



E&E

Eurofins MET Labs

HAZARDOUS LOCATIONS INTRODUCTION TO PROTECTION METHODS

Your industry, our focus

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HAZARDOUS LOCATION
PROJECT ENGINEER



- **Hazardous Location Classification**
- **Introduction to various protection methods allowed in hazardous locations**
- **Preliminary Design Considerations**
- **Understanding Hazardous Markings**
- **Overview of Safety Standards for Hazardous Locations**
- **Questions**

NFPA 70 – National Electrical Code (NEC)

Definition of Hazardous Location

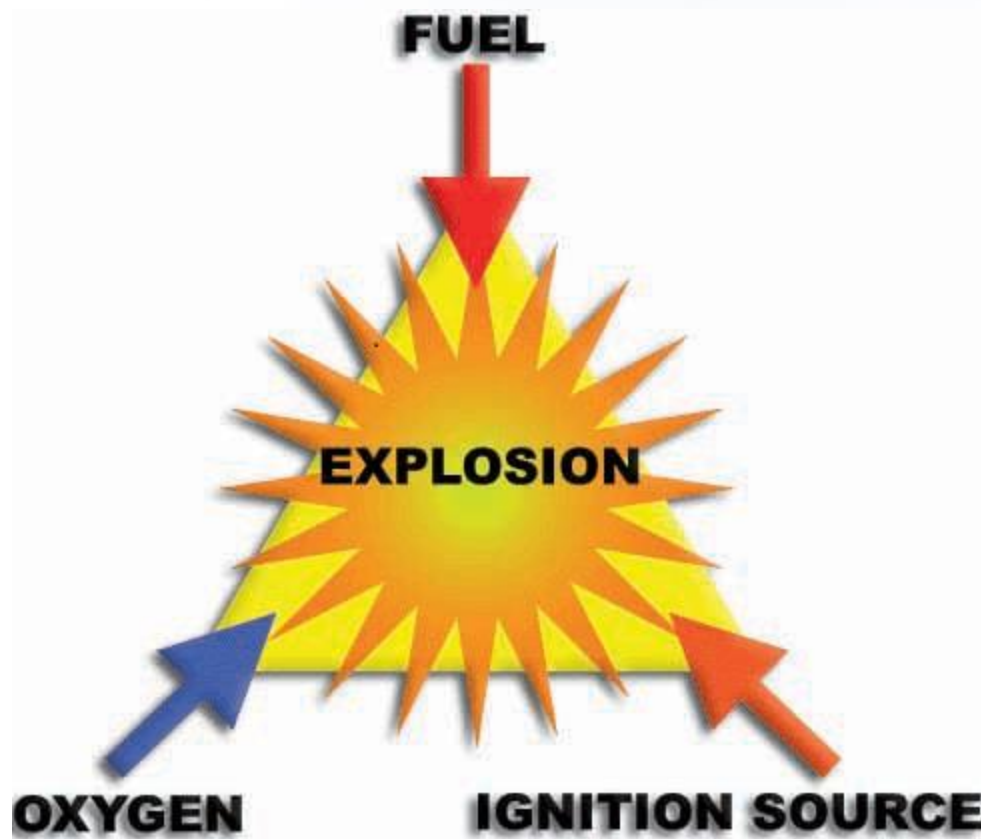
- Flammable or combustible liquid, vapor, dust, or easily ignitable fibers/flying
- Oxygen or Oxidizer
- In quantities necessary to create an ignitable mixture
- Source of energy (heat) able to create a reaction



Explosion Triangle



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Classifications



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NEC Article 500

Liquids or vapors

- **Class I Division 1 / Division 2**

Dust

- **Class II Division 1 / Division 2**

Fibers/Flyings

- **Class III Division 1 / Division 2**



Flammable gases vapors



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Class I Division 1

- Gases or vapors may exist continuously or occasionally under normal operating conditions

Class I Division 2

- Gases or vapors are not normally present under normal operating conditions

Examples: Paint booths, gas generator rooms, chemical processing plants, oil/gas platforms



