Overview of Explosion Protection Techniques

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INTRODUCING

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• Technical Manager
Why am I here...?

Promotion of IEC to be the one and only accepted certification system!
To achieve total ACCEPTANCE there’s a first need for CONFIDENCE.
Each stakeholder needs to understand ISO/IEC based Types of Protection.
Let’s start a quick guide:
Ignition sources

1. Hot surfaces
2. Flames, hot gases, hot particles
3. Mechanically generated sparks
4. Electrical equipment
5. Stray electric currents, cathodic corrosion protection
6. Static Electricity
7. Lightning
8. Radio Frequency (RF) electromagnetic waves ≤ 300 GHz
9. Electromagnetic waves > 300 GHz
10. Ionizing Radiation
11. Ultrasonics
12. Adiabatic compression and shockwaves
13. Exothermic reactions, including self-ignition of dusts
Ignition sources

IEC is commonly known as to deal with just Electrical Equipment.

Be aware that we have today ISO working close together.

Non-electrical equipment shall be assessed in hazardous areas as well.

Some basic knowledge is anyhow required.
Gas Groups

Gases are divided in sub groups because of:
1. Minimum Ignition Current / Energy
2. Maximum Experimental Safety Gap

<table>
<thead>
<tr>
<th>Gas group</th>
<th>Representative gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>IIC</td>
<td>Hydrogen, Acetylene, Carbon Disulphide</td>
</tr>
<tr>
<td>IIB</td>
<td>Ethene, Dimethylether</td>
</tr>
<tr>
<td>IIA</td>
<td>Propane, Petrol, Ethanol, Acetone, Acetaldehyde</td>
</tr>
</tbody>
</table>

Remark:
1st line (IIC) are most dangerous gases.
Dust Groups

Dusts are divided in sub groups because of types of dust:

<table>
<thead>
<tr>
<th>Dust group</th>
<th>Types of dust</th>
<th>Representative dust</th>
</tr>
</thead>
<tbody>
<tr>
<td>IIIC</td>
<td>Conductive dusts</td>
<td>Graphite Powder, Toner</td>
</tr>
<tr>
<td>IIIB</td>
<td>Non-conductive dusts</td>
<td>Milk Powder, Powdered Sugar</td>
</tr>
<tr>
<td>IIIA</td>
<td>Fibers and Flyers</td>
<td>Tobacco, Saw Dust</td>
</tr>
</tbody>
</table>

Remark:
1st line (IIIC) are most dangerous dusts (for IP rated electrical equipment) where IIIB is dangerous when there is possible electrostatic charge.
Temperature classes on equipment

are applicable to gases and indicate the max. acceptable surface temperature.

<table>
<thead>
<tr>
<th>T class</th>
<th>Surface Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>450°C</td>
</tr>
<tr>
<td>T2</td>
<td>300°C</td>
</tr>
<tr>
<td>T3</td>
<td>200°C</td>
</tr>
<tr>
<td>T4</td>
<td>135°C</td>
</tr>
<tr>
<td>T5</td>
<td>100°C</td>
</tr>
<tr>
<td>T6</td>
<td>85°C</td>
</tr>
</tbody>
</table>

How to read and use this table?

When a site is classified as Zone 1 / IIA / T4

Hot surfaces become dangerous ≥ 135°C. For that reason all Ex equipment shall be selected having a T class T4, T5 or T6.

Remarks:
The higher the T class, the lower the belonging acceptable temperature. (T6 classified sites are most dangerous, T6 certified equipment is most safe!)
Ambient temperature range

Ex manufacturers and IECEx ExCB’s apply -20°C to +40°C as a default.

When no indication on the Ex type label this default applies.

When an extended range is required because of the application; it shall be indicated and must be followed.

In Indonesia around the Equator you actually might have earlier troubles with the humidity instead of the ambient temperature…
## Equipment Protection Level

This is to identify in which Zone an equipment can be used:

<table>
<thead>
<tr>
<th>EPL</th>
<th>Applicable Zone</th>
<th>Safety level description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ga</td>
<td>0</td>
<td>Abnormal operation with 2 mal-functions</td>
</tr>
<tr>
<td>Gb</td>
<td>1</td>
<td>Normal operation with 1 mal-function</td>
</tr>
<tr>
<td>Gc</td>
<td>2</td>
<td>Normal operation</td>
</tr>
<tr>
<td>Da</td>
<td>20</td>
<td>Abnormal operation with 2 mal-functions</td>
</tr>
<tr>
<td>Db</td>
<td>21</td>
<td>Normal operation with 1 mal-function</td>
</tr>
<tr>
<td>Dc</td>
<td>22</td>
<td>Normal operation</td>
</tr>
<tr>
<td>Ma</td>
<td>Underground Mining</td>
<td>Explosion risk? Operation safely possible</td>
</tr>
<tr>
<td>Mb</td>
<td>Underground Mining</td>
<td>Explosion risk? Disconnection required</td>
</tr>
</tbody>
</table>
# Capitals?

