Agenda

- Hazardous Areas Overview

- Electrical Protection Methods –
  - XP, Intrinsic Safety, Purge, Non-Incendive
  - General Guidelines
  - Typical Applications
  - Strengths and Weaknesses

Hazardous Locations

- Kleen Energy in Connecticut (2010)
- Imperial Sugar in Georgia (2008)
- West Fertilizer in Texas (2013)
- BP Oil Refinery in Texas (2005)
- Timet Metals in Pennsylvania (2015)

Hazardous Locations

1986 Space Shuttle Challenger Disaster

The NASA and Morton-Thiokol lesson learned on Safety Decisions

Hazardous Locations

Definition

- A hazardous location is an area containing (or possibly containing) an ignitable concentration of flammable gas, vapor, or dust where a source of sufficient energy (electrical/thermal) cause an explosion.
- Identified by:
  - Material type
  - Risk
  - Boundaries

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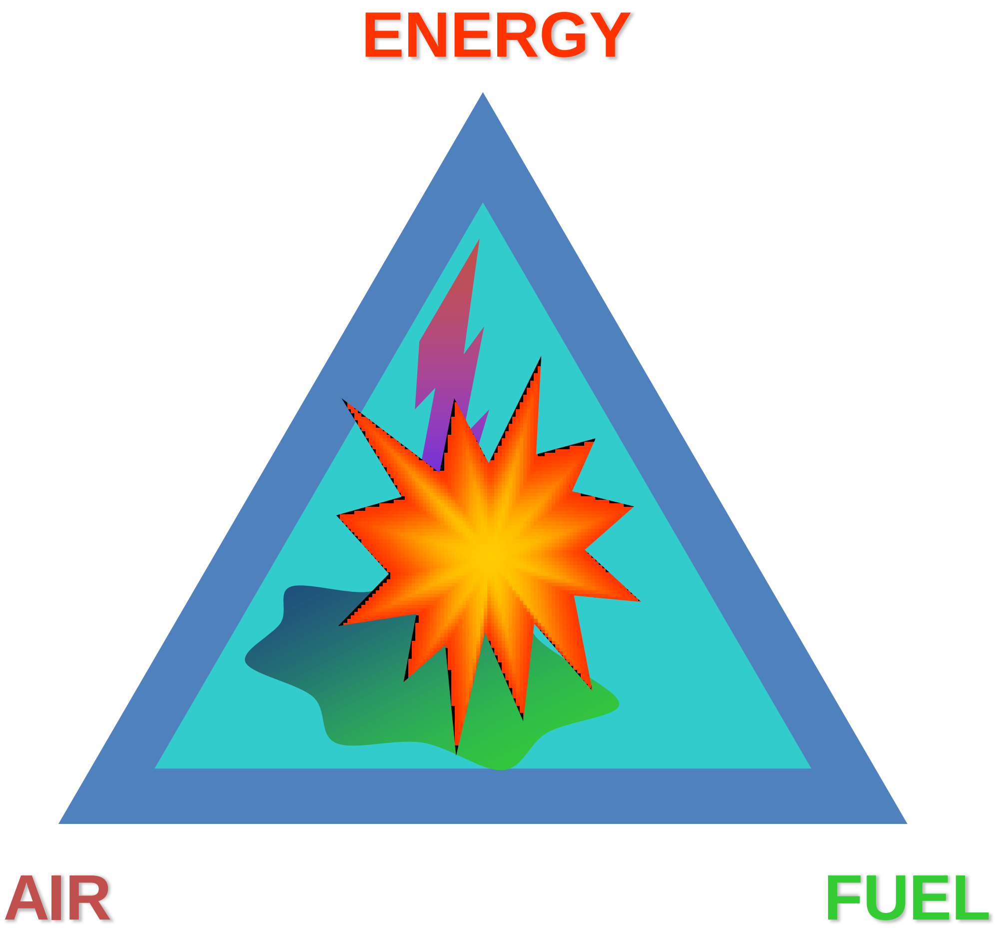
Hazardous locations

