

**INTRODUCTION TO :
EXPLOSION HAZARDOUS AREAS AND
PROTECTION METHODS
& WEATHER PROTECTION**

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TERMS & ABBREVIATIONS :

- Ignition Triangle
- Explosion Risk
- Area Classification
- Hazardous Area / Non Hazardous Area
- Zones 0 , 1, 2
- Explosion Proof
- Weather Proof
- Gas Group
- Temperature Class
- Ignition Temperature
- Flash Point
- Barriers
- Isolators
- Intrinsically safe
- international or national certifying authorities

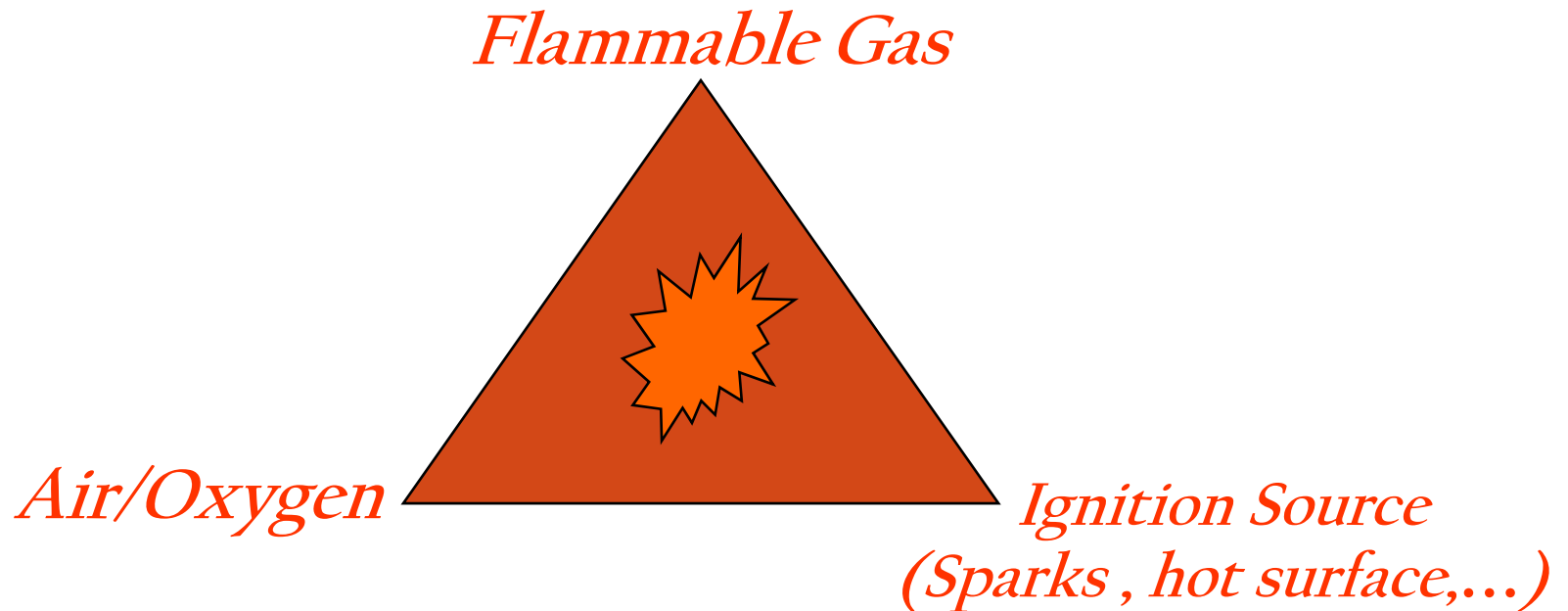
EXPLOSION ELEMENTS

To produce an explosion , three elements are required (**ignition triangle**):

- A rise in temperature , spark , ...
- Inflammable substances.
- Oxygen in the air.

EXPLOSION PROTECTION

- In order to reduce the risk of an explosion, elimination of one or more components of the **ignition triangle** (flame, oxygen, fuel) is necessary.



HAZARDOUS AREAS

- In many industrial processes where **flammable materials** are handled, any **leakage or spillage** may give rise to an explosive atmosphere, these **areas at risk** are known as hazardous areas.
- The areas are classified based on: **IS 5572**

HAS are classified in zones based on the **frequency of the appearance and the duration** of an explosive gas atmosphere. For this purpose , the specifications of the material being processed (**ignition temperature, ...**) the **temperature class** and **gas group** for the area should also be determined.

Hazardous Areas-Definitions

Petroleum Rules, 1976

An area shall be deemed to be a hazardous area, where:

- petroleum having **FP (Flash Point)** below 65 deg C or any inflammable gas or vapour in concentration capable of ignition is **likely to be present**.
- petroleum or any inflammable liquid having **FP (Flash Point)** below 65 deg C is likely to be **refined, blended or stored** at or above its FP.

IS 5572

- 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**.



Flash Point

- The flash point of a chemical is the lowest temperature where it will evaporate enough fluid to form a combustible concentration of gas. **The flash point is an indication of how easy a chemical may burn.**
- **Materials with higher flash points are less flammable or hazardous** than chemicals with lower flash points.

Hazard	Flash Point
Very Low Hazard	Flash point > 200°F (93°C)
Moderate Low Hazard	Flash point 150°F to 200°F (66°C to 93°C)
High to Moderate Hazard	Flash point 100°F to 150°F (38°C to 66°C)
Extreme to High Hazard	Flash point 0°F to 100°F (-18°C to 38°C)
Extreme Hazard	Flash point < 0°F (-18°C)

Flash Point is not the same as the Auto-Ignition Temperature. The Auto-Ignition Temperature is the minimum temperature required to ignite a gas or vapor in air without a spark or flame being present

Why Area Classification?