When identifying markings on equipment be aware!

<table>
<thead>
<tr>
<th>Level of protection</th>
<th>Safety level</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>Very high</td>
</tr>
<tr>
<td>b</td>
<td>High</td>
</tr>
<tr>
<td>c</td>
<td>Normal</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Grouping</th>
<th>Suitable for Gases (II)</th>
<th>Suitable for Dusts (III)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>Most easy ignitable</td>
<td>Conductive</td>
</tr>
<tr>
<td>B</td>
<td>Easy ignitable</td>
<td>Non-conductive</td>
</tr>
<tr>
<td>A</td>
<td>Ignitable</td>
<td>Ignitable Fibers &amp; Flyings</td>
</tr>
</tbody>
</table>
### Types of protection (electrical)

Most common applied types according to the IEC 60079 standards, parts:

<table>
<thead>
<tr>
<th>Part</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>d</td>
<td>Flameproof equipment</td>
</tr>
<tr>
<td>2</td>
<td>p</td>
<td>Pressurization</td>
</tr>
<tr>
<td>5</td>
<td>q</td>
<td>Quartz encapsulation</td>
</tr>
<tr>
<td>7</td>
<td>e</td>
<td>Increased safety</td>
</tr>
<tr>
<td>11</td>
<td>i</td>
<td>Intrinsic safety</td>
</tr>
<tr>
<td>15</td>
<td>n</td>
<td>Non incendive</td>
</tr>
<tr>
<td>18</td>
<td>m</td>
<td>Moulded encapsulation</td>
</tr>
<tr>
<td>28</td>
<td>op</td>
<td>Optical radiation</td>
</tr>
<tr>
<td>31</td>
<td>t</td>
<td>Protection by enclosure</td>
</tr>
</tbody>
</table>
Flame proof enclosure Ex d

Basic design is: enclosure is strong enough to withstand internal explosion

This design allows internal ignition sources, like sparks and (limited) hot spots.

Critical aspects:
1. Enclosure strength
2. Flame path based on joints
3. Pressure piling
4. Heat-loss of built-in apparatus
5. Entry devices (next speaker will explain)
Increased safety Ex e

Basic design is: increased safety level for normally non sparking apparatus

This design does not allow any (unprotected) sparking components inside

Critical aspects:
1. Creepages and clearances
2. Enclosure (IP rating, impact strength etc.)
3. Heatloss (wiring and terminations)
Intrinsic Safety Ex i

Basic design is: limitation of energy in the whole electrical circuit

Energy [µJ] = ½ x C x U² = Capacity [µF] x Voltage² [V]
Energy [µJ] = ½ x L x I² = Inductivity [mH] x Current² [mA]

Intrinsic safe circuits are normally supplied from safe area and basically limiting the Voltage by Zener diodes and the Current by a Resistor. Take into account maximum cable length because of increasing C and L.

'Typical' design

The blue circuit shall being verified before commissioning (see IEC 60079-14)
Moulded encapsulation Ex m

Basic design is: moulding of the electrical circuit

Examples of application:
- Solenoid Valves
- Printed Circuit Boards

Critical aspects (for Manufacturer):
1. Thickness of the potting
2. Internal free volumes are limited
3. Ageing of the potting material
4. Potting shall be non-hygroscopic
Non Incendive Ex n (for EPL Gc only)

Basic concept: Ex n consists of several sub types of protection. In most cases being simplified versions of existing types of protection:

IEC 60079-15
Ex nA  non Arcing  → becomes  →  Ex ec  IEC 60079-7
Ex nC  enclosed Construction  → becomes  →  Ex dc  IEC 60079-1
(or hermetically sealed)  or  →  Ex mc  IEC 60079-18
Ex nR  Restricted breathing

Remark: Not easy to guarantee ‘nR’ during Life Cycle
Optical radiation Ex op

Basic design is: safety by either limitation of radiation or protection of optical light. This type of protection is divided in:

Ex op is inherent safe (limited optical energy in mW/mm²)
Ex op pr protected (light source/channel is physical protected)
Ex op sh with interlock (fibre optic loop monitoring; no return = stop)