Ignition Triangle

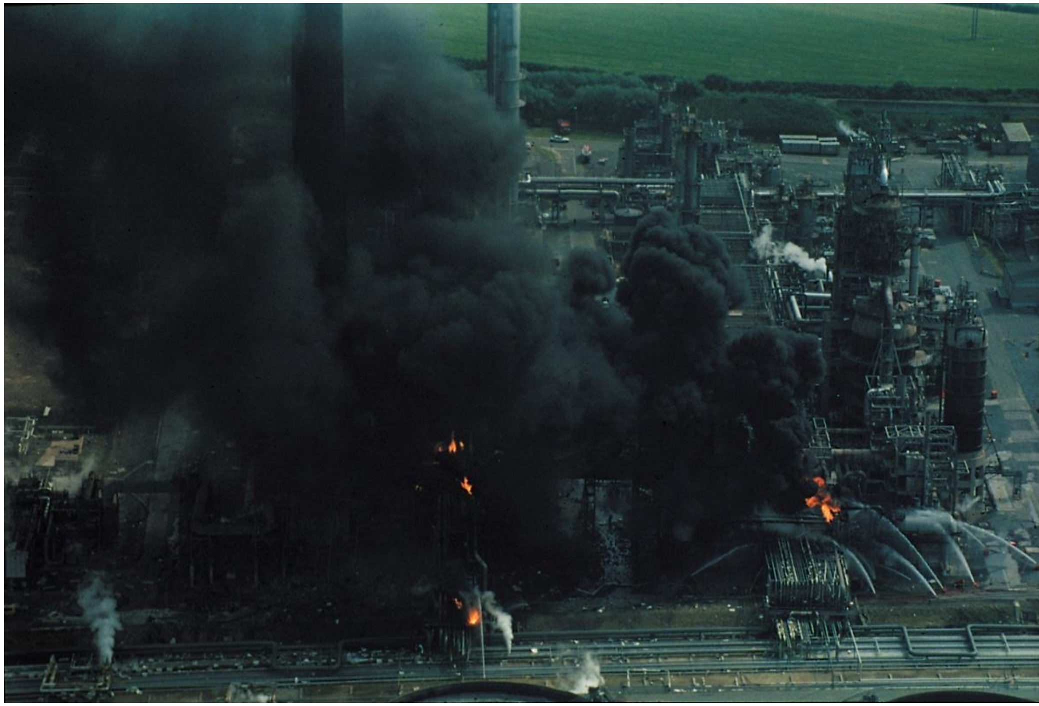
- Energy
- Air
- Fuel



Hazardous Locations

Elements of a hazardous Location

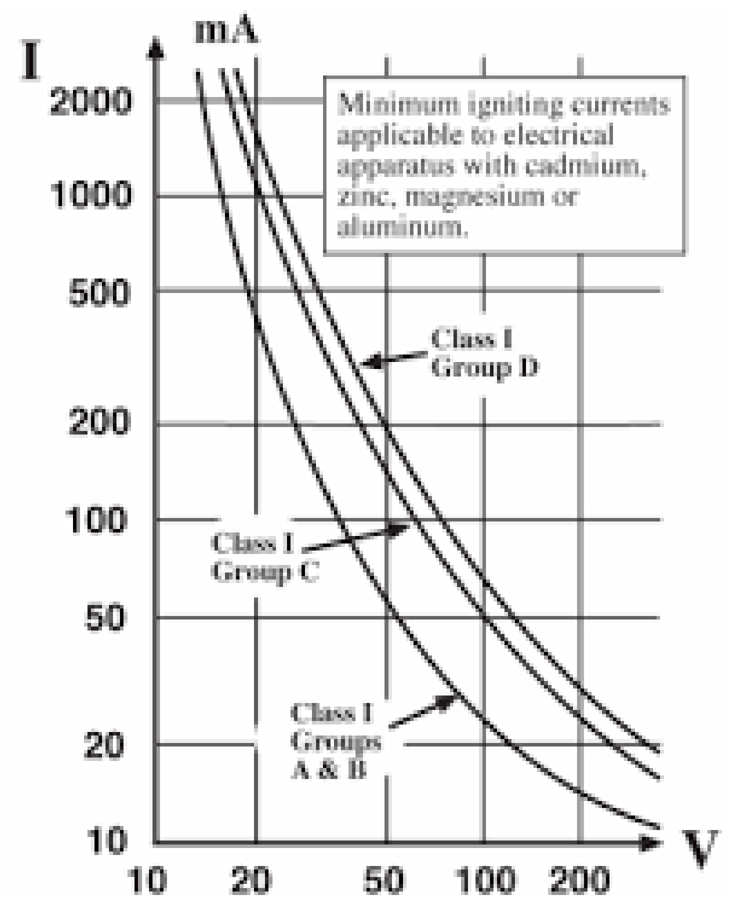
- Combustible material
  - Gas, vapor, dust
- Energy
  - Electrical
  - Thermal
- Oxygen



Hazardous Locations

Ignitable Energy of a hazardous Location

- Typically very low voltages and currents
- Varies by gas type
- Energy of ignition in some areas as little as a nickel or penny falling over



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Hazardous Locations

Classification of the Hazardous Location

- North America – Prefers Division Method
- European – Prefers Zone Method
- Rest of World – Mixture of both

Hazardous Locations – DIVS.

Classification – Material Type

Plants and installations are classified according to the <u>nature</u> of the hazard

<u>AREA CLASSIFICATION - DIVISIONS</u>

Class I…………… Gas

Class II……………Dust, Powder

Class III……………Fibers & Flyings

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Hazardous Locations – DIVS

Classification – Divisions

- The PROBABILITY that the hazardous atmosphere will be present determines the DIVISION

- Division 1 - Ignitable mixtures exist during:
  - normal operation
  - repair/maintenance
  - leakage
  - **Assumes greater than 10 hours per year of dangerous levels of gas**

- Division 2 – Ignitable mixtures exist during:
  - abnormal operation
  - Area adjacent to Div 1
  - **Assumes between 1 hour to 10 hours per year of dangerous levels of gas**

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Hazardous Locations – DIVS

Classification – Material Type

- **Groups – Division Method**

Group A - Acetylene
Group B - Hydrogen
Group C - Ethylene
Group D – Propane
Group E - Metal Dust
Group F - Carbon Dust
Group G - Flour, Grain, Starch Dust
No Group for Fibers/Flyings

Hazardous Locations – DIVS

Classification – Material Group

Representative (Test) GAS	CSA 22.1 NEC 500 Divisions 1 & 2	Spark ignition
Acetylene	Group A	Ease of ignition from spark energy
Hydrogen	Group B	
Ethylene	Group C	
Propane	Group D	

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Hazardous Locations – DIVS

Classification – Temperature Class

- **Divisions**

T1 -	450ºC	842ºF
T2 -	300ºC	572ºF
T2A -	280ºC	536ºF
T2B -	260ºC	500ºF
T2C -	230ºC	446ºF
T2D -	215ºC	419ºF
T3 -	200ºC	392ºF
T3A -	180ºC	356ºF
T3B -	165ºC	329ºF
T3C -	160ºC	320ºF
T4 -	135ºC	275ºF
T5 -	100ºC	212ºF
T6 -	85ºC	185ºF

