HAZARDOUS AREA CLASSIFICATION AND SELECTION OF EQUIPMENT FOR SAFE USE THEREIN FROM AN ELECTRICAL VIEWPOINT

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HÄGAR

THE HORRIBLE

by

Dik Browne

I'M HAPPY THAT
SO MANY OF YOU
SHOWED UP TODAY...

AS YOU KNOW, TODAY
I PLAN TO ASSEMBLE
A NEW CREW!

BEFORE I CHOOSE MY NEW CREW,
LET ME SAY THIS...

I WANT
MEN WHO
WILL MAKE
SACRIFICES!

MEN WHO
WON'T LET
ANYTHING
BOther THEM!

MEN WHO
WILL TAKE
ORDERS..

...EVEN
WHEN THEY
DISAGREE!

MEN WHO
ARE USED
TO FACING
DANGER
WITHOUT
FLINCHING!!

I WANT MARRIED MEN!!

FLUOR®
For an explosion/fire to take place there must be 3 elements present, namely:

- **FUEL** – Liquid, gas or vapour/mist of flammable mixtures
- **IGNITION SOURCE** - flames, sparks, friction, lightning, static or heat.
- **OXYGEN** - air, oxidising agent or chlorine
Prevention of Explosion

- Prevention of the formation of explosive atmospheres
  - Explosion confinement
- Avoidance of ignition of explosive atmospheres
  - Ignition source isolation
- Reduction of the effects of an explosion
  - Energy-release limitation
The range of flammable vapour or gas-air mixture between the LEL and HEL also known as the "explosive range" Measured in concentrations of % Volume in air.

<table>
<thead>
<tr>
<th>HEL/UEL</th>
<th>UPPER FLAMMABLE LIMIT (Too rich)</th>
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</thead>
<tbody>
<tr>
<td>% VOLUME IN AIR</td>
<td>FLAMMABLE LIMIT. IDEAL MIXTURE OF VAPOUR WITH OXYGEN</td>
</tr>
<tr>
<td>LEL</td>
<td>LOWER FLAMMABLE LIMIT (too Lean)</td>
</tr>
<tr>
<td></td>
<td>LIQUID</td>
</tr>
</tbody>
</table>

e.g. Hydrogen has a LEL of 4% and a HEL/UEL of 77%
HAZARDOUS AREAS

A Hazardous area is an area in which an explosive gas atmosphere is present, or likely to be present, in quantities such as to require special precautions for the construction, installation and use of electrical apparatus in order to remove, eliminate or mitigate the risk of an explosion or fire.

Hazardous Area Classification is the method of analysing and classifying the environment where explosive gas atmospheres may occur in order to facilitate the selection of suitable electrical apparatus to be installed in that environment.
HAZARDOUS AREA CLASSIFICATION ENCOMPASSES:

The nature of the flammable substances and the probability that the flammable substances can cause an explosion or fire, i.e. gas/vapour mist.

Area detailed plot plan to be marked up.

Source of release: Flange, pump seal, vent, open drain etc.

Grade of release: Continuous, Primary, Secondary.

Fluid Category: Category A, B, and C.

Ventilation: Open, Sheltered, Enclosed, Artificially ventilated.

Apparatus Group: Gas group 2A, 2B, and 2C

Temperature Class: T1…….T6

Auto ignition Temp: For determination of temperature class.

Flashpoint: For determination of fluid category.

Boiling range

Process temp

Process pressure

Product density: Lighter/heavier than air.
HAZARDOUS AREA ZONES
LIQUID, GAS, VAPOURS, MISTS

Zone 0 is an area where an explosive mixture of flammable gas, vapour or suspended liquid droplets/mist with air is continuously present, or present for long periods.

Zone 1 is an area where an explosive mixture of flammable gas, vapour or suspended liquid droplets/mist with air is likely to occur during normal operation.

Zone 2 is an area where an explosive mixture of flammable gas, vapour or suspended liquid droplets/mist with air is likely to occur under abnormal operating condition of the facilities.

