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# **ELECTRICAL RISK MANAGEMENT IN HAZARDOUS INDUSTRIES**

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## Hydrocarbon Risks

- OISD Accident compilation (1996-1999):
  - Out of the total 71 accidents (5 lakh property loss/fatality/loss of 500MH/led to plant SD ), **66% were fire accidents**
  - **47%** accidents happened during **operational jobs**
  - **Causes of accidents:**
    - 71% human error
    - 11% Failure of plant
    - 18% Presence of ignition source

Is the above '**accident cause**' grouping correct?



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## Hazardous Areas-Definitions

- **Petroleum Rules, 1976**
- An area shall be deemed to be a **hazardous area**, where:
  - petroleum having FP 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 above 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.

## COAL MINING SAFETY & CRUDE WAYS OF DETECTING METHANE GAS!!

- In the 1700's, certain gases or the lack of oxygen were detected with various hit and miss types of detection. The **candles on miners caps**, or if carried by the miner, would either go out from the lack of oxygen or the flame would get larger with a different coloring of the flame if certain gases were in the area.
- Of course, in some instances these open flames caused fires or explosions. By 1815, the **Davy's Safety Lamp** came into use in the mines. This certainly changed the way for miners to check for certain gases.
- They took these canaries in small cages with them down the coal mines where they worked. The **canaries were the miners alarm signal** to show them when the coal-gas levels got too high. The canary stopped singing and was most likely to be laid feet up on the bottom of the cage, poisoned by the mine gas.



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## 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 **not considered**
  - ESD
  - Sparks
  - Lightning
  - Flames/Fires
  - Hot surfaces
- **IS 5572**
  - HAs are classified in zones based on the frequency of the appearance and the duration of an explosive gas atmosphere.



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## Why Zoning?

- Leak Potential & Presence of Ignition Sources
- Hazardous properties of hydrocarbons
- Safe selection (& optimization) of Electrical Equipment



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## AREA CLASSIFICATION

- How many Zones as per Indian standards?
- European & American classifications (Zones and Divisions)
- Why not 'blanket' zoning?
- Is the 4th Zone really a 'safe' zone?
- Who should do HAC-Electrical or Process Engineer?



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HAC as per IS 5572 is **not applicable** for:

- Mining applications
- Explosive manufacturing
- Areas where ignitable dusts & fibers are present
- Catastrophic failures
- Ignition sources other than electrical apparatus



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## Zone 0 -Typical areas (Continuous grade)

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



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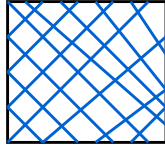
## How to identify Zone 1 areas (IS 5572) ?

(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 vapours may accumulate therein

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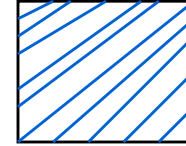
## Zone 1 -Typical areas



- 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

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## Typical Zone 2 areas (IS 5572) ? (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, Vapours 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



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## Safe Areas -Typical areas

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

- Areas where the piping system is without valves, fittings, flanges or similar appurtenances
- Areas where flammable liquids or vapours are transported only in suitable containers or vessels
- Areas where permanent ignition sources are present like area where combustion gases are present, for example flare pits, tips, other open flames & hot surfaces
- DG shed room / shed having adequate ventilation
- 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



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## 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 / Vapour
    - Class II- Combustible dust
    - Class III- Combustible fibres 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



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## A FEW RELEVANT DEFINITIONS

- Flash Point - A, B, C
- Ignition Temperature
- Explosive Limits (based on MIE)
  - LEL
  - UEL



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## HAZARDOUS AREA CLASSIFICATION-Guidelines

### Factors to be considered (IS 5572)

- Vapour / Gas Density
- Effect of Air Current
- Identification of leak scenarios



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## GENERAL CONSIDERATIONS

- In the absence of walls, enclosures, etc. & air currents, vapour/gas dispersion will depend on density & velocity. Denser gas/vapour will disperse downward and outward, lighter gases upward & outward. **HA** for a single leak source would be a circle.
- Vapours / gas released (high density releases) at or near ground level, will be found below ground, thus altering the shape of **HA**.



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## EFFECT OF AIR CURRENT

- Winds alter the shapes of hazardous areas
- A mild breeze may extend the HA and a strong wind could dilute the flammable concentration, making it non-hazardous
- But what are logically to be considered are the most unfavourable conditions

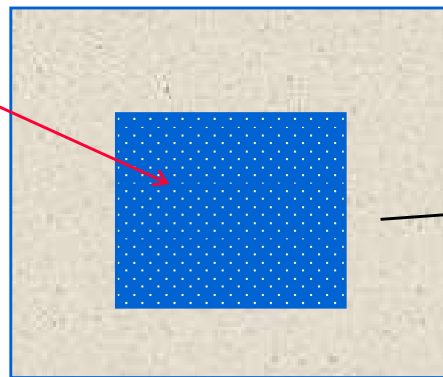
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## HEAVIER-THAN-AIR GASES & VAPOURS

- Open -Air Situations (freely ventilated Process Areas)
  - Figures 1,2)
  - Figures 3 & 4
- 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)