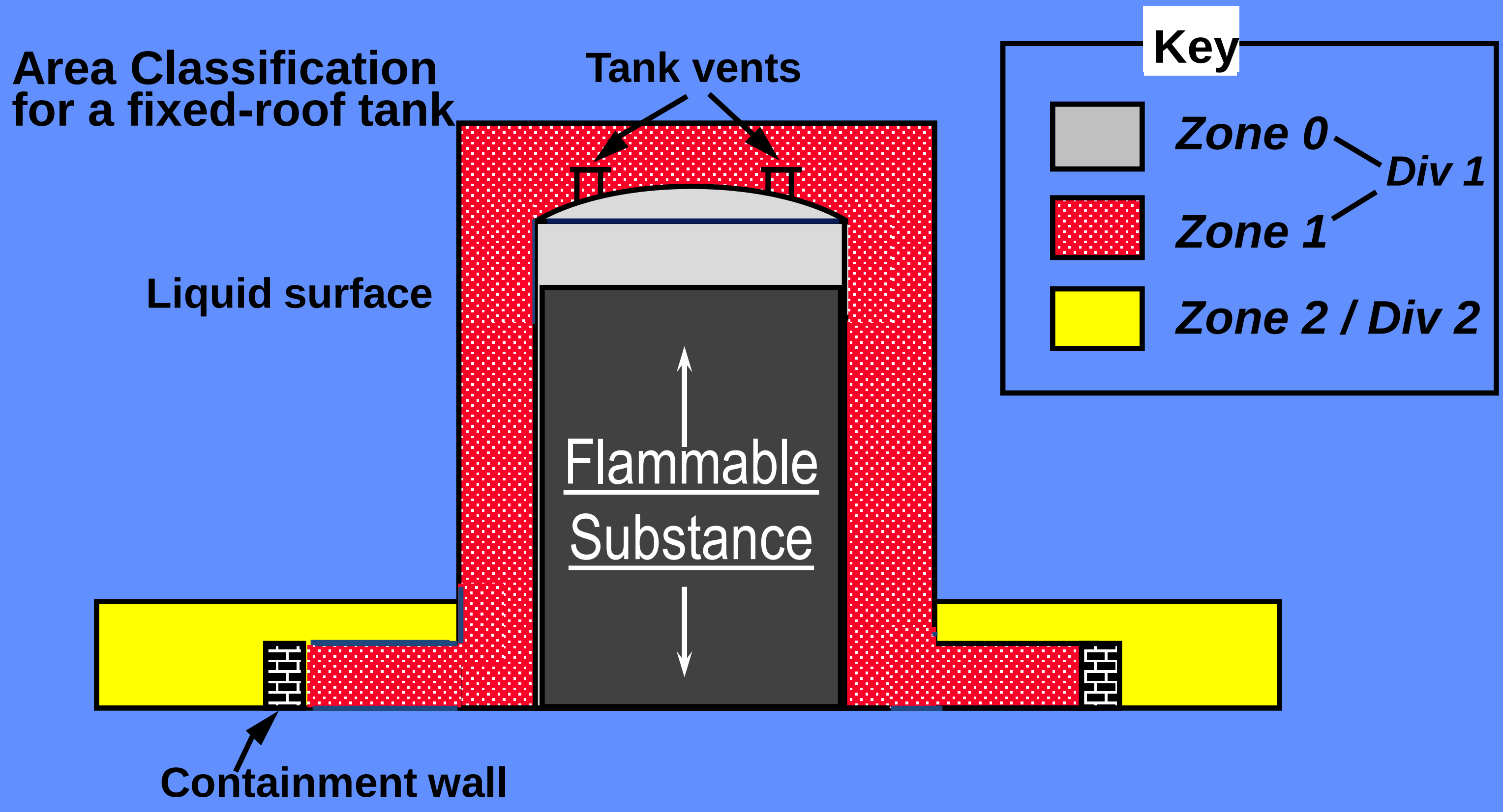
Hazardous Locations – DIVS

Classification – Temperature Class

- **Auto Ignition Temperature**

Methane – 580 Celsius
Hydrogen – 560 Celsius
Propane – 493 Celsius
Ethylene – 425 Celsius
Acetylene – 305 Celsius
Naptha – 290 Celsius
Carbon Disulfide – 102 Celsius
Sugar – 460 Celsius
Wood – 340 Celsius
Flour – 340 Celsius
Grain Dust – 300 Celsius
Tea – 300 Celsius

Hazardous Locations – DIVS



Division/Zone Classification Example

Overview – Divisions

- Division Method – Class; Division, Group, Temp
  - Class I, Division 1, Group A,B,C,D; T4 (haz. Present all the time)
  - Class I, Division 2, Group A,B,C,D; T4 (haz present abnormally or adjacent to Div 1)

Hazardous Locations - Zones

Classification – Material Type

AREA CLASSIFICATION - ZONES

Class I…………Flammable Gas or Vapor

Classification – Zones

- The PROBABILITY that the hazardous atmosphere will be present determines the Zone

- Zone 0 - Ignitable mixtures exist:
  - Continuously
  - Extended periods of time

- Zone 1 – Ignitable mixtures likely to exist:
  - Adjacent to Zone 0
  - Normal operation
  - During maintenance

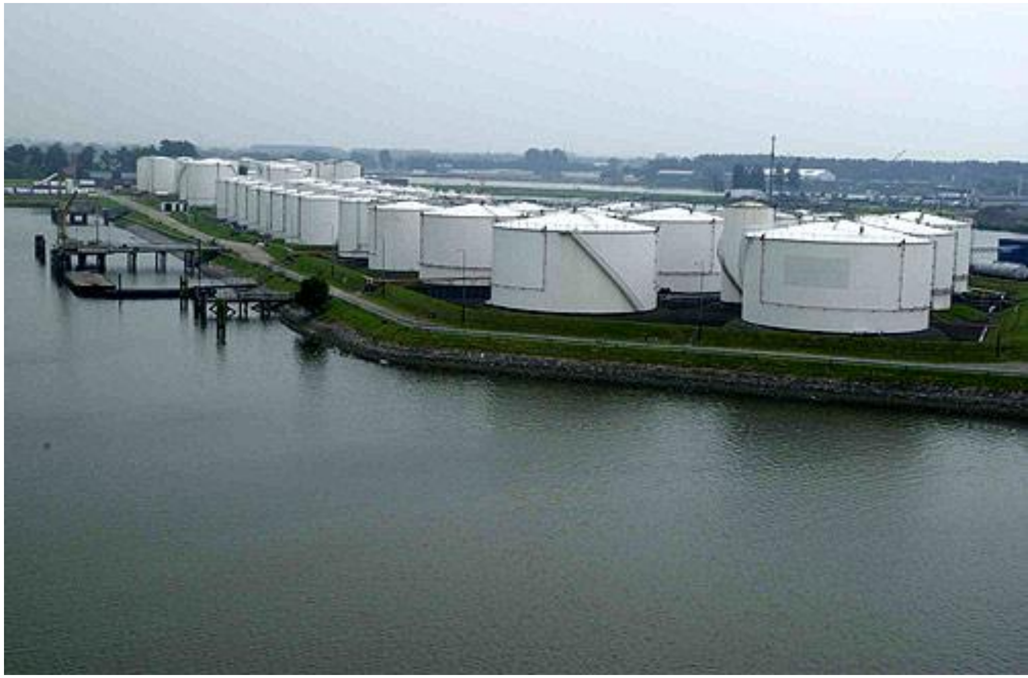
- Zone 2 – Ignitable mixtures likely to exist:
  - Adjacent to Zone 1
  - Not likely under normal operation
  - For Short periods of time

Hazardous Locations - Zones

Classification – Material Type

- **Groups – Zone Method**

Group I – Methane (mine use only)
Group IIC – Acetylene, Hydrogen
Group IIB – Ethylene
Group IIA – Propane