- HAC is a method of analyzing and classifying the environment where explosive gas atmospheres may occur to **allow the proper selection of electrical apparatus** to be installed in that environment.
- Ignition sources :
 - Sparks
 - Lightning
 - Flames/Fires
 - Hot surfaces

Why Zoning?

Safe & Optimized selection of Electrical Equipment

Why Important in oil, Gas & Petrochemical Industry?

Hazardous properties of hydrocarbons

HAZARDOUS AREA CLASSIFICATION Guidelines

the main factors to be considered are:(IS 5572)

- **Vapor / Gas Density** (lighter or heavier than air)
- Effect of **Air Current** , wind, amount of ventilation
- Identification of **leak Potential** scenarios
- **Location characteristics** : walls, shelter, enclosures, etc.
- **Frequency** of hazard (leakage possibility ,accident possibility and records,...)
- Presence of **Ignition Sources.**
- The quantity and **duration** of hazardous vapor
- The **Properties of Gas** (Ignition Temperature ,..)

IGNITION SOURCES

- **a) Electric sparks generated by open-circuiting, short circuiting or grounding.**
- **b) Sparks generated by mechanical contact (for example, when a nail is hit by a hammer or friction).**
- **c) Over-heating of electrical equipment due to equipment failure.**
- **d) Heat-generation by electro-magnetic action and chemical reaction.**

Hazardous Area Classification **/ Various Nation Codes**

	Always hazardous area	Sometimes hazardous area at normal condition	Hazardous area at abnormal condition
IEC	Zone 0	Zone 1	Zone 2
Australia	Zone 0	Zone 1	Zone 2
Germany	Zone 0	Zone 1	Zone 2
Japan	Division 0	Division 1	Division 2
United Kingdom	Division 0	Division 1	Division 2
USA	Division 1		Division 2
Canada	Division 1		Division 2
France	Zone E		Zone F
Netherlands	Increased Hazard		Limited Hazard

HAC- Comparison

- **North America** (NFPA / API/ NFPA 70E or NEC)
 - **Hazardous Areas:**
 - Division I- Z0 + Z1
 - Division II- Z2
 - **Hazardous Locations**
 - Class I-Flammable Gases / Vapor
 - Class II- Combustible dust
 - Class III- Combustible fibers or flyings
 - **Gas / vapour grouping**
 - A, B, C, D, E, F & G
- **Japan**
 - **Hazardous Areas**
 - Classes 1, 2 & 3
 - **Gas / vapour groups**
 - G1, G2, G3, G4, G5 & G6

ZONE 0

Explosive atmospheres present frequently or continuously **for long periods.**

- **Typically More than 1000 hours/year**

Example :

Vapour Space above flammable liquid in a tank , closed pressure vessel ,
Closed containers, areas containing open tanks of volatile, flammable liquid

ZONE 1

- Explosive atmospheres are **likely to occur** under normal operating conditions.
- **Typically between 10 and 1000 hours/year**

Example :

a) Around the openings of tank lorries or load tankers drums and tanks etc. when they contain flammable liquid.

b) At the moment of drawing off a flammable product, or around the outlet of a safety valve when the safety valve is discharging an explosive gas.

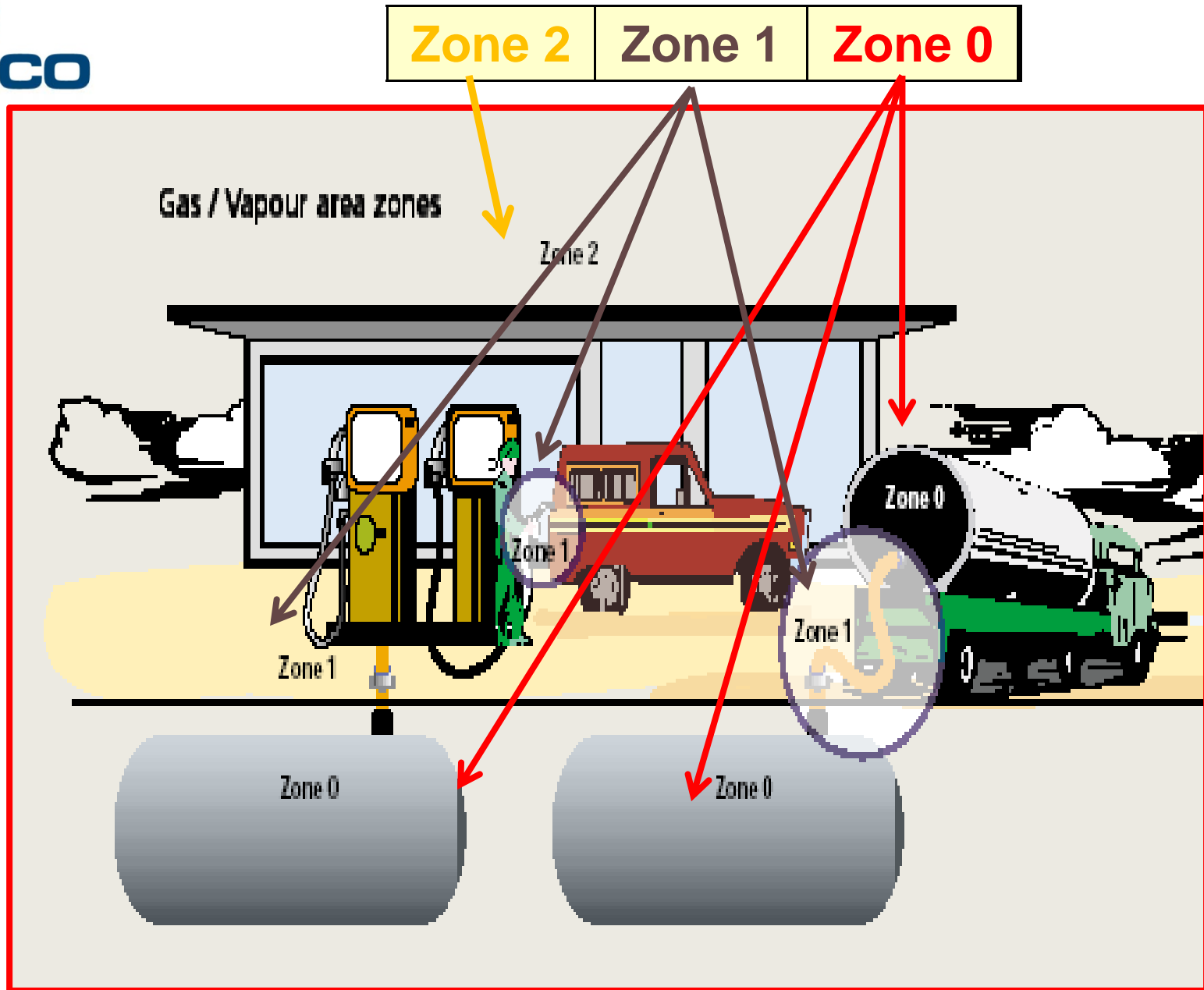
c) Pit in which gas accumulates, located near a place where there is a possibility of explosive gas leakage.