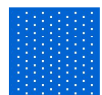
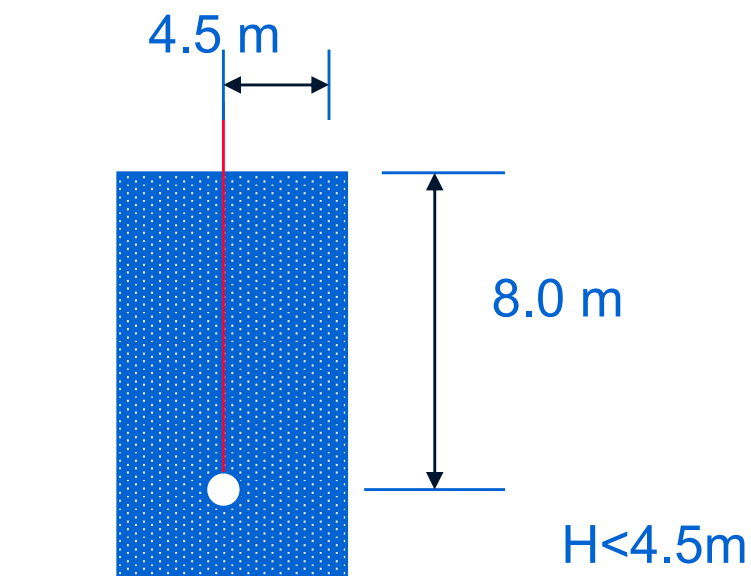
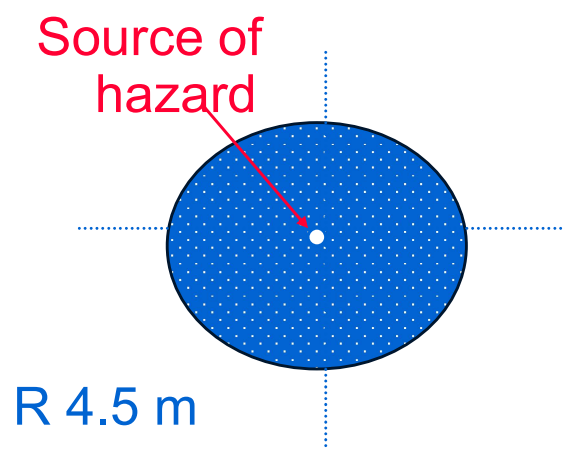
Zones 1 or 2

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## 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



Zone 2



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## How to classify areas?

- Mark in elevation and plan drawings
- Separate identification (hatching) for various zones
  - Zone 0
  - Zone 1
  - Zone 2
- Frequency of HAC?



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An experienced process engineer's judgement in visualizing leak scenarios and classifying hazardous areas is the most **CRUCIAL** factor in the **HAC** exercise



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## API RP 500- HAC Guidelines

- Adequacy of ventilation
- Accident record of the plant / business group / industry sector/maintenance standard adopted in the plant
- Sound judgement & Experience of the engineer who carries out HAC



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## AREA CLASSIFICATION AS A TOOL FOR RISK ASSESSMENT A LOGICAL APPROACH

- Perceived Limitations on the present HAC approach:
  - Ignition sources not considered
  - Reduction of zone areas & relaxation of zone designations not considered
  - Blinkers -On Approach , High cost, blanket zoning, narrow & easy approach

or in short, the full potential of HAC is not utilized at present



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## AREA CLASSIFICATION AS A TOOL FOR RISK ASSESSMENT

- EXTENDING HAC PROCEDURE

- Additional steps

- After applying the present HAC procedure, assess all ignition sources
    - Assess the grade of release using HAC-based risk assessment matrix
    - Assessing the ventilation & evaporation aspects of the chemicals considered

- Applying the new HAC procedure

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## HAC-based Risk Assessment Matrix

Grade of Ignition

| Grade of Release | Continous                                                                         | Frequent                                          | Infrequent                                    | Very Infrequent                   |
|------------------|-----------------------------------------------------------------------------------|---------------------------------------------------|-----------------------------------------------|-----------------------------------|
| Continous        |  | Unacceptable                                      | Unacceptable unless low consequences          | Acceptable (e.g. Ex i apparatus)  |
| Primary          | Unacceptable                                                                      | Unacceptable                                      | Risk Assessment required-look at consequences | Acceptable (e.g. Ex d apparatus ) |
| Secondary        | Risk Assessment required-look at consequences but probably unacceptable           | Risk Assessment required-look at consequences but | Acceptable (E.g. Ex n apparatus)              | Acceptable                        |
| Non-Hazardous    | Acceptable but examine catastrophic releases                                      | Acceptable but examine catastrophic releases      | Acceptable                                    | Acceptable                        |





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## AREA CLASSIFICATION AS A TOOL FOR RISK ASSESSMENT

### CONCLUSION

- A logical extension of the present HAC methodology & not a radical approach
- New European legislation, **ATEX 118a Directive** will be on similar lines
- The new focussed & practical HAC approach will make **HAC exercise more cost-effective**
  - **A SAFE APPROACH?**