Non-hazardous/safe area- are those where an explosive gas-air mixture shall not occur during normal and design emergency conditions (but, however, may occur during a “catastrophic” situation).
HAZARDOUS AREA ZONES
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
The atmosphere is likely to contain ignitable concentrations of inflammable dust or fibres under normal working conditions.

Zone 22
The atmosphere is not likely to contain suspended ignitable dust or fibres but such dust or fibres stored. (Silos, stores)
GRADES OF RELEASE

Continuous Grade
✓ Vapour space above: closed process vessels, storage tanks, closed containers, areas containing open tanks of volatile, flammable liquid

Primary Grade
✓ Flammable gas or vapour concentration is likely to exist in the air under normal operating conditions.
✓ Flammable atmospheric concentration is likely to occur frequently because of maintenance, repairs or leakage.
✓ Flammable liquid or vapour piping system (containing valves, meters, or screwed or flanged fittings) is in an inadequately ventilated area.
✓ The area below the surrounding elevation or grade is such that flammable liquids or vapour may accumulate therein.

Secondary Grade
✓ The system handling flammable liquid or vapour is in an adequately ventilated area and is so designed and operated that the explosive or ignitable liquids, Vapour or gases will normally be confined within closed containers or closed systems from which they can escape only during abnormal conditions such as accidental release of a gasket or packing.
✓ The flammable vapours can be conducted to the location as through trenches, pipes or ducts.
✓ Locations adjacent to Zone 1 areas.
✓ Pressurized rooms where flammable gas / vapour can enter in the case of failure of positive mechanical ventilation.
<table>
<thead>
<tr>
<th>FLUID CATEGORY</th>
<th>DESCRIPTION</th>
</tr>
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</table>
| A              | A flammable liquid that on release would vaporize rapidly and substantially. This category includes:  
  a) Any liquefied petroleum gas or lighter flammable liquid.  
  b) Any flammable liquid at a temperature sufficient to produce on release more than about 40% volume vapourisation with no heat input from other than from the surroundings. |
| B              | A flammable liquid not in Category A but which can be at sufficient temperature for boiling to occur on release. |
| C              | A flammable liquid not in categories A or B but which can on release be at a temperature above its flash point or form a flammable mist or spray. |
| G (i)          | A typical methane-rich gas. |
| G (i)          | Refinery hydrogen. |
| Unclassified   | Heavy oils etc. with flash point greater than 100° handled at a temperature below flash point which will not form a mist or spray on release. |
VENTILATION

Is the movement of air and its replacement with fresh air due to the effects of wind, temperature gradients, or artificial means (for example, fans or extractors)

Ventilation can be accomplished by the movement of air due to the wind and/or by temperature gradients or by artificial means such as fans. So two main types of ventilation are thus recognized:

a) natural ventilation;
b) artificial ventilation, general or local.

Ventilation could serve to reduce the extent of a hazardous location could so affect the frequency and duration of the flammable atmosphere that a reduced zone could be allocated. The latter effect is applicable to the division of hazardous locations into zones, and is discussed in detail in SANS 10119.
### Ventilation table as per: SANS IEC 60079-10:2002

**Table B.1 – Influence of ventilation on type of zone.**

<table>
<thead>
<tr>
<th>Grade of Release</th>
<th>Degree</th>
<th>Ventilation</th>
<th>Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td>Good</td>
<td>Fair</td>
<td>Poor</td>
</tr>
<tr>
<td>Continuous</td>
<td>(Zone 0 NE) Non-hazardous (a)</td>
<td>(Zone 0 NE) Zone 2 (a)</td>
<td>(Zone 0 NE) Zone 1 (a)</td>
</tr>
<tr>
<td>Primary</td>
<td>(Zone 1 NE) Non-hazardous (a)</td>
<td>(Zone 1 NE) Zone 2 (a)</td>
<td>(Zone 2 NE) Zone 2 (a)</td>
</tr>
<tr>
<td>Secondary</td>
<td>(Zone 2 NE) Non-hazardous (a)</td>
<td>(Zone 2 NE) Non-hazardous (a)</td>
<td>Zone 2</td>
</tr>
</tbody>
</table>