ZONE 2

- Explosive atmospheres are unlikely to occur under normal operating conditions or present only infrequently and for a short period.
- **Typically less than 10 hours/year**

Example :

- a) Area in which a dangerous concentration of gas is produced by the leakage of flammable gas brought about by the failure of a vessel due to corrosion etc.
- b) Area in which explosive gas is likely to be discharged by mis-operation or a leak caused by an abnormal reaction.
- c) A room into which explosive gas is likely to intrude adjacent to or around a Division 1 area.



How to identify Zone 1 areas (IS 5572) ?

- Flammable gas or vapor 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 vapor 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 vapors may **accumulate** therein

Zone 1 - Typical areas

- Imperfectly fitting peripheral seals on floating roof tanks
- Inadequately ventilated pump rooms for flammable gas or for volatile, flammable liquids
- Oily waste water sewer / basins
- Loading / unloading gantries of hazardous products

Zone 2 -Typical areas (IS 5572)

- The system handling flammable liquid or vapor is in an adequately ventilated area and is so designed and operated that the explosive or ignitable liquids, Vapors 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 vapors can be conducted to the location as through **trenches, pipes or ducts**
- **Locations adjacent to Zone 1 areas**
- **Pressurized rooms** where flammable gas / vapor can enter in the case of **failure of positive mechanical ventilation**

Safe Areas - Typical areas

The following locations are **considered safe** from the point of view of electrical installation:

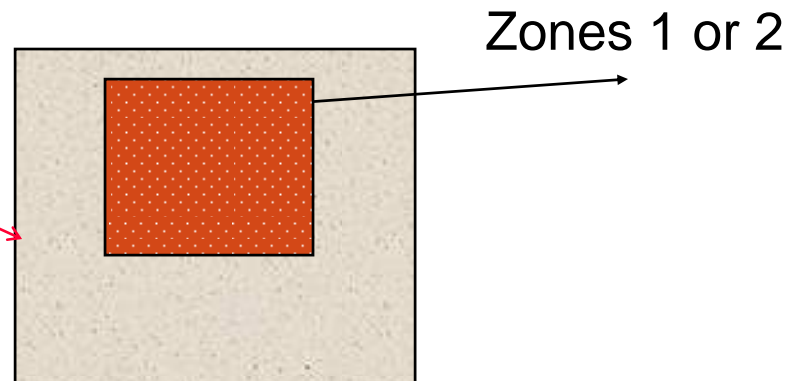
- Areas where the **pipng system** is without valves, fittings, flanges or similar appurtenances
- Areas where flammable liquids or vapors are transported only in suitable containers or vessels
- Areas where **permanent ignition sources area present** like area where combustion gases are present, for example flare pits, tips, other **open flames & hot surfaces**
- DG shed rooms having **adequate ventillation**
- GT installation meeting the ventilation (12 ACPH) , pressurization (0.5 mbar)and flange (not more than one pair of flanges inside the turbine room) requirements

HEAVIER-THAN-AIR GASES & VAPOURS

- Open -Air Situations (freely ventilated Process Areas)
 - In case of petroleum pipelines (where well-maintained valves, fittings, and meters and in well-ventilated areas or in a pit), **Zone 2 A/G shall be 4m in all directions, from the potential leak source.** Pit will be considered as Zone 1.

- **Zone 1**

(unless separated by a fire wall)

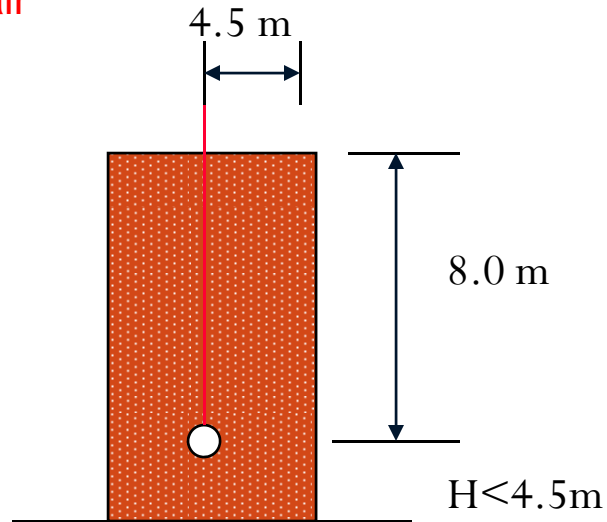
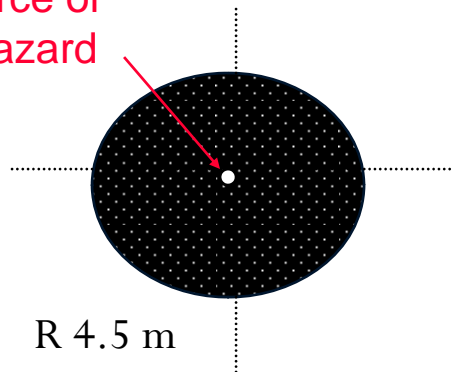


LIGHTER-THAN-AIR GASES & VAPOURS

- Vapour density of 0.75 is considered as the boundary between lighter and heavier gases / vapours as a safety measure.