Combustible Dust



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Class II Division 1

- Under normal operations combustible dust is in the air in quantities sufficient to produce an explosion or ignitable mixture

Class II Division 2

- Combustible dust in quantities necessary to cause an explosion or ignitable mixture are not present during normal operations

Examples: Flour, sugar, aluminum, magnesium

Combustible Fiber/Flyings



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Class III Division 1

- Location in which easily ignitable fibers/flyings are handled, manufactured or used

Class III Division 2

- Locations in which easily ignitable fibers/flyings are stored or handled other than in manufacturing



Examples: rayon, cotton, cotton-seed, wood

Combustible Gases / Vapors



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NEC Article 505

Liquids or vapors

- Class I Zone 0 / Zone 1 / Zone 2

Dust

- Class II Zone 20 / Zone 21 / Zone 22

Fibers/Flyings

- Class III Zone 20 / Zone 21 / Zone 22



Definitions of Zone Locations



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Zone 0

- **Present in flammable or ignitable concentrations continuously under normal operations**

Zone 1

- **Concentrations are likely under normal operations**

Zone 2

- **Not likely to occur under normal operations**

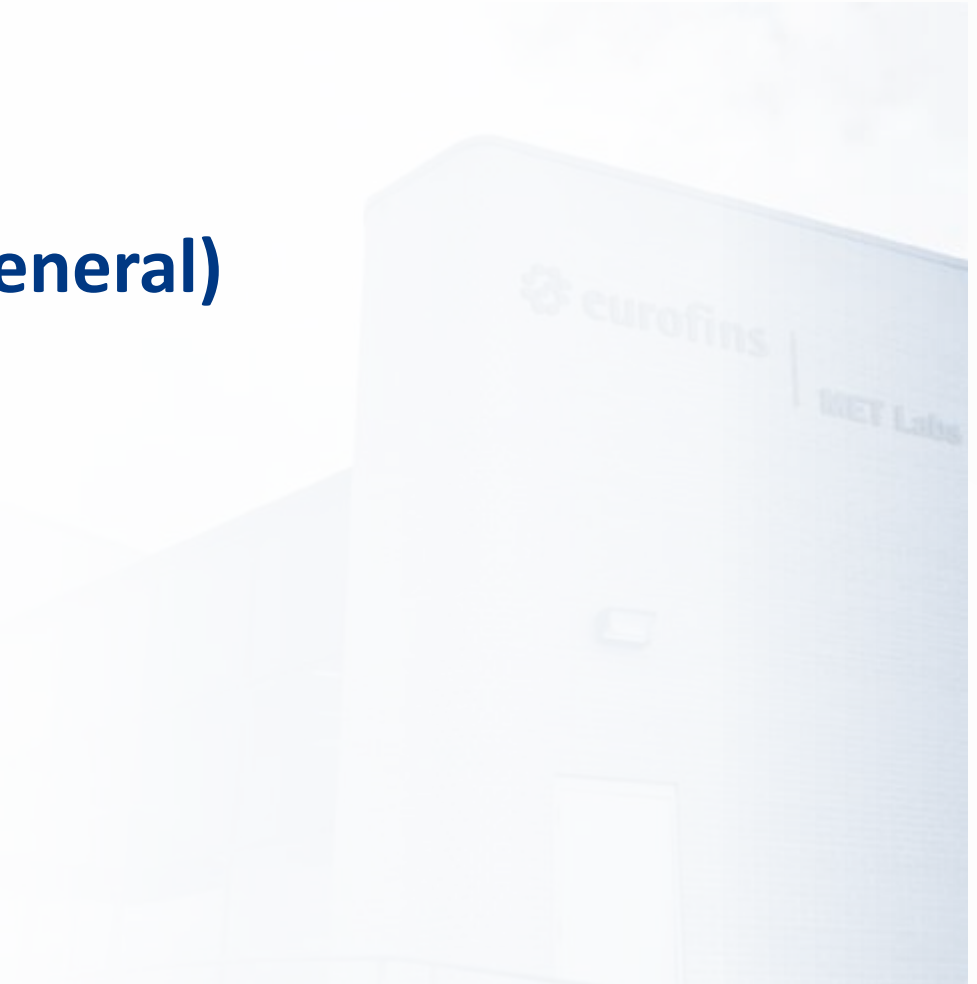


Protection Methods



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- **Explosion-proof enclosures**
- **Intrinsically safe**
- **Encapsulation (Oil, Sand, General)**
- **Pressurization**
- **Increased Safety**
- **Non-Incendive**