**NOTE “+” signifies “surrounded by”**

(a) Zone 0 NE, 1 NE or 2 NE indicates a theoretical zone which would be of negligible extent under normal conditions.
(b) The Zone 2 area created by a secondary grade of release may exceed that attributable to a primary or continuous grade of release; in this case the greater distance should be taken.
(c) Will be Zone 0 if the ventilation is so weak and the release is such that in practice an explosive gas atmosphere exists virtually continuously (i.e. approaching a “no ventilation” condition)
Gases are grouped together according to their degree of hazard. This is based on the amount of energy required to light the gas/air mixture.

<table>
<thead>
<tr>
<th>Gas Group</th>
<th>Representative Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>I (mining)</td>
<td>Methane</td>
</tr>
<tr>
<td>IIA (Surface)</td>
<td>Propane</td>
</tr>
<tr>
<td>IIB (Surface)</td>
<td>Ethylene</td>
</tr>
<tr>
<td>IIC (Surface)</td>
<td>Hydrogen</td>
</tr>
</tbody>
</table>
This relates to the maximum surface temperature of a piece of apparatus to the ignition temperature of a gas. (refer to - SANS 10108)

<table>
<thead>
<tr>
<th>T Class</th>
<th>Max surface temp.</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>
The amount of energy necessary to ignite flammable gases

Is the minimum temperature necessary to initiate combustion and have self sustained combustion of the solid, liquid, gas or vapour.

Temperature above which spontaneous combustion can occur without the use of a spark or flame.
FLASH POINT

Vapor Pressure % In Air

HEL

Too Lean

Too Rich

LEL

Temperature ->

Flash Point

Lowest temperature at which a flammable liquid exposed to air will burn when exposed to sparks or flame.
FLASHPOINT

- Is the minimum temperature at which a liquid gives off a sufficient vapour to reach 100% LEL - sufficient vapour to form an ignitable mixture with air near the surface of the liquid.

- Liquids with flashpoints below normal ambient temperatures automatically release vapour in sufficient volume to provide an explosive mixture. Thus leakage of such liquids is potentially as dangerous as a flammable gas leak.
Ignition Energy

Lowest amount of energy required for ignition

Minimum Ignition Energy

Lowest amount of energy required for ignition:
Major variable
Dependent on:
Temperature
% of combustible in combustant
Type of compound
IGNITION ENERGY

The graph shows the relationship between spark energy (in mJ) and methane percentage. The x-axis represents the methane percentage, ranging from 2% to 18%. The y-axis represents the spark energy, ranging from 0.2 mJ to 4 mJ.

The graph highlights the flammability limits of methane, where:
- **Too Lean** is indicated by SPARK ENERGY values below 0.4 mJ.
- **Ignitable** is indicated by SPARK ENERGY values between 0.4 mJ and 2.0 mJ, forming a parabolic shape.
- **Stoichiometric** is indicated by the lowest point of the parabola, where the energy is at its minimum.
- **Too Rich** is indicated by SPARK ENERGY values above 2.0 mJ.

The graph is labeled with key points, such as "Flammability Limits," "Too Lean," "Ignitable," "Stoichiometric," and "Too Rich."
Protection for Electrical Equipment

Flameproof Enclosure Ex-d

NON-SPARKING TYPE EQUIPMENT (Ex ‘n’)

Increased Safety Ex-e

Intrinsically Safe Ex-ia/b

Encapsulation Ex-m

Pressurised Enclosure Ex-p

SPECIAL TYPE EQUIPMENT (Ex ‘s’)

OIL IMMERSED TYPE EQUIPMENT (Ex ‘o’)

POWDER FILLED TYPE EQUIPMENT (Ex ‘q’)