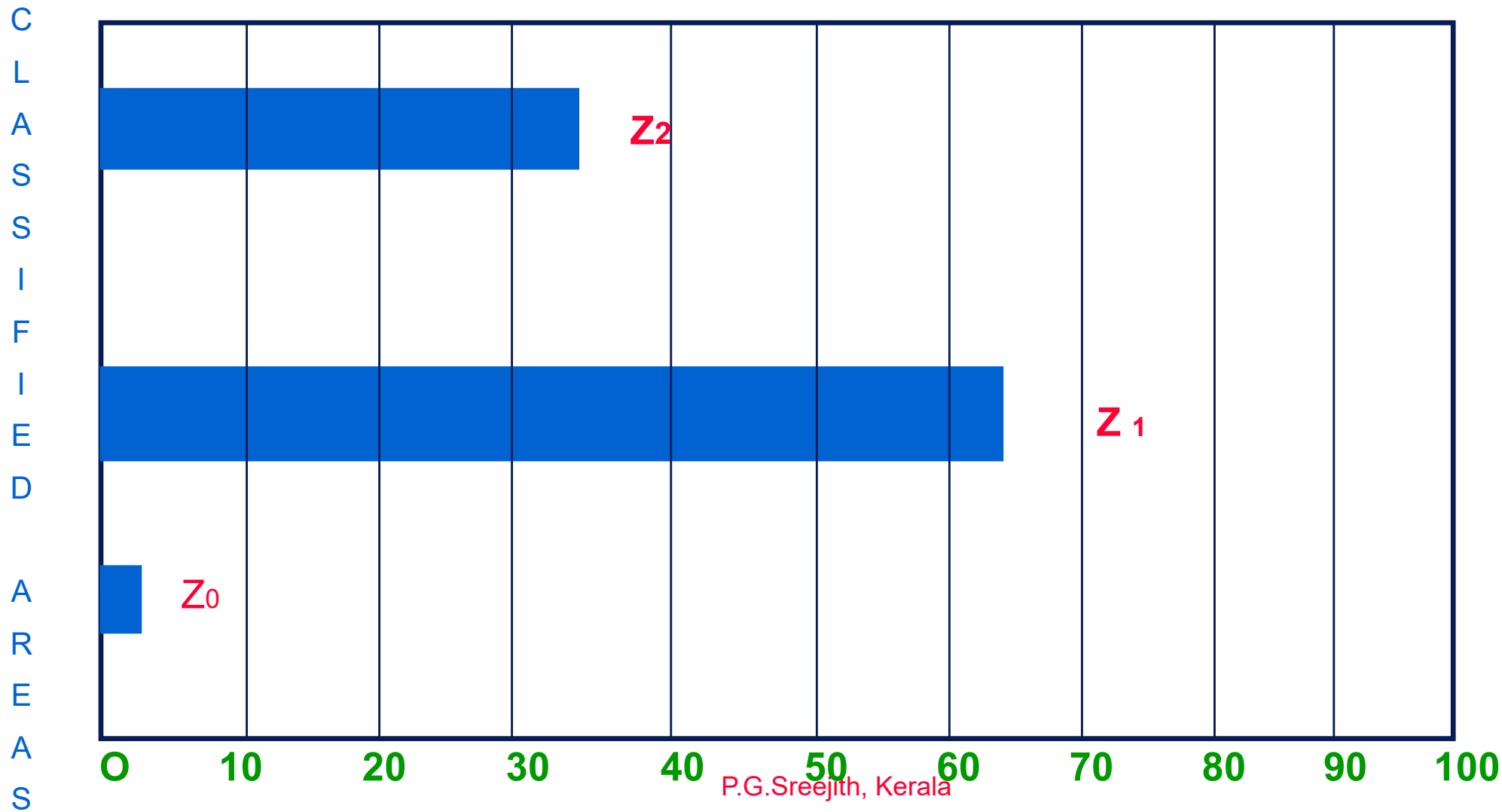
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## COMPARISON OF ZONES & DIVISIONS

| Classified area |    | Time that haz. gases are present in ignitable | Estimated % (Divisions) | Estimated % (Z) |
|-----------------|----|-----------------------------------------------|-------------------------|-----------------|
| Z0              |    | Continuously                                  |                         | <2%             |
|                 | D1 | Normally present                              | <5%                     |                 |
| Z1              |    | Occasionally in normal operations             |                         | >60%            |
| Z2              | D2 | Not normally present                          | >95%                    | <40%            |



PERCENTAGE OF CLASSIFIED AREAS



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# HAC- A RECAP



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## HAC-RELEVANT INTERNATIONAL STANDARDS

- API RP 500- Area Classification of Petroleum Installations
- IEC 79-10 :1995 -Electrical Apparatus for Explosive Gas Atmospheres, part 10 Classification of hazardous areas
- IP Part 15, 1990- Area Classification Code for Petroleum Installations
- BS EN 60079-10, : 1996 -Electrical Apparatus for Explosive Gas Atmospheres, part 10 Classification of hazardous areas
- BS 5345, 1983-Selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres (other than mining applications or explosive manufacturing), part 2, Recommendations for particular industrial situations



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## USEFUL REFERENCE BOOKS ON HAC

- Classification of Hazardous Locations, I.Chem. *E. Cox, A.W., Lees, F.P. and Ang, M.L, 1990*
- IP Model Code of Safe Practice, 1990, Part 15, Area Classification Code for Petroleum Installations
- NFPA 69, 1992, Explosion Prevention Systems
- ICI/RoSPA, 1972, ICI Electrical Installations Code
- NFPA 325M, Properties of Flammable Liquids, gases and solids
- Electrical Safety in Hazardous Locations, *William Calder & Ernest C. Magison*



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# SELECTION OF ELECTRICAL EQUIPMENT IN HAZARDOUS AREAS



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## SELECTION OF ELECTRICAL EQUIPMENT IN HAZARDOUS AREAS

- How to select equipment for various zones?
- Selection Criteria
  - Gas Grouping (based on ignition energy)
  - Temperature Classification
  - Classified Zones