- Relies on an enclosure to prevent the spread of an explosion
- Enclosures are usually designed with a maximum permitted gap (i.e. flamepath) that prevents the explosion from propagating to the external atmosphere
- Enclosures are usually very robust in design
- Suitable in Class Division 1 and 2, Zone 0, 1 , and 2





Advantages

- **Suitable for all hazardous locations**
- **Robust design**
- **Protection against surges**
- **Protection against high temperatures**
- **Protection against erratic operating conditions**



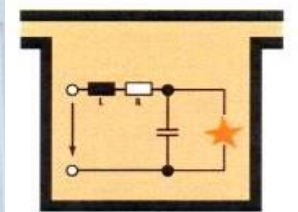


Disadvantages

- **Expensive**
- **Installation intensive**
- **Maintenance**
- **Heavy**
- **Enclosures are not easily modified**
- **Requires extensive training**
- **Large size**

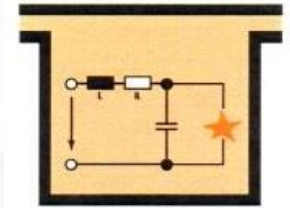


- Refers not only to individual items of equipment, but to the entire circuit.
- A circuit is considered intrinsically safe if the current and voltage are limited to such an extent that no spark or thermal ignition can occur.
- Single and multiple fault scenarios are considered
- Includes “ia” (double fault), “ib” (single fault), and “ic” (normal operation) methods
- Suitable in Division 1, 2, Zone X0, X1, and X2



Advantages

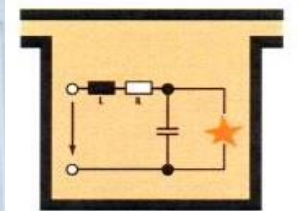
- **High reliability**
- **Maintenance is easier / low downtime**
- **Protection method is recognized worldwide**
- **Easier to install**
- **Increased personnel safety with low voltage operation**
- **Calibration and maintenance can be performed with system in operation**





Disadvantages

- Operates on low power levels
- Safety components must be appropriately rated (including temperature)
- Batteries and battery packs should have appropriate certification and protection
- Non-metallic enclosures
- Expensive





Protection Methods: Encapsulation

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- **Sand encapsulation – the enclosure of an electrical apparatus is filled with a finely granulated material**

Applications: Fuses, capacitors, circuit boards

- **Oil encapsulation – Electrical or parts of the electrical apparatus is immersed within an oil based fluid**

Applications: Switch gears, circuit-breakers, transformers

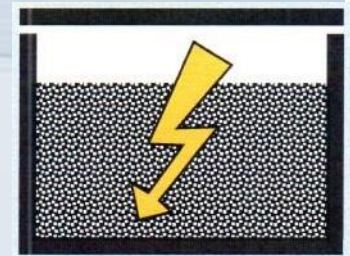
- **General encapsulation – A device that could ignite an explosive atmosphere is enclosed in a resin**

Applications: Circuit Boards, miniature motors, valves

Suitable in Division 1 and 2, Zone X0, X1 , and X2



- Voltages from 10 to 11kV are allowed
- Surrounds possible sources of ignition with sand/oil/liquid/resin
- Prevents the explosive atmosphere from igniting by gas exclusion

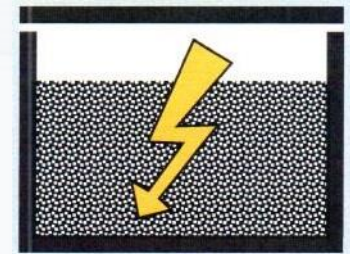


Advantages

- Low cost
- High reliability

Disadvantages

- Temperature dissipation
- Repair / reusability





- Relies on purging/pressurizing an enclosure prior to operation
- Creates a “safer” environment within the enclosure compared to external environment
- A static pressure may be used
- Continuous purging and compensation of leakage is more common
- Suitable in Division 1, 2, Zone X1, and X2





