface temperature

It is a physical property of each gas that it has a minimum ignition temperature. Below this temperature the gas will not ignite. The ignition temperatures of the gasses are grouped into certain categories or Temperature Classes as follows:

<table>
<thead>
<tr>
<th>Temperature class</th>
<th>T6</th>
<th>T5</th>
<th>T4</th>
<th>T3</th>
<th>T2</th>
<th>T1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min. Ignition Temp. of gas (ºC)</td>
<td>&gt;85</td>
<td>&gt;100</td>
<td>&gt;135</td>
<td>&gt;200</td>
<td>&gt;300</td>
<td>&gt;450</td>
</tr>
</tbody>
</table>

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Temperature classes are only applicable for gas group II. The limiting temperature for gas group I is determined by the ignition temperature of the coal dust (150º) or the ignition temperature of methane gas if the equipment is protected against dust layers.

The maximum surface temperature of the flameproof apparatus shall be less than the ignition temperature of the hazardous environment in which it is intended to be used.

The external surface temperature is determined by load tests of the internal components under extreme power conditions.

An empty (flameproof) enclosure has no temperature class.

### 3 Differences between Group I and Group II Flameproof Enclosures

Apart from the different flamepath requirements there are other significant differences between Gr I and Gr II flameproof equipment. These are:

<table>
<thead>
<tr>
<th></th>
<th>Gr I (Zone 1) note 1</th>
<th>Gr II (Zone 1) note 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. surface temp.</td>
<td>150ºC</td>
<td>T6 to T1</td>
</tr>
<tr>
<td>Aluminium content</td>
<td>&lt; 15% note 2</td>
<td>No limitation note 3</td>
</tr>
<tr>
<td>Magnesium content</td>
<td>&lt; 7.5% (previously 6%)</td>
<td>&lt; 7.5%</td>
</tr>
<tr>
<td>Zirconium content</td>
<td>&lt; 7.5%</td>
<td>No limitation</td>
</tr>
<tr>
<td>Zink content</td>
<td>&lt; 80%</td>
<td>&lt; 80%</td>
</tr>
<tr>
<td>Isolation of internal conductors</td>
<td>Required</td>
<td>Not specifically required</td>
</tr>
<tr>
<td>Protection of bolt heads/nuts</td>
<td>Shrouded or counter bored</td>
<td>No requirement</td>
</tr>
<tr>
<td>Use of conduit</td>
<td>Not allowed</td>
<td>Allowed</td>
</tr>
<tr>
<td>Empty enclosures</td>
<td>Ratio L:W &lt; 4:1</td>
<td>Ratio L:W &lt; 2:1</td>
</tr>
</tbody>
</table>

Note 1: Group I is NOT under ground. Gr I is fiery mine (Methane with coal dust)

Group I equipment may not be suitable for hard rock mines.

Note 2: Mining regulations prohibit the use of unprotected aluminium.

Note 3: For Zone 0, Aluminium content <10%

### 4 Fasteners for flameproof equipment

The following basic rules apply to fasteners for flameproof equipment:

- Fasteners accessible from the outside and necessary for the assembly of the enclosure shall for: Group I be special fasteners (shrouded or counter bored)
  - Group II be special fasteners (thread shall be metric, tolerance of fit shall be 6g/6H, length of thread in holes shall be at least nominal size of bolt.

- Light alloy or plastic fasteners are not allowed.
- Yield stress shall be at least 240 N/mm². (calculation required)
- Fasteners shall not pass through the walls of an enclosure.
- For blind holes, the material remaining around the bolt shall be at least 3 mm or 1/3 of nominal diameter.

### 5 Cable entries for flameproof equipment

Entries for electrical connections to equipment inside flameproof equipment shall be achieved by the following means:

- Cable glands (min. threads: 8) – needs separate certification (in most cases)
- Conduit with stopping box (not allowed for Gr I)
6 Batteries inside flameproof enclosures

Only cells for which IEC standards exist may be used inside flameproof enclosures. In general the following restrictions apply:

- Vented or open secondary cells shall not be used
- Sealed valve regulated cells are allowed
- Only sealed, gas tight secondary cells may be charged inside a flameproof enclosure

For primary cells, a large range are listed in table E.1 of SANS IEC 60079-1
For secondary cells, only Ni-Cd, NiMH and Lithium may be used.

In all cases, cells shall be properly fixed and the necessary clearances shall be maintained.

7 Application of flameproof equipment

Flameproof equipment are normally found as:

- Control panels
- Luminaires
- Electric motors
- Associated apparatus

Flameproof equipment are suitable for use in:

- Zone 1 (Surface and under ground)
- Zone 2 (Surface)
- Zone 21/22 if additionally certified.

8 Marking of flameproof enclosures

Flameproof equipment is marked as all other explosion protected equipment, with the following exceptions:

The symbol is “d”, eg. Ex d
The sub group must be added, eg. Ex d IIB T5 or Ex d I/IIA T4
The equipment protection level (EPL) must be added (mostly Gb)
A temperature or temperature class is not required for empty enclosures, eg.
IA number is SAEx MS/10-241U (note the “U” for empty enclosures),
Then Ex dl/IIB+H₂