Ex

## TEMPERATURE CLASSIFICATION

| T Class | Max. Surface Temperature<br>(Deg. C) |
|---------|--------------------------------------|
| T1      | 450                                  |
| T2      | 300                                  |
| T3      | 200                                  |
| T4      | 135                                  |
| T5      | 100                                  |
| T6      | 85                                   |



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## GAS GROUP CLASSIFICATION (based on MESG & MIE)

- Gas group I  
–Methane
- Gas group II A  
–Ammonia, CO, Propane, Butane, Benzene, Acetone, Methanol
- Gas group II B  
–Butadiene, Ethylene, Ethylene Oxide, Diethyl Ether
- Gas group II C  
–Hydrogen

**Which is the most hazardous group ?**



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

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



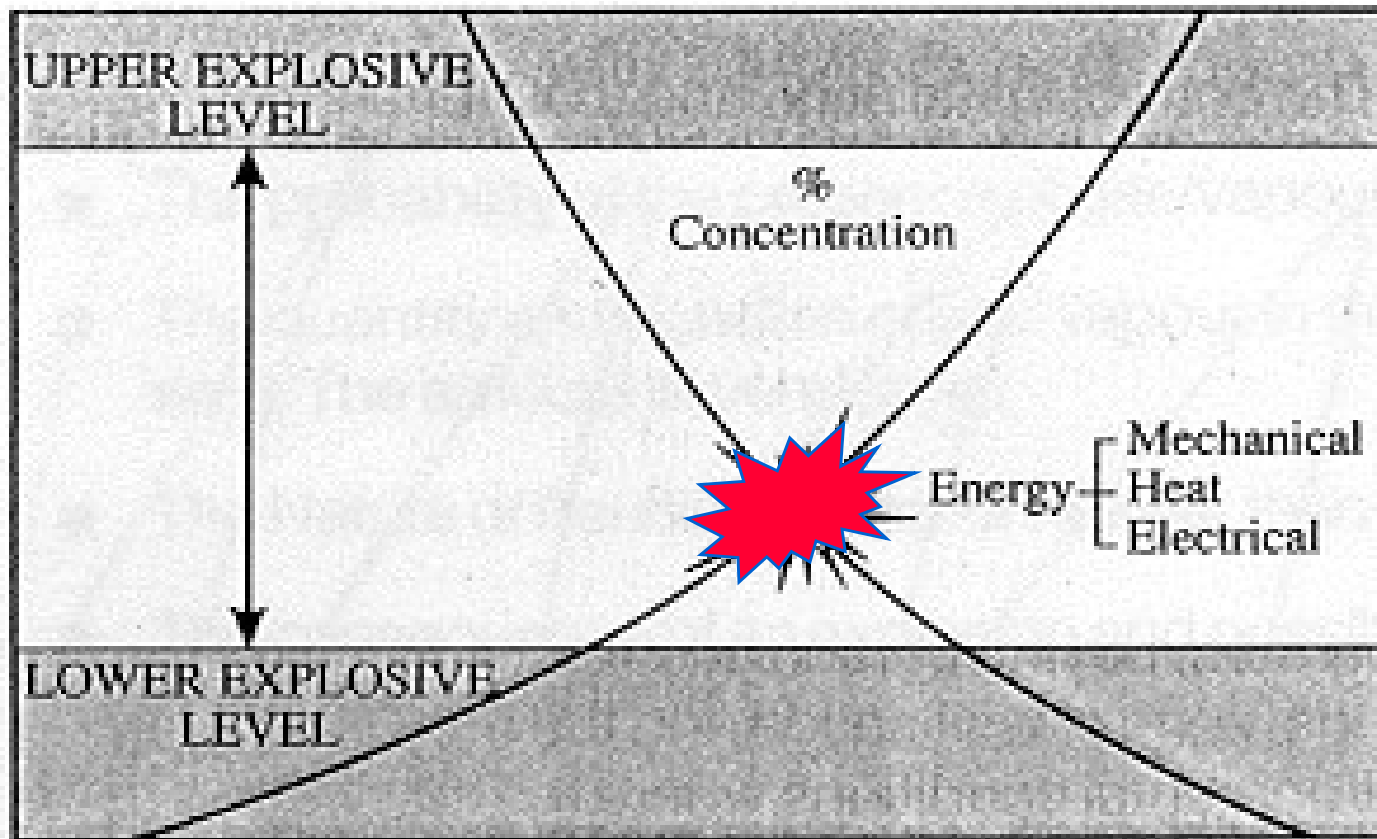
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## **GAS GROUP & TEMPERATURE CLASSIFICATION- VARIOUS GASES/VAPOURS**

| <b>Gas<br/>Group</b> | <b>Representative Gas</b> | <b>Ignition Energy<br/>(mj)</b> |
|----------------------|---------------------------|---------------------------------|
| <b>I</b>             | <b>Methane</b>            | <b>280</b>                      |
| <b>II A</b>          | <b>Propane</b>            | <b>260</b>                      |
| <b>IIB</b>           | <b>Ethylene</b>           | <b>95</b>                       |
| <b>IIC</b>           | <b>Hydrogen</b>           | <b>18</b>                       |

Ex

## FLAMMABLE MIXTURE, MIG, EXPLOSION





Ex

## RECOMMENDED PROTECTION METHODS FOR **ZONE 0**

No electrical equipment should be allowed. When this is not practicable, **Ex 'i'** (ia or ib) apparatus or circuits to be used