Advantages

- **Reduces hazard classification**
- **Can use standard components**
- **Disadvantages**
- **Additional cost**

Disadvantages

- **Requires equipment be turned off when pressure is lost**
- **Higher operating cost (Energy, filters, seals)**



- Intended for products in which arcs and sparks do not occur under normal operations
- Specific fault conditions are considered
- Surface temperatures
- Achieved by enhancing insulation values
- Increased creepage and clearance distances





Advantages

- **High reliability**
- **Ease of design**

Disadvantages

- **Higher cost**
- **Must use IP54 or high rated enclosure**
- **Shorter life span due to higher internal temperatures**
- **Maintenance**





- Can be described as an improved industrial quality that is designed for normal operation
- No fault scenarios are considered
- Make/break components
- Sealed components or design
- Temperature
- Ingress Protection
- Suitable in Division 2, Zone 2 only





Advantages

- **Easier to install**
- **Less complicated to maintain**
- **Less expensive**

Disadvantages

- **Can only be used in Division 2 / Zone 2 applications**
- **Non-arcing /sparking equipment**



- **Group A: Acetylene**
- **Group B: Examples – Hydrogen, butadiene, ethylene oxide**
- **Group C: Examples – Ethyl, hydrogen sulfide, ether**
- **Group D: Examples – Hexane, methane, ethanol**
- **Group E: Examples – Aluminum, bronze, zinc, titanium**
- **Group F: Examples – Carbon, charcoal, coal, coke dust**
- **Group G: Examples – wood, starch, plastics, grain**



- **Group IIA: Examples – butane, benzene, ammonia**
- **Group IIB: Examples – Acetaldehyde, ethylene,**
- **Group IIC: Examples – acetylene, hydrogen, propylene oxide**
- **Group IIIA: Examples - wood, starch, plastics, grain, solid particles greater than 500um**
- **Group IIIB: Examples – Carbon, charcoal, coal, coke dust**
- **Group IIIC: Examples – Aluminum, bronze, zinc,**



Temperature Code (T Code)

Maximum Surface Temperature

T1

$\leq 450^{\circ}\text{C}$

T2

$\leq 300^{\circ}\text{C}$

T3

$\leq 200^{\circ}\text{C}$

T4

$\leq 135^{\circ}\text{C}$

T5

$\leq 100^{\circ}\text{C}$

T6

$\leq 85^{\circ}\text{C}$

Preliminary Design Considerations



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- **Market location: USA, Canada, EU, Other**
- **Hazard locations: Class Division, Zone**
- **Environmental: Indoor, outdoor, temperature, chemicals**
- **Protection methods: Intrinsically safe, Encapsulation,...**

Preliminary Design Reviews



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Brief review of product design intended to identify major non-compliances

- Increases the chance that the product will comply when applying for certification
- Potential changes are identified up-front in the development cycle
- Decrease time and cost of certification



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- **Bill of materials (BOMs)**
- **Component certifications**
- **Power source(s) ratings**
- **User Manual**
- **Label drawings**
- **Ambient temperature ranges**





- **Product description**
- **Protection method**
- **Samples of product to be tested**
- **Desired certification US, Canada, ATEX, IEC ex**
- **Product drawings**
- **Electrical Schematics and wiring diagrams**



Additional Items

- Fully functional sample
- populated and unpopulated PCB samples
- Critical components manufacture datasheets
- Conditional of Acceptability for Recognized components
- Input / output ratings (voltage, current, power, frequency)
- Ability to apply maximum load to product



- **Mechanically generated sparks**
- **Flames**
- **Static**
- **Ionizing Radiation**
- **Stray electric currents**
- **Ultrasonic**
- **Lighting**
- **Surface Temperatures**



Markings NEC 500



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- **Manufactures Name**
- **Model Number**
- **Ambient temperature range greater or less than -20°C to +40°C ($-40^{\circ}\text{C} \leq T_{\text{amb}} \leq +60^{\circ}\text{C}$)**
- **Class I, II, or III**
- **Division 1 or 2**
- **Gas Group (A, B, C, D)**
- **Temperature Code (T1, T2, T3, T4, T5, T6)**



ABC Manufacturing Inc.