Hazardous Locations - Zones

Classification – Material Group

Representative (Test) GAS	CSA 22.1 NEC 505 Zones 0,1 & 2	Spark ignition
Acetylene	Group IIC	Ease of ignition from spark energy
Hydrogen	Group IIC	
Ethylene	Group IIB	
Propane	Group IIA	

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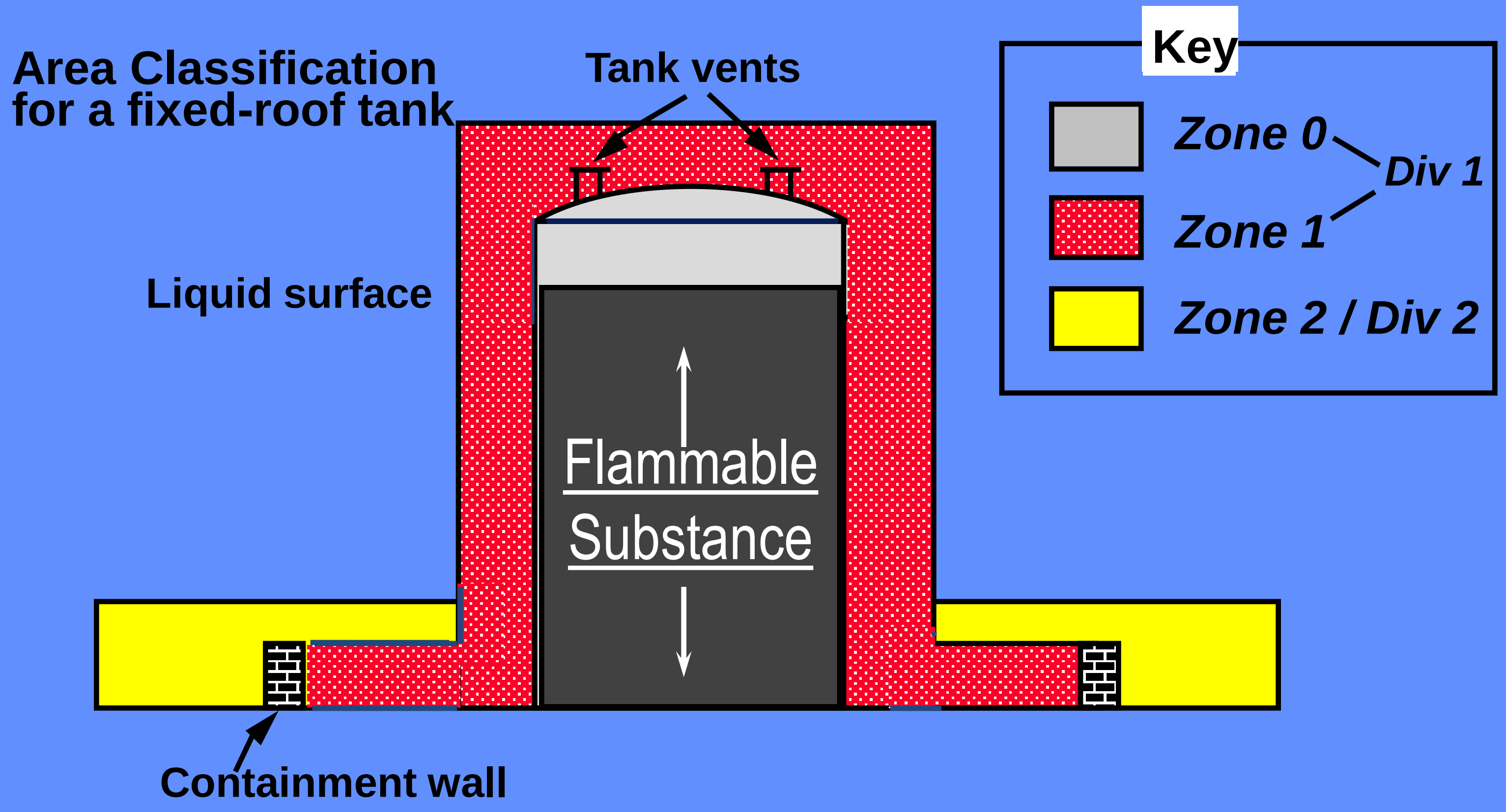
Hazardous Locations - Zones

Classification – Temperature Class

- **Zones**

T1 -	450ºC	842ºF
T2 -	300ºC	572ºF
T3 -	200ºC	392ºF
T4 -	135ºC	275ºF
T5 -	100ºC	212ºF
T6 -	85ºC	185ºF

Hazardous Locations - Zones



Division/Zone Classification Example

ts

Hazardous Locations - Zones

Classification – Grade of Release

- **Zones** (quantified compared to Divisions)

Grade of release	Nature of release	Presence in hours/year	Hazardous ZONES/DIVISIONS Gas or Vapors
Continuous	Continuously or for long periods	>1000h	ZONE 0
Primary	Periodically or occasionally during normal operation	10h to 1000h	ZONE 1
Secondary	Not in normal operation, infrequently and for short periods	0.1h to 10h	ZONE 2

Hazardous Locations - Zones

Overview – Zones

- Zone 0 – hazardous continuous or more than 100hrs
- Zone 1 – Likely to be hazardous under normal operation (10 to 100hrs)
- Zone 2 – Not likely to be hazardous under normal operation (0.1 to 10hrs)

Hazardous Locations

Classification – Comparison

- **Divisions Vs. Zones**

AREA CLASSIFICATION			
HAZARD / COUNTRY	CONTINUOUS	PRIMARY (Likely)	SECONDARY (Not Likely)
European / International	ZONE 0 ZONE 20	ZONE 1 ZONE 21	ZONE 2 ZONE 22
North American Zones	ZONE 0	ZONE 1	ZONE 2
North American Divisions	DIVISION 1 (Normal Operation)		DIVISION 2 (Abnormal Op)