HA of a leak source located in air

Source of hazard

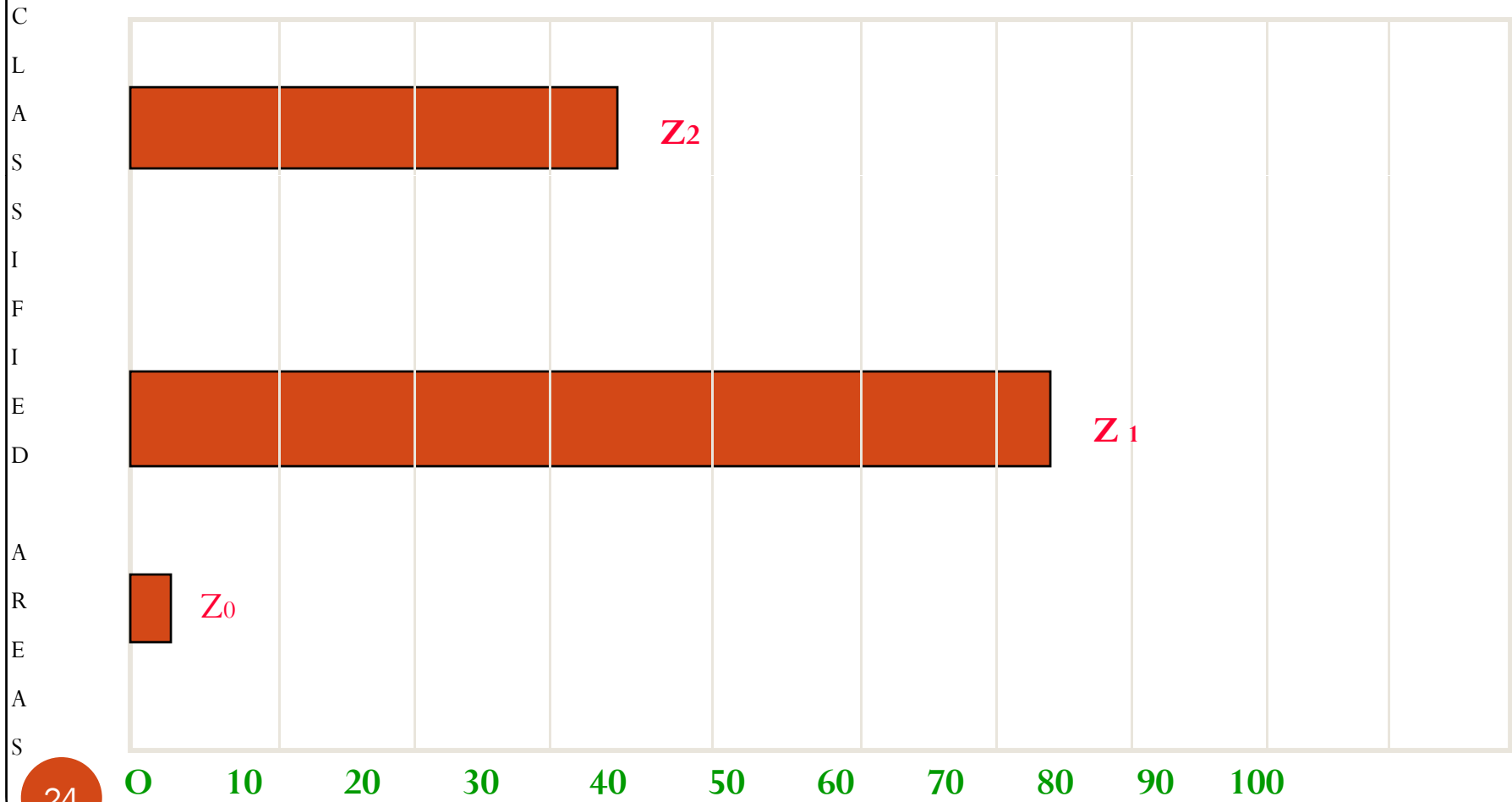


Zone 2



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PERCENTAGE OF CLASSIFIED AREAS