1234 S. Main St.

Baltimore MD, 12345

Box Model: Box 1234

24VDC 1.0A

$-30^{\circ}\text{C} \leq T_{\text{amb}} \leq +55^{\circ}\text{C}$

Serial No. 0123456

CLASS 1 DIVISION II, GROUP D T4

Hazardous
Location

Gas
Group

Temperature
Class

NEC 505 Markings



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- **Manufactures Name**
- **Model Number**
- **Ambient temperature range greater or less than -20°C to +40°C ($-40^{\circ}\text{C} \leq T_{\text{amb}} \leq +60^{\circ}\text{C}$)**
- **Class I, Class II, Class III**
- **Zone 0, Zone 1, Zone 2 or Zone 20, Zone 21, Zone 22**
- **Gas Group (IIA, IIB, IIB + H2, IIC)**
- **Temperature Code (T1, T2, T3, T4, T5, T6)**



Electrical Protection Types – Gas Atmospheres

- **Frameproof – “d”, “db” (Zone 1)**
- **Intrinsic safety – “ia”, “ib”, “ic” (Zone 0, Zone 1, Zone 2)**
- **Increased safety – “e”, “eb” (Zone 1)**
- **Encapsulation – “ma”, “mb”, “mc” (Zone 0, Zone 1, Zone 2)**
- **Nonsparking – “nA”, “nAc” (Zone 1, Zone 2)**
- **Pressurization – “px”, “py”, “pz” (Zone 1, Zone 2)**
- **Oil immersion – “o”, “ob” (Zone 1)**



Equipment Protection Level (EPL)

- Gas Zone 0 – Ga
- Gas Zone 1 – Gb
- Gas Zone 2 – Gc
- Dust Zone 0 – Da
- Dust Zone 1 – Db
- Dust Zone 2 – Dc





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Serial No. 0123456

Class 1 Zone 1, AEx d IIC T4 Gb

Protection
Level

Hazardous
Location

North
American

Protection
Method

Gas
Group

Temperature
Class



- **ANSI/UL 698A – Industrial Control Panels relating to Hazardous Locations (Division 1, Zone 0, 1)**
- **ANSI/UL 12.12.01 – Electrical Equipment for use in Class I and II, Division 2 and Class III, Division 1 and 2 Hazardous Locations**
- **UL 844 – Luminaires for use in Hazardous locations (Division 1, 2 and/or Zone 0, 1, 2)**
- **UL 913 – Intrinsically Safe Apparatus and Associated Apparatus for use in Class I, II, and III, Division 1 Hazardous Locations**



- **UL 1203 – Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous Locations (Class I, II, Division 1, Zone 1, Zone 20, 21, 22)**
- **UL 2225 – Cables and Cable-Fittings for Use in Hazardous Locations (Class I, II, Division 1, Zone 1, Zone 20, 21, 22)**
- **60079-0 – Explosive atmospheres – Part 0: Equipment General Requirements**
- **60079-1 – Flameproof Enclosures “d”**
- **60079-2 – Pressurized Enclosure “p”**



- **60079-5 – Powder Filling “q”**
- **60079-7 – Increased Safety “e”**
- **60079-11 – Intrinsic Safety “I”**
- **60079-15 – Non-sparking “n”**
- **60079-18 – Encapsulation “m”**
- **CSA C22.2 No. 157-92 – Intrinsically Safe and non-incendive equipment**
- **CSA C22.2 No.25-1966 – Enclosures for Use in Class II Groups E, F, and G**



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- **CSA C22.2 No.30-M1986 – Explosion-proof enclosures for use in Class 1**
- **CSA C22.2 No.213-16 – Nonincendive electrical equipment for use in Class 1 and II, Division 2 and Class III, Divisions 1 and 2**

Thank you!



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- **Are there any questions?**