- No transformers, motors, lights, switch gear or control gear



Ex

## 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



Ex

## 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

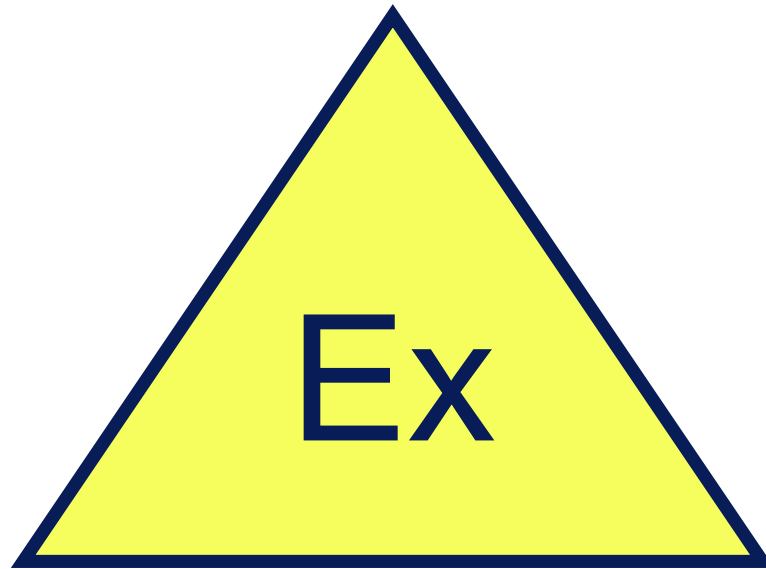
**Lighting Fitting -** Ex d, Ex e, Ex n

**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



# EXPLOSION-PROTECTION EQUIPMENT



Ex

## EXPLOSION-PROTECTION METHODS / EQUIPMENT -Popular types

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



Ex

## OTHER TYPES OF EXPLOSION PROTECTION- Not so popular types

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



Ex

Definition as per IS 2148:

EX 'd' Type **FLAMEPROOF EQUIPMENT**

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

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

**FLAMEPROOF** EQUIPMENT- A MISNOMER?



Ex

## FLAMPROOF (EXPLOSION-PROOF) PROTECTION (Ex 'd')

Assumptions based in IS 2148 are:

- Flammable gases / vapours, if present in atmosphere will enter the enclosure
- The apparatus will be selected, installed, operated and maintained within the acceptable ratings. The maintenance and use of FLP equipment shall be so that its safety will not be impaired, is the responsibility of the user
- The electric circuit of the FLP equipment will have all required protection devices
- Sparking which will ignite a flammable gas or vapour, may occur at any part of the equipment contained in the enclosure in normal operation due to an internal fault due to insulation failure, etc.



Ex

## FLAMPROOF (EXPLOSION-PROOF) PROTECTION (Ex 'd')

- **FLAME PATH** - Width of Joint  
–Minimum
- **GAP** - Diametrical Clearance  
–Maximum



Ex

## FLAMPROOF (EXPLOSION-PROOF) PROTECTION (Ex 'd')

- Maximum gaps and flame path for gas groups depends on ignition energies of the gas / vapour and the volume of the enclosure
- For example, for IIB gas group, for 100 Cubic cm volume, for flanged joints:
  - Flame Path - 6 mm
  - Maximum Gap - 0.3 mm
- For II C Hydrogen, 100 cubic cm volume, for flanged joints:
  - Flame path - 9.5 mm
  - Maximum Gap - 0.1 mm



Ex

## FLAMEPROOF EQUIPMENT- CONSTRUCTIONAL REQUIREMENTS

- USE OF APPROVED MATERIAL WITHOUT THE USE OF **INCENDIVE FRICTIONAL SPARKING**
- EQUIPMENT SHOULD **WITHSTAND ROUGH USAGE**
- EQUIPMENT SHALL BE **ADEQUATELY STRONG** TO WITHSTAND ALL REQUIRED TESTS
- THE EFFECTIVE THREADED METAL TO METAL JOINTS SHALL HAVE A MINIMUM OF 5 FULL UNINTERRUPTED ENGAGED THREADS & A MINIMUM EFFECTIVE UNINTERRUPTED DIRECT AXIAL LENGTH OF **THREADED ENGAGEMENT OF 9 mm**
- THERE SHALL BE **NO INTENTIONAL GAP** BETWEEN JOINT SURFACES
- **NO PACKING MATERIAL SHALL BE USED** BETWEEN OPPOSED SURFACES TO FORM A FLAMEPROOF JOINT
- IF COMPRESSIBLE PACKING MATERIAL OR A GASKET IS NECESSARY TO SEAL A JOINT (eg. IP) THE PACKING SHALL BE APPLIED AS A SUPPLMENT TO, BUT SHALL **NOT BE INCLUDED IN THE FLAMEPROOF JOINT**
- **ANY DISPLACEMENT, DAMAGE, INTEGRATION OR OMISSION OF THE PACKING** SHALL NOT RESULT IN THE FLAMPROOF NATURE OF THE JOINT BEING ADVERSELY



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## FLAMEPROOF EQUIPMENT- CONSTRUCTIONAL FEATURES

EX d typical marking: **EEx d IIB T5**



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## 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 vapour**



Ex

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

(insert a small photo)

- Only electrical protective measure (protection technology by way of power limitation), the other protective techniques use mechanical means to prevent ignition from electrical faults (max. 30 volts or 50 mA)
- Ex 'i' apparatus is the one which has all the circuits within intrinsically safe
- Ex 'i' circuit is the one which has intrinsically safe barriers with Zenner diodes for power limitation
- Minimum IP 20 ingress protection



Ex

## INTRINSICALLY SAFE EQUIPMENT- Category- **Ex ib**

**Ex ib** equipment shall be **incapable** of causing ignition in normal operation, with a single fault and with the following safety factors:

- 1.5** in normal operation and with one fault
- 1.0** with one fault, if the equipment contains no unprotected switch contacts in parts likely to be exposed to a potentially explosive atmosphere and the fault is self-revealing

EX i typical marking: **EEx ia IIC T5**



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## INTRINSICALLY SAFE EQUIPMENT (**Ex 'i'** )

- Cell phone explosion accident in an offshore platform
- Fuel outlets- restricted cell phone usage?