A FEW RELEVANT DEFINITIONS

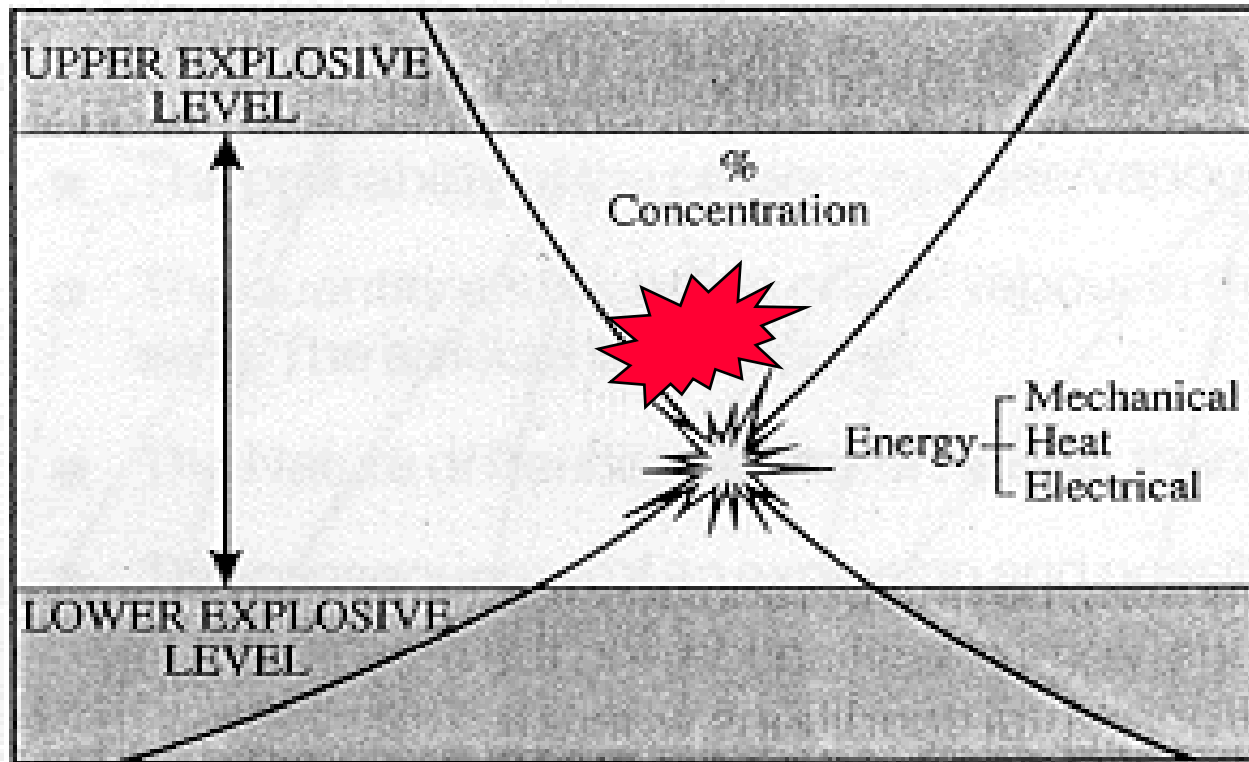
- Explosive Gas
- Flash Point - A, B, C
- Ignition Temperature
- Explosive Limits
 - LEL
 - UEL

Explosive Gases

- Flammable gases and the vapor of flammable liquids are collectively termed explosive gas as they are likely to explode when mixed with other gases. e.g., oxygen in air.
- A **critical mixing ratio**, which causes explosion, is termed the **explosion limit** and is expressed by the **volumetric ratio (Vol.%)** of the explosive gas.
- If the temperature of the mixture of explosive gas and air is raised, combustion or explosion occurs. The **minimum temperature** at which this combustion or **explosion occurs** is termed the **ignition temperature** and it varies with the kind of explosive gases.
- The hazardous characteristics of explosive gases readily create an explosive atmosphere. When electrical equipment is used in such an atmosphere, it is important to be aware of and to take measures against the generation of energy as **ignition sources**.

EXPLOSIVE LIMITS

FLAMMABLE MIXTURE, MIG, EXPLOSION





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GAS GROUP

Hazardous area is specified in term of the type of present gas

Gas Group	Representative Gas	Ignition Energy(mj)
I	Methane	280
II A	Propane	260
IIB	Ethylene	95
IIC	Hydrogen	18

Gas Group Classification

Hazardous area equipment is specified in terms of the types of gases present, being:

Group I **For mining applications**

Group II **For general industry**

Equipment must be categorized as being suitable for use with gases in Group II industries.

Group Classification Representative Gas

I	Methane
IIA	Ammonia, CO, Propane, Butane, Benzene, Acetone, Methanol
IIB	Butadiene, Ethylene Oxide, Diethyl Ether
IIC	Hydrogen

As stated these are only representative gases where in fact there are many different types of gases one can be presented with when classifying equipment.

Surface Temperature Classification Based on Ignition Temperatures

Temperature grade for explosion-protected electrical installations	Classification of explosive gases by ignition temperature
T1	Over 450°C
T2	Over 300°C up to 450°C (inclusive)
T3	Over 200°C up to 300°C (inclusive)
T4	Over 135°C up to 200°C (inclusive)
T5	Over 100°C up to 135°C (inclusive)
T6	Over 85°C up to 100°C (inclusive)

Explosive Gasas Classification Based on Ignition Temperatures

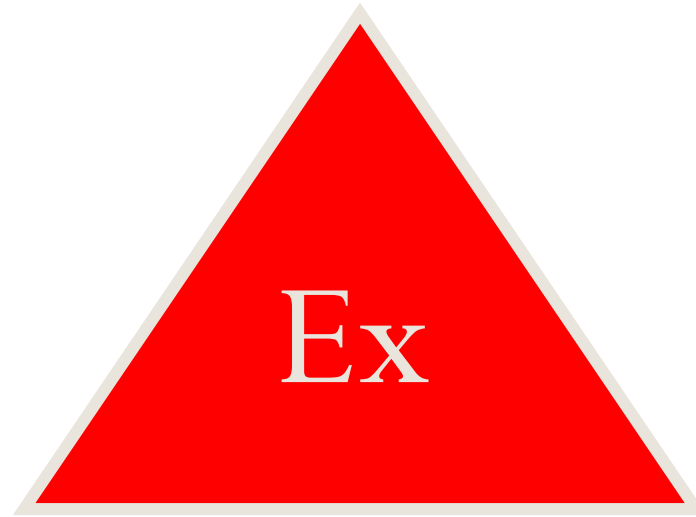
Ignition group	Ignition temperature
G1	Over 450°C
G2	Over 300°C up to 450°C (inclusive)
G3	Over 200°C up to 300°C (inclusive)
G4	Over 135°C up to 200°C (inclusive)
G5	Over 100°C up to 135°C (inclusive)
G6	Over 85°C up to 100°C (inclusive)

Auto-Ignition Temperature

is the minimum temperature required to ignite a gas or vapor in air without a spark or flame being present

GAS GROUP & TEMPERATURE CLASSIFICATION- VARIOUS GASES / VAPOURS (IS 13408 Part I)