Hazardous Locations
Classification – Comparison

➢ **Divisions Vs. Zones**

GAS/APPARATUS CLASSIFICATION				
HAZARD	IEC CENELEC	NEC 505	NEC 500	Ignition Energy
METHANE	GROUP I (Mining)	Under M.S.H.A jurisdiction		>320µJ
ACETYLENE HYDROGEN ETHYLENE PROPANE	Group IIC Group IIC Group IIB Group IIA	Group IIC Group IIC Group IIB Group IIA	Class I Group A Class I Group B Class I Group C Class I Group D	> 20µJ > 20µJ > 60µJ >180µJ
Metallic Dusts Carbon Dusts Non-Cond. Dusts	In Preparation	None	Class II Group E Class II Group F Class II Group G	More Easily ignited
Fibers & Flyings	None	None	Class III	

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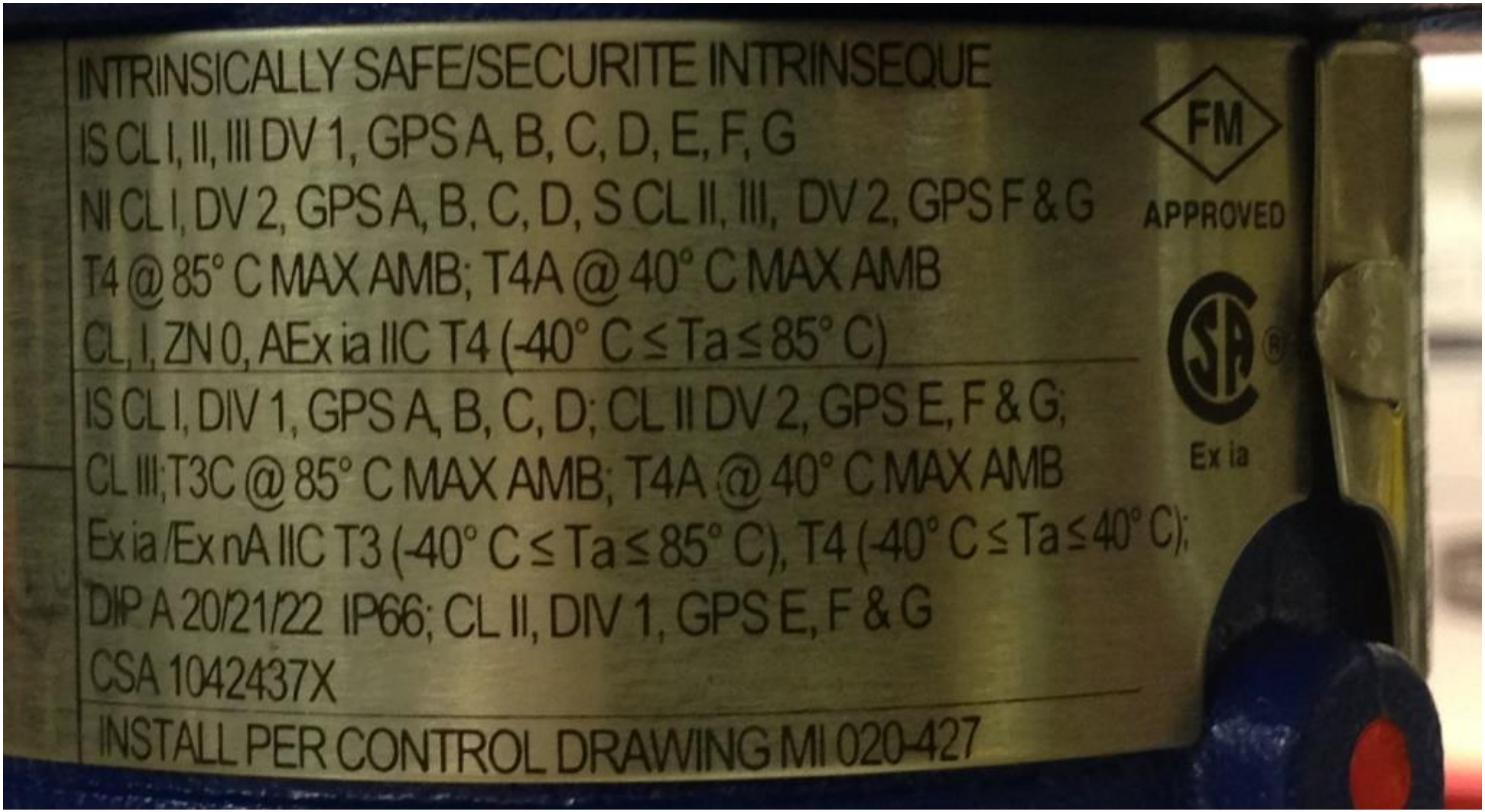
Hazardous Locations