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## 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**



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## 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 use in **T1, T2, T3** classes only
- Terminal with minimum **IP 54** ingress protection

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



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## PRESSURIZATION TYPE (**Ex 'p'** )

Definition as per IS 7389

**A type of protection by which the entry of surrounding atmosphere into the enclosure of the electrical apparatus is prevented by maintaining inside the said enclosure, a protective gas at a higher than that of the surrounding atmosphere**



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## PRESSURIZATION TYPE (**Ex 'p'**) TYPES

- **Dynamic Pressurization** (DP) or pressurization by continuous circulation of protective gas (purging)
  - DP is a method of maintaining pressure in an enclosure in which after purging the protective gas is passed continuously through the enclosure at a pressure above that of the specified minimum and discharged to the outside atmosphere
  - **Static Pressurization** or pressurization with leakage compensation
    - Air supplied & pressurized continuously from a non-hazardous area to avoid ingress of flammable gases / vapour inside the enclosure



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## PRESSURIZATION TYPE (**Ex 'p'** )

### Pressurized Equipment

- Ingress protection minimum **IP 4X**
- Over pressure 1.5 times or 0.2 kPa
- Material of construction should be **flame retardant**, self- extinguishing and should not be affected by protective gas



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## 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



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## Minimum actions of Failure of Protective Gas for Ex 'p'

| Area   | Enclosure does not contain Ignition-capable apparatus | Enclosure contains I-C Apparatus |
|--------|-------------------------------------------------------|----------------------------------|
| Zone 2 | No Action required                                    | Alarm                            |
| Zone 1 | Alarm                                                 | Alarm with trip                  |



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## 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**



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## 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



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## POWDER FILLED TYPE EQUIPMENT ( Ex 'q')

- Equipment enclosure filled with quartz /sand so that in normal operating condition, any arc occurring within the enclosure of electrical equipment will not ignite the surrounding atmosphere
- No ignition shall be caused either by flame or by excessive temperature of the surfaces of the enclosure
- Enclosure constructional features:
  - High mechanical strength
  - Ingress protection
  - Powder filled
  - Insulation of enclosed equipment



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## 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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## SPECIAL TYPE EQUIPMENT (Ex 's')

- This is a concept that has been adopted to permit the certification of those types of equipment which by their nature, do not comply with the constructional or other requirements specified for equipment with established types of protection but which, nevertheless, can be shown, wherever necessary, by test to be suitable for use in hazardous areas in prescribed zones
- This concept permits flexibility on the part of certifying and assessment authorities in their approach to applications for certification of equipment the use of which would otherwise not be permitted in hazardous areas on account of non-compliance with the requirements of standards for established types of protection. This allows flexibility of approach to innovative ideas and new designs, the development of which otherwise be obstructed.
- Examples:
  - Factory sealed hand lamps, Encapsulation (Ex 'm' type), Gas detection apparatus



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Add an appropriate photo

# INGRESS PROTECTION (IP)

Ex

Insert a IP photo with gasket

Ingress of Liquid

IP

XY

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

P.G.Sreejith, Kerala



Ex

## 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



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## Indian Standards for Various Protection Techniques

- IS 5571 Guide For Selection Of Electrical Equipment For Hazardous Areas
- IS 5572 –Part I Classification of Hazardous Areas for Electrical Installations
- IS 13408 Part I, II, III Code of Selection, Installation and Maintenance of Electrical Apparatus for Use in Explosive Atmospheres
- IS 8239 Classification of Maximum Surface Temperature of Electrical Equipment for Use In Explosive Atmospheres
- IS 6381 Construction and testing of Electrical Apparatus with type of protection 'e'
- IS 2148 Flameproof Enclosures of Electrical Apparatus



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## Indian Standards for Various Protection Techniques

- IS 13346 General Requirements for Electrical Apparatus for Explosive Gas Atmospheres
- IS 5780 Specification For Intrinsically Safe Electrical Apparatus and Circuits
- IS 8240 Guide for Electrical Equipment for Explosive Atmospheres
- IS 2147 Degrees of Protection Provided by Enclosures For Low Voltage Switch Gear & Control Gear
- IS 4691 Degrees of Protection Provided by Enclosures For Rotating Electrical Machinery
- IS 8241 Methods of Marking for Identifying Electrical equipment for Explosive Atmospheres
- IS 8224 Specification for Electric Lighting fitting for Explosive Atmospheres
- IS 8289 Electrical Equipment with Type of Protection 'n'
- IS 7389 Specification for Pressurized Enclosures
- IS 2206 (PART I,III) Specification for Flame proof Electric Light Fixtures



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# INSTALLATION & MAINTENANCE OF ELECTRICAL EQUIPMENT IN HAZARDOUS AREAS