Ex db op is
Ex db op pr sensor connector connector
Pressurized enclosures Ex p

Basic design is: keep dangerous atmosphere outside by overpressure

Aspects:
1. First a purging of $\geq 5$ times the internal volume
2. For EPL Gb redundant guarding of the flow required
3. Then 'compensation of leak losses' + power on
4. For EPL Gb mandatory power off when pressure drops

Spark arrestor in the outlet!
Powder (quartz) filling Ex q

Basic design is: extinguish any ignition source in a quartz filled enclosure

Example: Mobile Computer

Electronics in quartz
Keyboard and Touch screen
intrinsic safe controlled

Remarks:
1. Combination with intrinsic safety [ib]
2. X certificate = specific conditions of use!!
Protection by enclosure Ex t (for dust only)

Basic design is: minimum IP degree for dust tight enclosure

Depending on the dust group a minimum IP rating of either IP5X or IP6X

Remark:
X = ‘don’t care’ (for dust)

because 2\textsuperscript{nd} digit is for ingress protection against water

Critical aspects:
1. IP5X or 6X rating depending on EPL and Dust group
2. Heat dissipation to fulfil the max. surface temperature indicated as T…°C
Marking of equipment

Based on applied type(s) of protection including their level of protection

These levels of protection are:  for Product … from Manufacturer …

<table>
<thead>
<tr>
<th>Level</th>
<th>Safety level description</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>Very high</td>
</tr>
<tr>
<td>b</td>
<td>High</td>
</tr>
<tr>
<td>c</td>
<td>Normal</td>
</tr>
</tbody>
</table>

Remark:
1 product, 10 certificates! not covering world wide sales
Manufacturers and users prefer one single system!

In previous Conferences we did already do some calls…

Malaysia 2014

We want the IECEx System!!

Poland 2015

We want the IECEx System!

China 2017

We want the IECEx System!!
Today here in Jakarta shortly again

Let’s do a call…

We want the IECEx System!!
## Overview of types of protection

IEC 60079-14 differentiates these types for each Equipment Protection Level

<table>
<thead>
<tr>
<th>Level</th>
<th>Ex d</th>
<th>Ex e</th>
<th>Ex i</th>
<th>Ex m</th>
<th>Ex n</th>
<th>Ex op</th>
<th>Ex q</th>
<th>Ex p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ga</td>
<td>Ex da</td>
<td>-</td>
<td>Ex ia</td>
<td>Ex ma</td>
<td>-</td>
<td>Ex op is</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Gb</td>
<td>Ex db</td>
<td>Ex eb</td>
<td>Ex ib</td>
<td>Ex mb</td>
<td>-</td>
<td>Ex op is/pr/sh</td>
<td>Ex qb</td>
<td>Ex pxb/pyb</td>
</tr>
<tr>
<td>Gc</td>
<td>Ex dc</td>
<td>Ex ec</td>
<td>Ex ic</td>
<td>Ex mc</td>
<td>Ex nA/nC/nR</td>
<td>Ex op is/pr/sh</td>
<td>-</td>
<td>Ex pzc</td>
</tr>
</tbody>
</table>

### Remark:

Don’t mix up Db & db !!

<table>
<thead>
<tr>
<th>Level</th>
<th>Ex i</th>
<th>Ex m</th>
<th>Ex op</th>
<th>Ex p</th>
<th>Ex t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Da</td>
<td>Ex ia</td>
<td>Ex ma</td>
<td>Ex op is</td>
<td>-</td>
<td>Ex ta</td>
</tr>
<tr>
<td>Db</td>
<td>Ex ib</td>
<td>Ex mb</td>
<td>Ex op is/pr/sh</td>
<td>Ex pb</td>
<td>Ex tb</td>
</tr>
<tr>
<td>Dc</td>
<td>Ex ic</td>
<td>Ex mc</td>
<td>Ex op is/pr/sh</td>
<td>Ex pc</td>
<td>Ex tc</td>
</tr>
</tbody>
</table>
How to read the markings?

Let’s demonstrate a sample:

Ex : Explosion protected.
db : Flameproof ’d’ with level of protection ’b’.
eb : Increased safe ’e’ with level of protection ’b’.
[ia Gb] : Square brackets [ ] = associated apparatus,
intrinsic safety with level of protection ’a’,
overall application is because of the insert
max. for Equipment Protection Level Gb.

IIB+H₂ : Group IIB additional including Hydrogen.
T5 : Max. surface temperature classified T5 (100°C).
Gb : This whole assembly has EPL Gb (zone 1).

DEK : Responsible Certification Body DEKRA.
13 : Year (2013) of initial issue 0.
0075 : Certificate (serial) number from DEKRA.
How to read the online Certificate of Conformity?