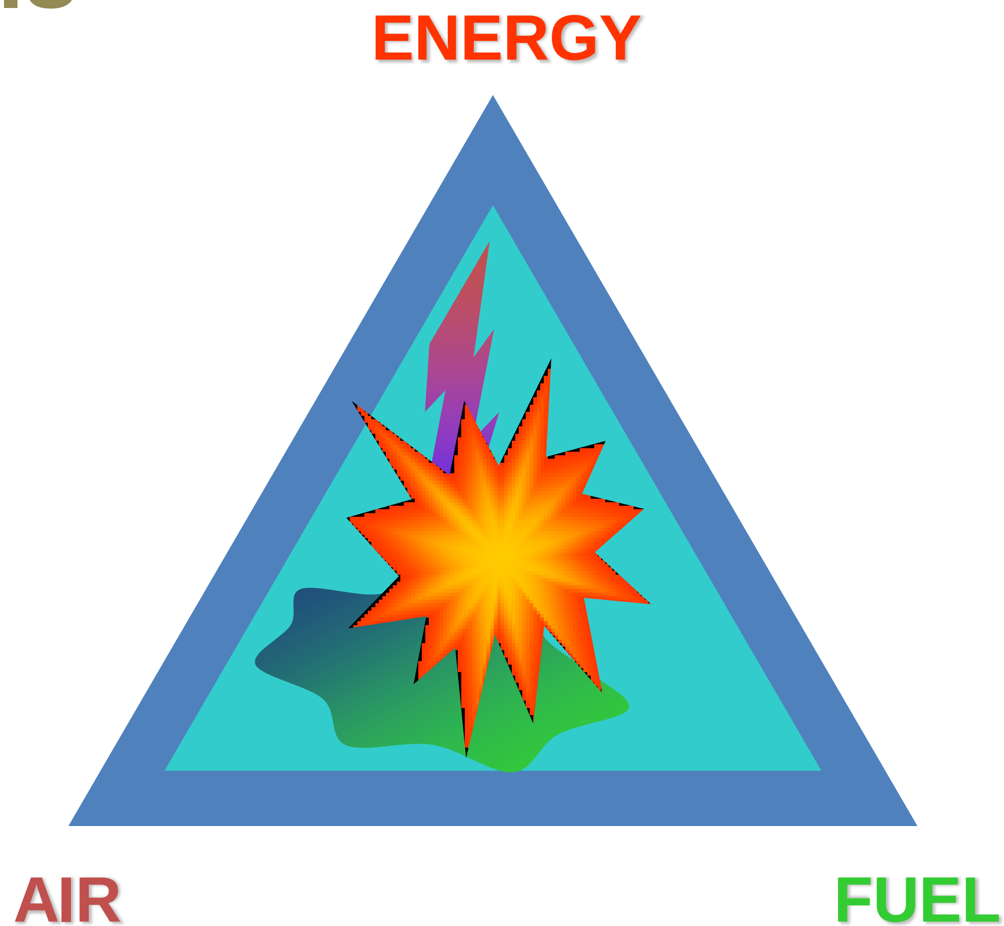
A "simple" label example



Methods of Protection

3 Basic Principals

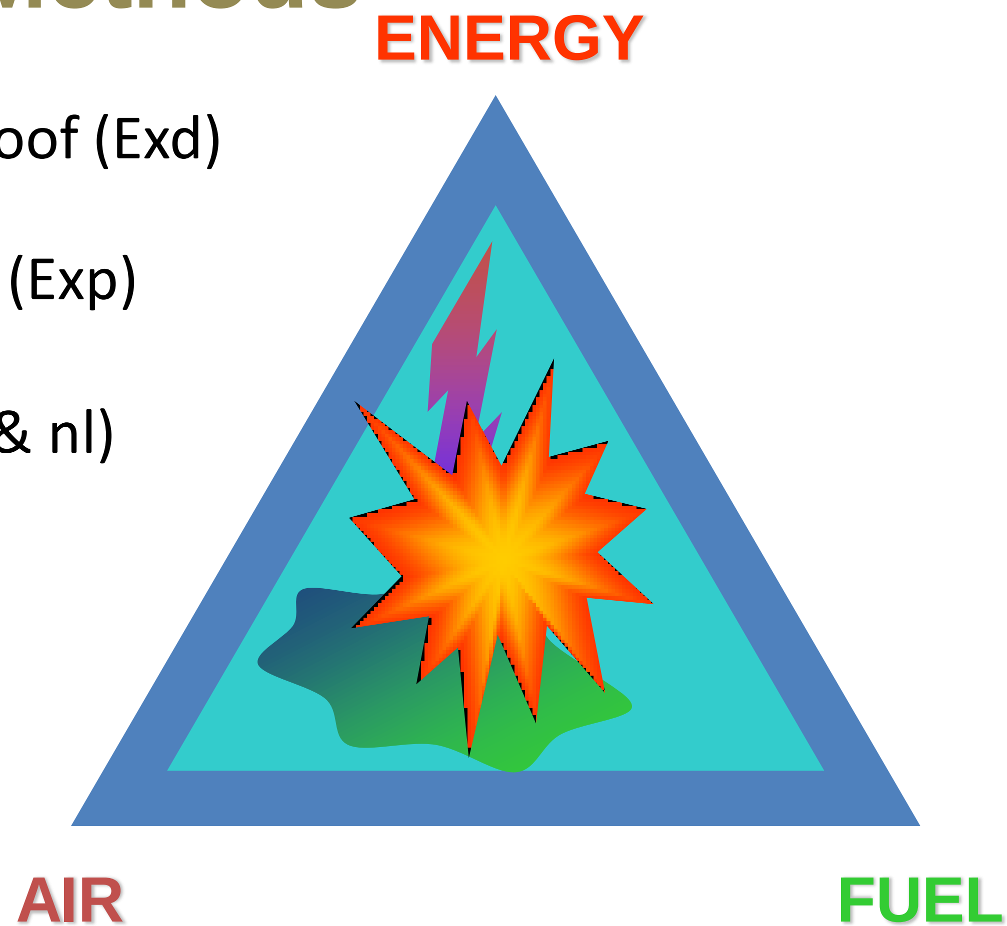
- Containment
- Segregation
- Prevention



Methods of Protection

NEC Classified Methods

- Explosion or Flame Proof (Exd)
- Purging / Pressurizing (Exp)
- Non-Incendive (ExnA & nl)
- Intrinsic Safety (Exi *)



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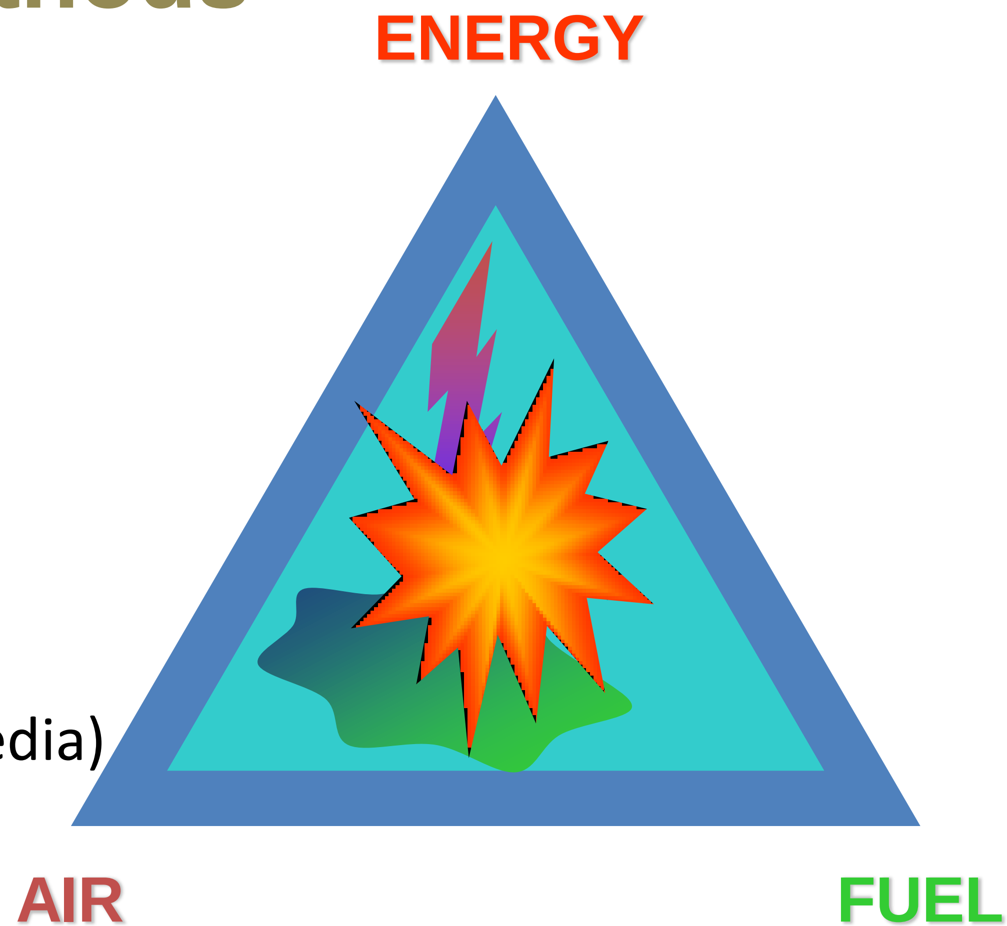
Methods of Protection

