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Intrinsic Safety Concepts
Intrinsic safety concepts

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- Ratings of components
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Intrinsic Safety Principles
Basic principles:

- A circuit in which no spark or thermal effect in any part of the equipment or circuit intended for use in a hazardous area is capable of causing ignition.
- Fault conditions are applied in the circuit. Therefore, safety components are in many cases duplicated / triplicated.
- Intrinsic safety is the only techniques considering faults IN the CONNECTING CABLES.
- The system / interconnecting of different certified intrinsically safe units effect the overall safety and needs to be approved.
Fault Conditions
Intrinsic Safety Categories ("ia", "ib" & "ic")

1,5 times safety factor on rating per component
### Intrinsic Safety Categories ("ia", "ib" & "ic")

<table>
<thead>
<tr>
<th>Category</th>
<th>Code</th>
<th>Safety Description</th>
<th>Zones</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ex ia</td>
<td>(Ga, Ma)</td>
<td>Intrinsically safe with TWO countable faults</td>
<td>Zones 0, 1 and 2</td>
</tr>
<tr>
<td>Ex ib</td>
<td>(Gb, Mb)</td>
<td>Intrinsically safe with ONE countable fault</td>
<td>Zones 1 and 2</td>
</tr>
<tr>
<td>Ex ic</td>
<td>(Gc)</td>
<td>Intrinsically safe with NO countable faults</td>
<td>Zone 1</td>
</tr>
</tbody>
</table>

[Diagram showing the safety categories with symbols representing faults and their counts.]
Gas Groups
Ignition Curves

Spark Test Apparatus
Ignition Curves

50 % safety factor is applied when using the curves.

Ignition graphs exist for:

- **resistive energies**, (50% safety factor on current)
- **capacitive energy**, (50% safety factor on voltage) and
- **inductive energy**, (50% safety factor on current)
Ignition Temperatures / Temperature Classes
### Temptures

<table>
<thead>
<tr>
<th>Gas</th>
<th>Ignition energy</th>
<th>Ignition Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methane</td>
<td>Group I (250µJ)</td>
<td>537°C (T1 gas)</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>Group IIIC (20µJ)</td>
<td>560°C (T1 gas)</td>
</tr>
</tbody>
</table>

A 5°C to 10°C **safety factor**
is applied to the surface temperature of a component.
Temperatures

**Group I: IP54 housing:**
- Components with surface area $<$20 mm$^2$ may reach 950 °C @ 40 °C ambient.
- Components with surface area $>$20 mm$^2$ may dissipate 3.3 W @ 40 °C ambient.
- 150 °C still applicable on outside of housing

**Group I: NOT IN AN IP54 housing:**
- 150 °C still applicable on inside components.

**Group II:**
- No allowance is made for IP rating / sealing of enclosures and therefore the surface temperature is measured on the inside of the equipment on internal components / tracks.
Temperatures

HOW HOT DO INTERNAL COMPONENTS ACTUALLY GET?

Approximately 20 mm$^2$ surface area and
340 °C @ 1 W and 40 °C ambient

>>20mm$^2$ surface area

Approximately 20 mm$^2$ surface area and
220 °C @ 1 W and 40 °C ambient
Ratings of components
Safety components must be sufficiently rated:

- 150% rating required
- Derating of semiconductor components e.g. Zener diodes according to:
  - Assembly conditions (e.g. TL = 75°C, derate 40mW/C above 75°C
  - Ambient conditions (affects TL)

  e.g. A 5W Zener diode is typically <2.5W

Use of components in parallel to share power?
Construction
Some construction features include:

- IP rating
- Electrostatic hazard (Plastic)
- Drop test (typically no impact test)
Installation of Intrinsic safety in (flameproof) enclosures
Installation of Intrinsic safety in (flameproof) enclosures

- Connections inside (flameproof) enclosures
- Ambient temperatures
- Internal Wiring / Installation in (flameproof) enclosure (including empty enclosure)
- ia equipment / double protection vs. 1.4% methane isolation requirement
Connections inside (flameproof) enclosures

- A 50 mm separation I.S. To Non-I.S.  
  (A partition may be used)

- I.S. To earth ≥ 3mm

- I.S to I.S. ≥ 6mm
Default ambient temperature:
(-20 °C to +40 °C)
e.g. Ex d I or Ex ib I/IIA T4

OR

[Ex ib] I/II C T6 (-20°C < Tamb < 55°C)
Internal Wiring / Installation in (flameproof) enclosure (including empty enclosure)
Intrinsic safety requirements include:

- **Separation Distance between:**
  - Non-I.S. and I.S.
  - I.S. and I.S.
  - I.S. and earth.
- **Safety Parameters (Um)**
- **Earthing requirements for I.S.**
- **Internal wiring requirements**
  - Bundling / Trays
  - Constructional / insulation
  - Ferrules
- **Gland requirements for I.S. wiring**
- **Internal temperature rise. (Ambient for I.S)**
Internal Wiring / Installation in (flameproof) enclosure (including empty enclosure)

Flameproof requirements include:

- Energy storing components
- Pressure piling
- Temperatures (Temp. classification / ambient / temp. at gland entries and branching point of cable / ratings of components (e.g. bushes) etc.)