Ser No	Name of the chemical	Minimum Ignition Current (MIC) mA	Flash point Deg. Cen.	ignition temp. Deg C)	Flammable limit	
					LEL	UEL
1	Methane I, T1	85	-	595	5%	15%
2	Ammonia II A T1	-	-	630	105 mg/l	200 mg/l
3	Ethylene II B T2	45	-	425	2.7%	34%
4	Propane II A T1	70	-	470	2%	9.5%
5	Acetylene II C T2	24	-	305	1.5 %	100%



EXPLOSION-PROTECTION METHODS

EXPLOSION-PROTECTION METHODS

Popular types

- Flameproof (**EX d**)
- Increased Safety (**Ex e**)
- Non-Sparking (**Ex n**)
- Pressurization (**Ex p**)
- Intrinsically Safe (**Ex i**)

OTHER EXPLOSION PROTECTION METHODS *(Not so popular types)*

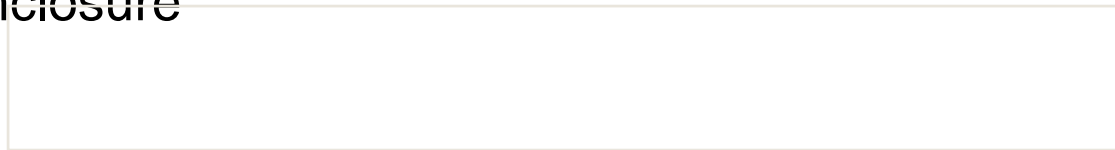
- Powder filled **Ex 'q'** type
- Oil immersed **Ex 'o'** type
- Special **Ex 's'** type

EX 'd' Type

US- Explosion-Proof, UK- Flame-Proof, GERMANY - Pressure-Proof

Definition as per IS 2148:

A type of protection in which **the parts can ignite an explosive atmosphere are to be placed in an enclosure, which can withstand the pressure developed during internal explosion of an explosive mixture**, and which prevents the transmission of the explosion to the explosive atmosphere surrounding the enclosure



Exd typical marking:

EEx d IIB T5

INTRINSICALLY SAFE EQUIPMENT & CIRCUITS **(Ex 'i')**

Definition as per IS 5780

A type of protection which a circuit or part of the circuit is intrinsically safe when any spark or thermal effect produced normally is incapable, under prescribed test conditions, of causing ignition of prescribed gas or vapor

Intrinsically safe equipment is that which has been certified safe after standard tests to ensure that the ignition sources have been suppressed.

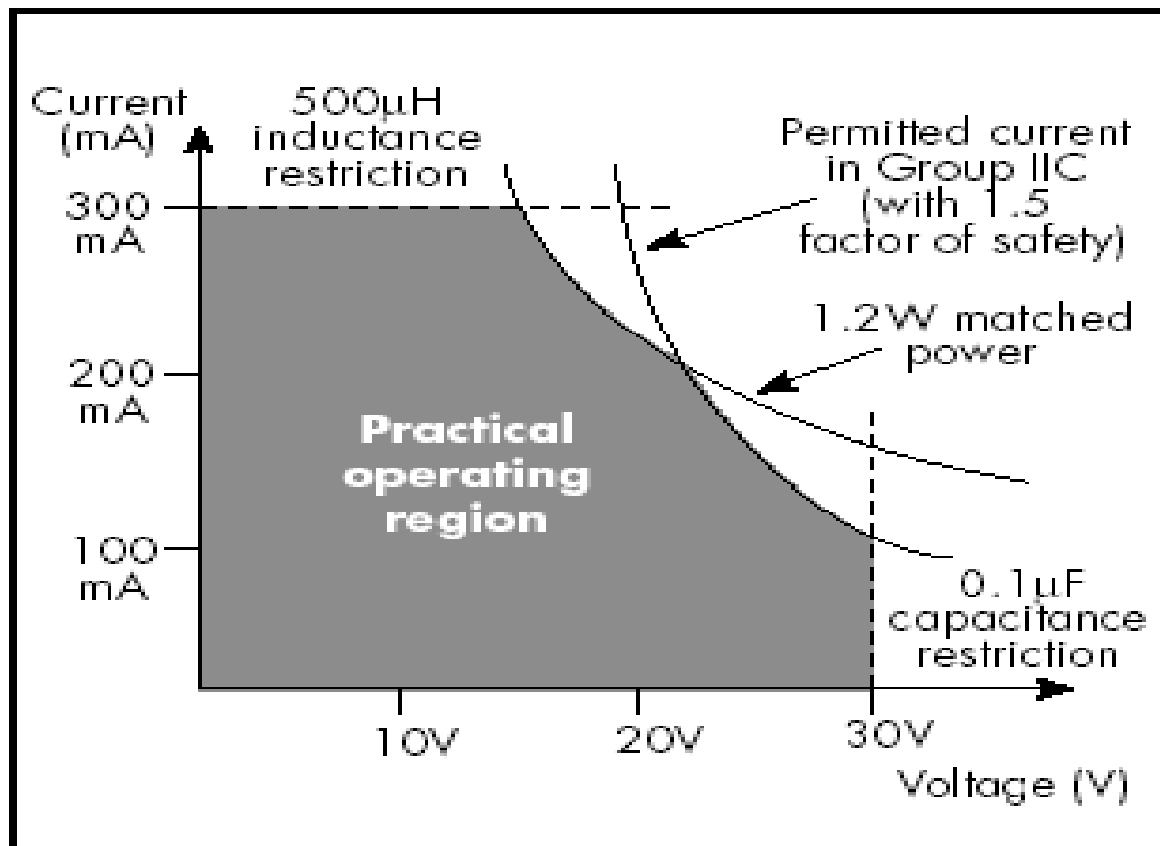
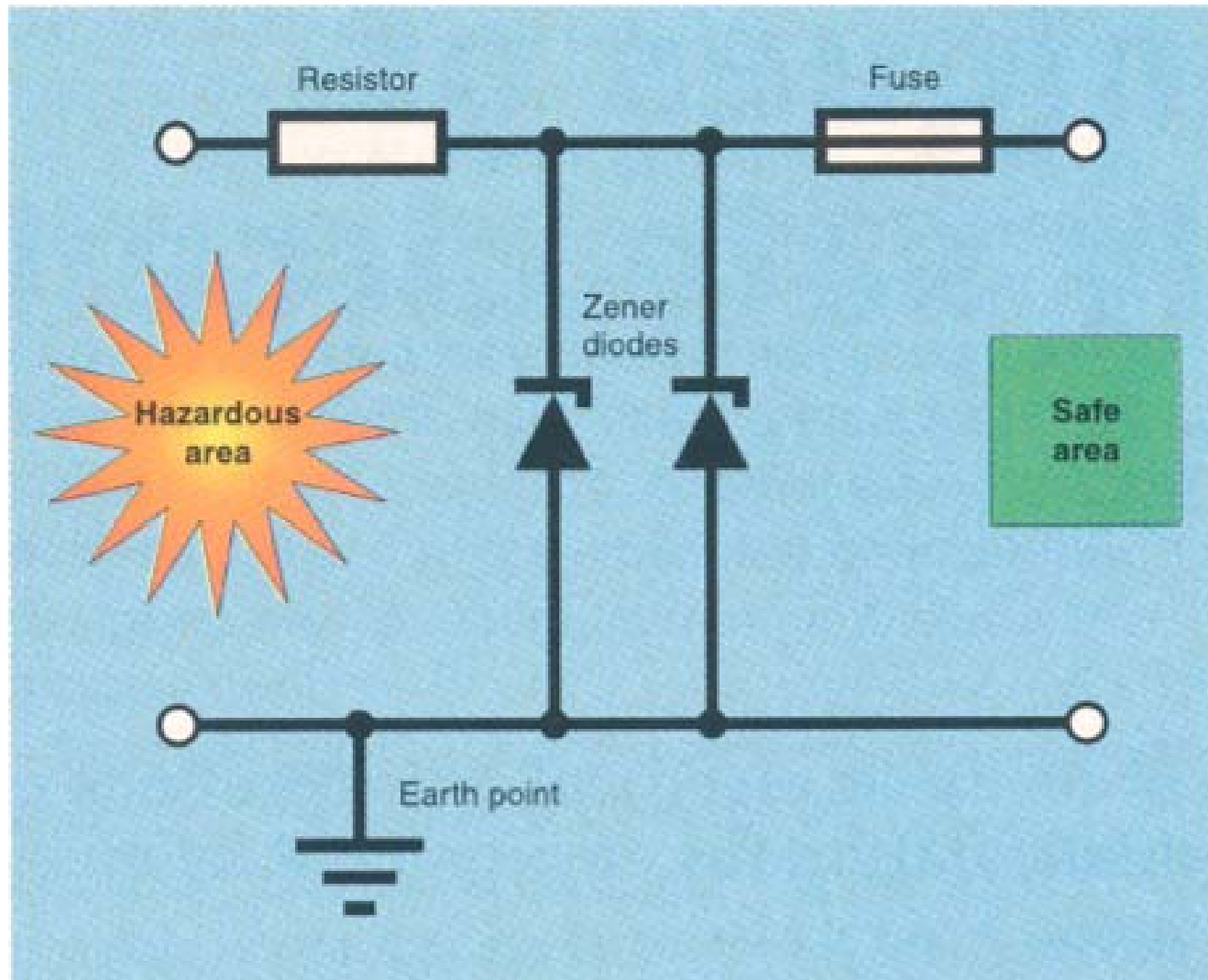