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## INSTALLATION GUIDELINES OF ELECTRICAL EQUIPMENT IN HAZARDOUS AREAS (IS 5571)

- Adequate precautions to avoid ESD & Lightning to be implemented
- Use of light alloy (Mg, Al, Ti, ) material to be assessed critically in HAs due to its incensive 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



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## INSTALLATION GUIDELINES OF ELECTRICAL EQUIPMENT IN HAZARDOUS AREAS

- 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 IS 3043
- Bonding of all pipeline flanges should be carried out so as to avoid Electro-static discharges
- Internal earthing to be provided for all FLP equipment in addition to external earthing



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## INSTALLATION GUIDELINES OF ELECTRICAL EQUIPMENT IN HAZARDOUS AREAS

- 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-HAs 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



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## INSTALLATION GUIDELINES OF ELECTRICAL EQUIPMENT IN HAZARDOUS AREAS

- Copper or Aluminium (above 16 sq. mm only) conductors can be used
- FLP plugs & sockets should have preferably PUSH-IN, TWIST-ON type to avoid ignition while insertion or removal
- Adequacy of IP equipment
- Test equipment
  - Insulation Resistance megger shall be Ex i type
  - Earth Megger shall be Ex i type
  - Hotspot Detection equipment



Ex

## 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)



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## 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 any repair



Ex

## MAINTENANCE RECOMMENDATIONS IN HAZARDOUS AREAS

- Drawings /Records
  - Updated **SLD**
  - Updated **HAC** drawing
  - Drawing with various equipment installed in various identified zones
  - Certification / re-certification records
  - IR / ER** records
- Sufficient Spare stock of critical equipment (various **Ex** types)
- **Solid obstruction**(steel structures, walls, other electrical equipment) effects (close to equipment flanges)
  - IIC - 40 mm clearance
  - IIB - 30 mm
  - II A - 10 mm
  - I - no clearance envisaged



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## MAINTENANCE RECOMMENDATIONS IN HAZARDOUS AREAS

- Integrity of **IP** equipment
  - Use of gasket is permitted if certified as part of the equipment
  - No sealing of flange faces (this could affect the ability of the enclosure to withstand the maximum explosion pressure)
  - Application of non-setting grease or anti-corrosive agent is permissible
  - Non-hardening tape can be used in II A gas groups, II B tape is to be avoided and no use of tape in II C gas groups
- Insulation integrity to be periodically tested and maintained
- Maintenance personnel
  - Inspection, Maintenance, testing, replacement and repair in HAs shall be carried out by trained personnel only
  - Refresher training for them is essential



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## 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



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## MAINTENANCE RECOMMENDATIONS FOR VARIOUS **Ex** Types (except **Ex d**)

- **Ex i** - No addition / alteration of circuit components / power limitation barriers, etc.
- Check **Ex p** equipment / panels / rooms for low pressure interlock operations, periodic review of air in take stack location
- Terminations in **Ex e, n** types equipment
- Use of non-sparking tools

**“ELECTRICAL EQUIPMENT USED IN HAZARDOUS ARAES ARE SPECIAL AND THEY NEEDS TO BE TREATED SPECIAL”**



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# STATUTORY REGULATIONS & APPROVAL REQUIREMENTS



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## Approval / Testing Agencies

- **CMRI** (Central Mining Research Institute), Dhanbad, BIHAR
- **CCoE** (Chief Controller of Explosives), Nagpur
- **BIS** (Bureau Of Indian Standards)
- **DGMS** (Director General Mine Safety), Dhanbad, BIHAR
- **DGFASLI** (Director General of Factory Advice Service and Labour Institutes), Mumbai



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## Statutory Regulations For Plants Utilizing Hydrocarbons

- Petroleum Act, 1884
  - Petroleum Rules, 1976
- Explosive Act, 1934
  - Explosive Rules, 1983
  - Gas Cylinder Rules, 1981
  - Static & Mobile pressure Vessel (Unfired) Rules, 1981

**CCE, Department of Explosives** is entrusted with the responsibility of administration of the above statutory rules in India



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## Statutory Regulations For Plants Utilizing Hydrocarbons

- Petroleum Rules, 1976 (**Chapter IV**)
- Static & Mobile Pressure Vessels (U) Rules, 1981 ( **Rule 31**)
- Gas Cylinder Rules, 1981 (**Rule 21**)

- Hazardous Area- Definition

- An area shall be deemed to be a hazardous area, where:
  - i) petroleum having FP below 65 deg. C or any other flammable gas or vapour in concentration capable of ignition is likely to be present
  - ii) petroleum or any inflammable liquid having FP above 65 deg centigrade is likely to be refined, blended, handled or stored at or above its FP



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## EXTRACTS FROM PETROLEUM ACT, 1934

- HAC- Zones 0, 1, 2
- Earth resistance values:
  - 4 ohm for electrical systems
  - 10 ohms for non-current carrying metallic parts
  - all joints in pipelines, valves, etc. shall be bonded and the earth resistance between each joint shall be 1 ohm
- Hazardous Areas as per 4th Schedule:
  - In-line with IS 5571
- Tables 1 & 2 (as per Form XIII)
  - Inter-Distances between tanks (with Classes A, B, C products)
  - Distance between tanks and tankers, offices, motors