Relabeling for empty enclosure certification / new certificate number. Do not remove empty enclosure certification label.
Examples of Category Ma Equipment having two forms of protection

Category "M1" encapsulated 'm' or powder filled 'q' apparatus inside a flameproof ‘d' or pressurized ‘p' enclosure (with optional power supplies)

Marking relating to the method of protection (see 10.2e)

Figure 3
Hazardous area in a mine (Zone 0)

>1.4% methane in air
- flameproof equipment must be switched off.
- Intrinsically safe category “ia” equipment or double protected equipment allowed to remain energized.

Questions
- Ex d [ia] I, may this remain on?
- How is batteries in flameproof enclosures handled?
System / Loop installations
System / Loop Certification

- I.S. Loops / Systems
- Simple apparatus
- Earthing / Isolation requirements
- Use of I.S. certified multimeters
- Battery powered equipment
I.S. Loops / Systems
**IS LOOPS**

**(MUST be approved by an approved tests laboratory)**

Safe area, ambient 10°C to 25°C

Barrier device [Ex ia] IIA
(-20<Tamb<55)

- $U_o = 28V$
- $I_o = 93mA$
- $P_o = 0.65W$
- $C_o = 83nF$
- $L_o = 4.2mH$

Cable:
- Capacitance / km
- Inductance / km
- Resistance / km

Safety Parameter rules:
- $U_o \leq U_i$
- $I_o \leq I_i$
- $P_o \leq P_i$
- $C_o \geq C_{cable} + C_i$
- $L_o \geq L_{cable} + L_i$

Transmitter
Ex ib IIC T3
(-20<Tamb<55)

- $U_i = 30V$
- $I_i = 120mA$
- $P_i = 0.7W$
- $C_i = 0$
- $L_i = 0$

Simple apparatus

Hazardous area (Zone 1, Group IIA, T3 gas, ambient temperature 50 degC)

Non-certified electronics

Guidelines for more than one interface connected in a single loop may be obtained from SANS 10086-1
Machine certification / Misconceptions

- System certification required for I.S Loops / Systems
- Mine machines are approved without intrinsic safety systems certification / installation requirements.

- RS485 / Data signals not protected with barrier devices e.g. Return from fixed gas sensors in a mine to a PLC.

- Direction of barrier devices.
- Multiple barrier devices / I.S. sources in a single loop.
- Common ground return for multiple barrier devices / I.S. sources.
Common misconceptions:
When a barrier / I.S. Power Supply is used, the whole circuit is intrinsically safe.

Interconnection of non-certified equipment in an I.S. Loop e.g.
- Non-certified relays
- Solenoids
- Indicators etc.
Combination of capacitance & Inductance

Typical condition on a barrier device (LINEAR) for handling of Co and Lo

- **Li < 1% of Lo** or **Ci < 1% of Co**
- Or inductance & capacitance is distributed (cable)
  -- No restriction to Co and Lo use

Or

- **Li ≥ 1% of Lo** and **Ci ≥ 1% of Co** -- 50% of Co and 50% of Lo allowed

- The reduced capacitance of the external circuit (including cable) shall not be greater than:
  - 1μF for Groups IIB, IIA & I and
  - 600nF for Group IIC.
Simple apparatus
Simple Apparatus:
Connected to I.S. equipment

Passive Components

- Resistor
- Potentiometer / RTD
- Switch
- LED
- Photo Sensor
Simple Apparatus shall:

- conform to all relevant requirements of the Standard but
  - need not be certified and
  - need not be marked with i.s. marking

NB: 500V Isolation requirement to earth / body

Mine machines?
Earthing / Isolation requirements
Typical protection by a barrier device / High quality earth (HQE):
Typical protection by an isolator / Isolation:

- **Mains Fault**
- **Hazardous Location**
- **Power Supply / Electronics fault**
ISOLATION REQUIREMENTS FOR I.S. CIRCUITS

- **500 V isolation** between **i.s. circuits** and **earth**
- **1500 V isolation** between **i.s. and non-i.s. circuits**.
- **500 V isolation** is required between **i.s. and i.s. circuits**.
Earthing for I.S. Circuits

Supply Transformer

24 V dc PS
24 V dc Electronics
Mains Powered Electronics

Barrier Device

Armouring / Screen

Optional I.S. Link for testing

I.S. busbar

Screened pairs

Junction box

Overall Screen

Armouring

Terminals

500V isolation between I.S. And earth

500V isolation required

500V isolation required

HQE (High Quality Earth)

Safety earth conductor and rest of the equipotential bonding system not indicated
Use of cables for intrinsic safety on mine machines:

- Mechanical protection?
- HQE on mine machines / inside flameproof boxes?
- 500V isolation on mine machines e.g. junction boxes, connection to earth etc.
- Handling of screen?
  - HQE
  - 500V isolation
- Multiple I.S circuits in a single cable?
Use of I.S. Certified multimeters
Intrinsically-safe multi-meters

Special conditions of use “X”
Battery powered equipment
Special conditions for safe use (X)

Use only Duracell plus AA 1.5V Alkaline MN1500 batteries
Typical examples of handheld units are radios, multi-meters and gas sensors.
Typical protection circuit for lithium batteries

Intrinsically safe?

Picture appears much bigger than actual size