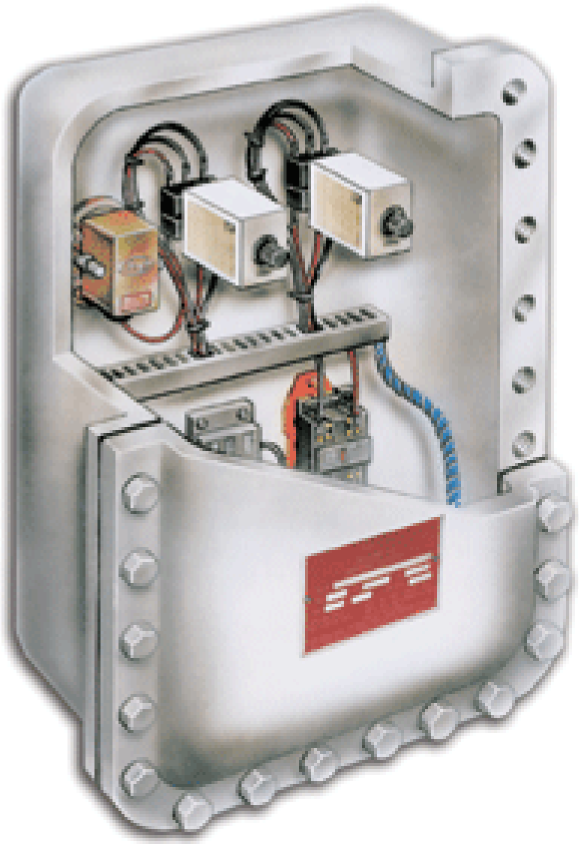
Lesser Used Methods

- Hermetically Sealed
- Dust-Tight
- Increased Safety
- Encapsulated
- Oil-Filled (or other media)



Methods of Protection
Flame proof / Explosion proof (Exd)

Containment



Methods of Protection

Flame proof / Explosion proof (Exd)

- **NEC Rule #1: Must be able to contain an internal explosion enough, or prevent an internal spark enough, to prevent a much larger explosion external to the box**

- **NEC Rule #2: Must be able to operate at a temperature (both internally and on the box surface itself) that is below the lower temperature threshold of the surrounding potential gas so as to avoid a temperature ignition from occurring**

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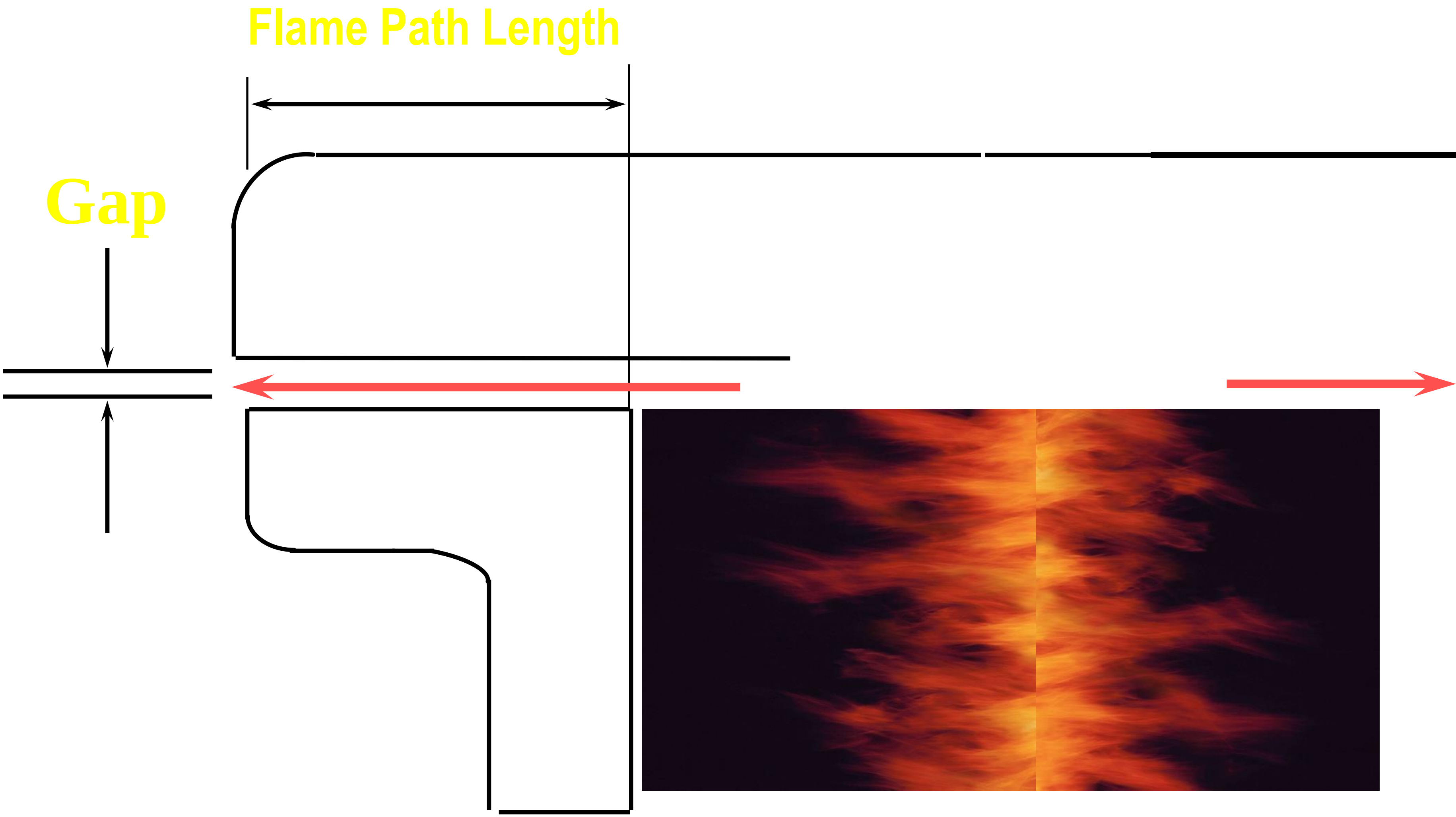
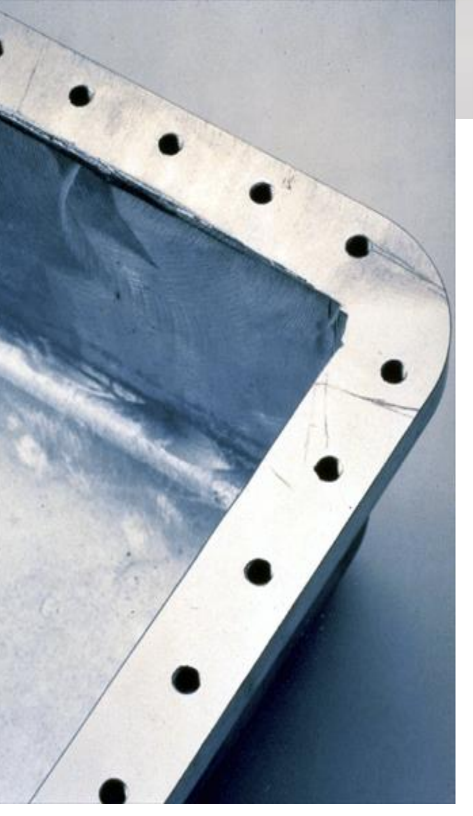
Explosion Proofing