FLUOR®
SELECTION OF ELECTRICAL EQUIPMENT IN FOR SAFE USE IN HAZARDOUS AREAS

- Selection Criteria
  - Gas Grouping (based on ignition energy)
    - Temperature Classification
    - Classified Zones
  - Adequate precautions to avoid ESD & Lightning to be implemented.
  - Use of light alloy (Mg, Al, Ti, ) material to be assessed critically in HA due to its incendive properties.
  - Where reasonably practical, electrical apparatus generally and switch & control apparatus should be installed outside the Hazardous Areas.
  - Electrical apparatus may be installed in open air in a non-hazardous area.
  - Equipment designed for higher gas groups can be used for less hazardous gas groups (for e.g., Equipment certified for II C can be used for II A, B or I)
  - Portable hand-lamps, communication equipment and other test equipment shall be Ex i type
  - All equipment shall be installed so as to avoid mechanical damage.
  - Earthing shall be carried out as per SANS 10198-3, SANS 10199.
  - Bonding of all pipeline flanges should be carried out so as to avoid Electro-static discharges.
  - Internal earthing to be provided for all Flameproof equipment in addition to external earthing.
• All circuits and apparatus in Hazardous Areas should be provided with means to ensure quick disconnection in the event of any fault (O/C, S/C or E/F)

• **Protection & Control apparatus** shall be normally located in non-HA but if unavoidable, they may be of the right protection type

• All electrical apparatus (for every apparatus or sub-groups) should be provided with an **effective means of isolation**, including neutral

  • Metal conduits, armoured cables

    • Correct terminations using proper sized cable glands (double-compression, FLP type)
    • Unused cable openings of all electrical apparatus shall be closed with plugs suitable for the type of protection

    • Copper or Aluminium (above 16 sq. mm only) conductors can be used

• Flameproof plugs & sockets should have preferably PUSH-IN, TWIST-ON type to avoid ignition while insertion or removal

  • Adequacy of IP equipment
SANS 10108:2008: The classification of hazardous locations and the selection of equipment for use in such locations

ARP 0108: recommended practice – Regulatory requirements for explosion-protected equipment.


IEC 60079-10 -Electrical Apparatus for Explosive Gas Atmospheres, part 10 Classification of hazardous areas


SANS 10086-1, The installation, inspection and maintenance of equipment used in explosive atmospheres – Part 1: Installations including surface installations on mines.

SANS 10089-2 The petroleum industry – Part 2: Electrical installations in the distribution and marketing sector.


SANS 61241-2-1 IEC 61241-2-1 - Electrical apparatus for use in the presence of combustible dust Part 2: Test methods Section 1: Methods for determining the minimum ignition temperatures of dust.


SANS 61241-3 IEC 61241-3 -Electrical apparatus for use in the presence of combustible dust Part 3: Classification of areas where combustible dusts are or may be present.

SANS 61241-4 IEC 61241-4 - Electrical apparatus for use in the presence of combustible dust Part 4: Type of protection "p
IP Part 15 - Area Classification Code for Petroleum Installations

API RP 500: Recommended practice for classification of locations for electrical installations at Petroleum Facilities
Classified as Class 1, Division 1 and Division 2.

API RP 505: Recommended practice for Classification of locations for Electrical installations at Petroleum Facilities classified as Class 1, Zone 0, Zone 1 and Zone 2

NFPA 69, 1992, Explosion Prevention Systems
ACKNOWLEDGEMENTS

I hereby wish to express my thanks to Fluor and SAFA for allowing me the opportunity to publish and present this paper and extend my appreciation to the delegates who sat so patiently and listened.

I also wish to thank and give credit to all those in the industry who have kindly allowed me the use of some of this information and for the many years assistance and dedication.

The information contained in this paper is based on many years experience and exposure of the author, in the field of hazardous area classification and selection of equipment for safe use therein, as well as the review and study of technical publications and other writers. While the statements purpose to be accurate, each reader is responsible for their own interpretation.
QUESTIONS?