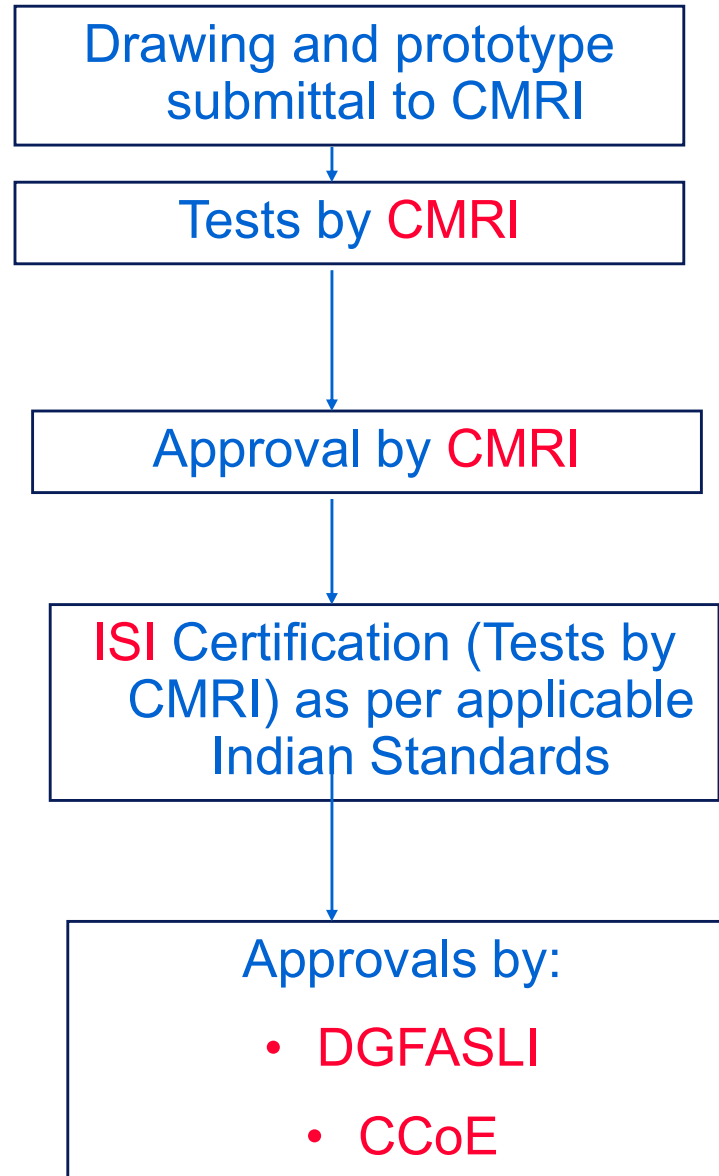
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## CMRI, Dhanbad -Approval Agency for Electrical Equipment for Use In Hazardous Areas

- Equipment testing and approvals (for all gas groups- I, II A, IIB, IIC)
- Testing and approval required for modified equipment

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# Equipment Approval Procedure





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# ELECTRICAL SAFETY AUDITING IN HAZARDOUS AREAS



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## Focus Areas

- Original HAC drawings (IS 5572)
- Plant additions / alterations
- Installation of electrical equipment in hazardous areas (IS 5571)
- Valid applicable statutory approvals (CCoE)
- Maintenance of Electrical Equipment
  - FLP
  - Pressurized equipment
  - Earthing (internal & external)



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## European ATEX Directive

- Advantages include CLEAR Zone marking, stringent quality requirements, very user-friendly
- Products will have to be re-certified as per the new harmonized ATEX standards
- CAT 3 (Zone 2) products will not require approval from a notified body (could be self-certified, if in-house test facilities are available)
- **Use** Directive ATEX137 'Protection of workers at Risk from Potentially Explosive Atmospheres'
  - Another directive for user industries
  - Will be mandatory under EU laws in 2003
  - Requirements
    - Documented evidence of analysis, HAC, inspections carried out
    - Use of ATEX certified (E & M) equipment & safety systems



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## Auditing Checklists

- OISD 145 (Section 9)
- IS 5571
- IS 5572
- IS 13408 Part I, II, III (Code of practice for selection, installation & maintenance of Electrical equipment in potentially Explosive atmospheres)



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## MAINTENANCE RECOMMENDATIONS IN HAZARDOUS AREAS

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  - IR measurements
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## TOTAL RECAP

- HAC
- EQUIPMENT SELECTION
- VARIOUS EXPLOSION PROTECTION TECHNIQUES
- INSTALLATION , MAINTENANCE & AUDITING GUIDELINES
- STATUTORY REQUIREMENTS



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## European ATEX Directive

- ATEX Directive 94/9/EC is adopted by the EU members & is concerning technical & legal requirements applicable for potentially explosive atmospheres
- CE marking is a pre-requisite if products are to be used in EU nations
- ATEX directive 100a will become mandatory on July 1, 2003
- Equipment groups (non-mining)
  - CAT 1 (Zone 0)
  - CAT 2 (Zone 1)
  - CAT 3 (Zone 2)

# CHOLAMANDALAM AXA RISK SERVICES LTD.

## COMPANY PROFILE

- JV between **Cholamandalam Investment & Finance Co. Ltd.** (Part of Murugappa group) and **AXA Insurance** of France
- Offers customized Risk Management solutions to industrial clients in ASIA, which include:
  - **Business Continuity Planning**, **Risk Analysis**, **Electrical Safety Audits**, **Safety Audits as per IS 14489**, Specialized **safety training**, Review of Fire Protection systems, etc. (as per NFPA, BIS, OISD, API, etc.)

**LET US MAKE OUR REFINERIES SAFER !!!**

**THANK YOU!!!**

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