Figure 2: Practical operating region for intrinsically safe circuits



INCREASED SAFETY EQUIPMENT (Ex 'e')

Definition as per IS 6381

A type of protection by which measures are applied so as **to prevent with a minor degree of security, the possibility of excessive temperature and the occurrence of arcs or sparks in the interior and the external parts of electrical apparatus** which does not produce them in normal service

INCREASED SAFETY EQUIPMENT (Ex 'e')

Stringiest construction methods to ensure that no sparks, excessive temperature are produced

- Careful terminal design
- Use of good quality insulation material
- Use of special materials to protect the enclosure against impact, ingress of dust & moisture
- Can be used for **I, II A, B, C** gas groups
- **Permitted for us in T1, T2, T3 classes only**
- **Terminal with minimum IP 54 ingress protection**

EX d typical marking: **EEx e IIA T3**

PRESSURIZATION TYPE (Ex 'p')

Pressurized Equipment / Panels

- A minimum overpressure of **0.2 kPa (2mbar)** with reference to external atmospheric pressure
- Air intake from a safe area
- Exhaust duct outlet to be located in safe area
- **Zone 1** - can be used if there is no spark in normal service
- **Zone 1 or 2** -if ejection of spark is prevented by effective device and rapid suction of external atmosphere is prevented

NON-SPARKING TYPE EQUIPMENT (Ex 'n')

Definition as per IS 8289

A type of protection applied to electrical apparatus such that , in normal operation it is not capable of igniting a surrounding atmosphere and a **fault capable of causing ignition is not likely to occur**

EX n typical marking:

EEx n II T5

NON-SPARKING TYPE EQUIPMENT (Ex 'n')

- Equipment construction in such a way that in normal operation, it is incapable of igniting a surrounding explosive atmosphere and **a fault incapable of causing ignition**
- Hermetically sealed type
- Restricted breathing type
- Careful design of terminals
 - SUBSTANTIAL COST SAVING
- Applications
 - Tools
 - Equipment

OIL IMMERSED TYPE EQUIPMENT (Ex 'o')

- Protection technique in which the equipment or its parts are **immersed in oil** in such a way that an explosive atmosphere which, may be above the oil or outside the enclosure cannot be ignited.
- Oil used shall be mineral oil confirming to relevant standards
- Constructional features:
 - Fully enclosed, leak-proof enclosure
 - Oil level indicator
- Transformers, Switch gears, Control gears