Certificate No.: IECEx DEK 13.0075 issue No.: 2

Status: Current

Date of Issue: 2018-04-25

Applicant: BARTEC NEDERLAND B.V.
Boelewerf 25
2987 VD Ridderkerk
The Netherlands

Equipment: Control/distribution panels, Series BARTEC B/C/D/E-ASSEMBLY
Optional accessory: 

Type of Protection: d e i m op q and t

Marking: BARTEC B (-ASSEMBLY): Ex db ... IIB / IIB + H2 T6 ... T3 Gb
BARTEC C (-ASSEMBLY): Ex db ... IIC T6 ... T3 Gb
BARTEC D (-ASSEMBLY): Ex tb ... IIC T80 °C ... T130 °C Db
BARTEC E (-ASSEMBLY): Ex eb ... IIB / IIC T6 ... T3 Gb
BARTEC E (-ASSEMBLY): Ex ia / ib ... IIB / IIC T6 ... T4 Gb

Additional markings are provided depending on the certified components used in the actual construction.
Preferable you select equipment to current editions

This certificate is issued as verification that a sample(s), representative of production, was assessed and tested and found to comply with the IEC Standard list below and that the manufacturer's quality system, relating to the Ex products covered by this certificate, was assessed and found to comply with the IECEx Quality system requirements. This certificate is granted subject to the conditions as set out in IECEx Scheme Rules, IECEx 02 and Operational Documents as amended.

STANDARDS:
The apparatus and any acceptable variations to it specified in the schedule of this certificate and the identified documents, was found to comply with the following standards:

- IEC 60079-0 : 2007-10 Edition: 5
- IEC 60079-31 : 2008 Edition: 1
- IEC 60079-7 : 2006-07 Edition: 4

Explosive atmospheres - Part 0: Equipment - General requirements
Explosive atmospheres – Part 31: Equipment dust ignition protection by enclosure "t"
Explosive atmospheres - Part 7: Equipment protection by increased safety "e"

This certificate is issued as verification that a sample(s), representative of production, was assessed and tested and found to comply with the IEC Standard list below and that the manufacturer's quality system, relating to the Ex products covered by this certificate, was assessed and found to comply with the IECEx Quality system requirements. This certificate is granted subject to the conditions as set out in IECEx Scheme Rules, IECEx 02 and Operational Documents as amended.

STANDARDS:
The apparatus and any acceptable variations to it specified in the schedule of this certificate and the identified documents, was found to comply with the following standards:

- IEC 60079-0 : 2017 Edition: 7.0
- IEC 60079-1 : 2014-06 Edition: 7.0
- IEC 60079-31 : 2013 Edition: 2
- IEC 60079-5 : 2015 Edition: 4.0
- IEC 60079-7 : 2017 Edition: 5.1

Explosive atmospheres - Part 0: Equipment - General requirements
Explosive atmospheres - Part 1: Equipment protection by flameproof enclosures "d"
Explosive atmospheres - Part 11: Equipment protection by intrinsic safety "i"
Explosive atmospheres - Part 18: Protection by encapsulation "m"
Explosive atmospheres - Part 28: Protection of equipment and transmission systems using optical radiation
Explosive atmospheres - Part 31: Equipment dust ignition protection by enclosure "t"
Explosive atmospheres –Part 5: Equipment protection by powder filling “q”
Explosive atmospheres - Part 7: Equipment protection by increased safety "e"
Non-electrical equipment

Today, there are two parts in ISO/IEC 80079 series of standards available:

<table>
<thead>
<tr>
<th>Part</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>36</td>
<td>h</td>
<td>Basic requirements; Hazard assessment</td>
</tr>
<tr>
<td></td>
<td>c*</td>
<td>Constructional Safety</td>
</tr>
<tr>
<td>37</td>
<td>b*</td>
<td>Control of Ignition Sources</td>
</tr>
<tr>
<td></td>
<td>k*</td>
<td>Liquid immersion</td>
</tr>
</tbody>
</table>

* Types of protection ’c, b en k’ will not being marked on the product, because of possible user mis-interpretation with levels of protection ’c and b’.

Manufacturers shall indicate Ex h only and have to define the specific used method(s) in the user installation instructions.
Last but not least:

When a Certificate of Conformity has a numbering like SIR 13.0047X

That ‘X’ is for CoC’s **always** indicating a ’Specific Condition of Use’!
So; it is **neither** a placeholder for any future numbering **nor** a ’don’t care’!!!
Thank you

Karel Neleman
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BARTEC
karel.neleman@bartec.nl