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RECOMMENDED PROTECTION METHODS **FOR ZONE 0**

- a) No electrical equipment should be allowed.
- b) When this is not practicable, **Ex 'i'** (ia or ib) apparatus or circuits to be used
 - No transformers, motors, lights, switch gear or control system

RECOMMENDED PROTECTION METHODS FOR ZONE 1

Motors- Ex d, Ex p

Transformers & Capacitors - Ex d

Control & Instrument Transformers - Ex i

Lighting Fitting - Ex d

Switch Gear & Control Gear - Ex d

Communication/ Telephone equipment/Meters - Ex i

Portable Hand Lamps- Ex i

*Ex o, Ex q type equipment are also allowed for use as per IS

5571

RECOMMENDED PROTECTION METHODS FOR ZONE 2

Motors- Ex d, Ex p, Ex n, Ex e,

Transformers & Capacitors - Ex d, Ex p (auxiliary devices to be located in pressurized room/hermetically sealed / intrinsically safe)

Control & Instrument Transformers - Ex i

Lighting Fitting - Ex d, Ex e, Ex n

Switch Gear & Control Gear - Ex d, Ex o, Ex

Communication/ Telephone equipment/Meters - Ex i

Portable Hand Lamps- Ex i

* Minimum IP 55 (for UN-insulated parts) and IP 44 (for insulated parts) if Ex e protection is used for outdoor applications

INGRESS PROTECTION (IP)

IP XY

Ingress of Liquid

Degree of Protection of
persons against contact
with or moving parts
inside the enclosure &
Protection Of Equipment
against Solid ingress

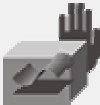





IP Types and Protection Details









FIRST NUMERAL

- 0 No protection
- 1 Objects greater than 50 mm
- 2 Objects greater than 12 mm
- 3 Objects greater than 2.5 mm
- 4 Objects greater than 1.0 mm
- 5 Dust - protected
- 6 Dust tight

SECOND NUMERAL

- 0 No protection
- 1 Vertically dripping
- 2 Angular dripping
- 3 Sprayed water
- 4 Splashed water
- 5 Water jets
- 6 Heavy seas
- 7 Effects of immersion
- 8 Indefinite immersion

1st Digit	Protection	Explanation
0	No protection	-
1	Protection against large foreign bodies 	Protection of persons from accidental large area direct contact with active or internal moving parts (e.g. hand contact), but no guarding against intentional access to such parts. Protection of the object from access of solid foreign matter larger than Ø50mm.
2	Protection against medium-size foreign bodies 	Protection of persons from finger contact with active or internal moving parts. Protection of the object from access of solid foreign matter larger than Ø12mm.
3	Protection against small foreign bodies 	Protection of persons from contact with active or internal moving parts with tools, wires or similar foreign matter thicker than Ø2.5mm. Protection of the object from access of solid foreign matter larger than Ø2.5mm.
4	Protection against granular foreign bodies 	Protection of persons from contact with active or internal moving parts with tools, wires or similar foreign matter thicker than > than Ø1mm.
5	Protection against deposits of dust 	Total protection of persons from contact with voltage carrying or internal moving parts. Protection of the object from harmful deposits of dust. Ingress of dust is not completely prevented, but dust is prevented from entering in a quantity that would impair the functioning of the object.
6	Protection against ingress of dust 	Total protection of persons from contact with voltage carrying or internal moving parts. Protection of the object from ingress of dust.

2nd Digit	Protection	Explanation
0	No protection	-
1	Protection against water dripping vertically	 <p>Water drops falling vertically must not have any harmful effect.</p>
2	Protection against water dripping up to 15°	 <p>Water drops falling at any angle up to 15° from vertical must not have any harmful effect.</p>
3	Protection against spray water	 <p>Water hitting the object at any angle up to 60° from vertical must not have any harmful effect.</p>
4	Protection against splash water	 <p>Water splashing against the object from all directions must not have any harmful effect.</p>
5	Protection against jet water	 <p>A jet of water nozzled against the object from all directions must not have any harmful effect.</p>
6	Protection against flooding	 <p>Water of temporary flooding, as in heavy seas, must not enter the object in any harmful quantity.</p>
7	Protection against dipped state	 <p>If the object is dipped into water (150mm to 1000mm), under the defined conditions of pressure and time, water must not enter the object in any harmful quantity.</p>
8	Protection during submerged state	 <p>If the object is submerged in water under defined extreme conditions, water must not enter the object in any harmful quantity.</p>

MAINTENANCE RECOMMENDATIONS IN HAZARDOUS AREAS

- FLP Equipment
 - All bolts in place
 - All openings closed
 - No site modification / alteration
 - Internal & external earthing
 - Double-Compression, FLP cable glands
 - No physical damage
 - No damage to Flame path
 - All threaded connections-minimum 5/ 6 threads engagement
 - Flange faces to be smooth & original (to be careful while opening stuck covers)

MAINTENANCE RECOMMENDATIONS IN HAZARDOUS AREAS

- Light alloy paint even for the purpose of maintenance must not be applied on any external surface of the equipment to prevent incendive frictional sparking
- Equipment shall not be tampered to open covers, etc.
- No components shall be added or removed or even replaced. This has to be done after getting re-certified by the OEM
- A scheme of regular inspection & maintenance of the items should be made on the basis of guidelines / standards. **Any equipment which is originally flameproof may lose its integrity if not maintained properly**
- **The equipment should be de-energized before attempting a repair**

MAINTENANCE RECOMMENDATIONS IN HAZARDOUS AREAS

- Periodic examination of flange gaps and flange faces for any effects of corrosion / damage, etc.
- Maintenance Tests (at an interval not exceeding 3 years)
 - IR measurements
 - Earth electrode resistance measurements
 - Earth loop resistance measurements
 - Operation & Setting of Protection devices

**THANK
YOU**