Strengths of XP

- ➢ *Higher Power Applications*
- ➢ *Fairly Simple to Understand*
- ➢ *Widely Accepted in USA*
- ➢ *Applicable to a lot of applications and hazardous areas*

Weaknesses of XP



- ***Compromised Flanges***
- ***Forgotten Bolts***
- ***Forgotten Conduit Seals***
- ***Heavy / Expensive Metal***
- ***Ignored Temperature Specs During Design***

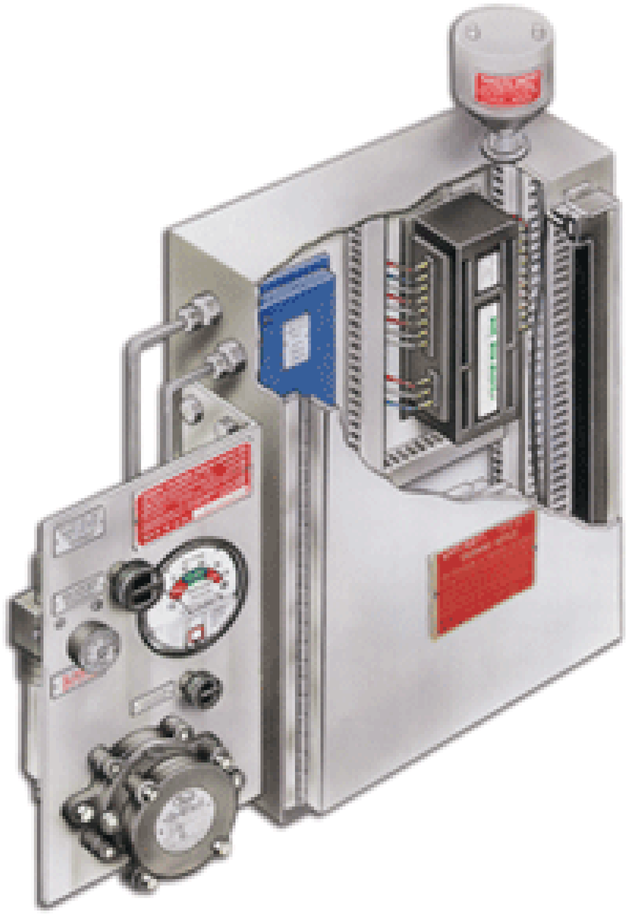
Typical XP Applications

- ***Some Higher Powered Motors***
- ***Process Transmitters***
- ***Panels with higher power or unclassified products inside***
- ***Lights / Horns / Safety Equipment***
- ***Some Pumps***

Methods of Protection

Purging / Pressurizing

Segregation



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Methods of Protection

Purge and Pressurization (Exp)

NEC Rule: Equipment defined in National Fire Protection (NFPA) 496 that will reduce, limit, or eliminate hazardous gases / dusts by using positive pressure ventilation with clean air or noble gas (nitrogen).

Methods of Protection

Purge and Pressurization (Exp)

X Purge: Panel or Room or Motor that is in a Division 1 hazardous area and must be reduced to a general purpose area on the inside due to unclassified equipment internally

Y Purge: EITHER (a) A Div 1 area with Div 2 equipment on the inside of the purged system, or (b) a Div 2 area with general purpose equipment on the inside of the purged system

Z Purge: Div 2 area with general purpose equipment on the inside of the purged system

Methods of Protection

Purge and Pressurization

How it works…

- **Pressurized air fed into "sealed" enclosure**
- **The pressure of the cabinet is maintained to at least 0.1 inches of water column (Class 1)**
- **Four (4) total volume exchanges of protective gas before power permitted for panels**

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Methods of Protection

Purge and Pressurization

Strengths of Purge

- *Great for panels and high power motors*
- *Fairly Simple to Understand*
- *Widely Accepted*
- *Applicable to a lot of applications and hazardous areas, including dust*

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Weaknesses of Purge

- ***Can be difficult to seal panel well enough***
- ***More engineering know-how than XP***
- ***Continual source of protective gas needed***
- ***Live work inside panel requires gas sniffer to guarantee no potential issues with gas or dust***

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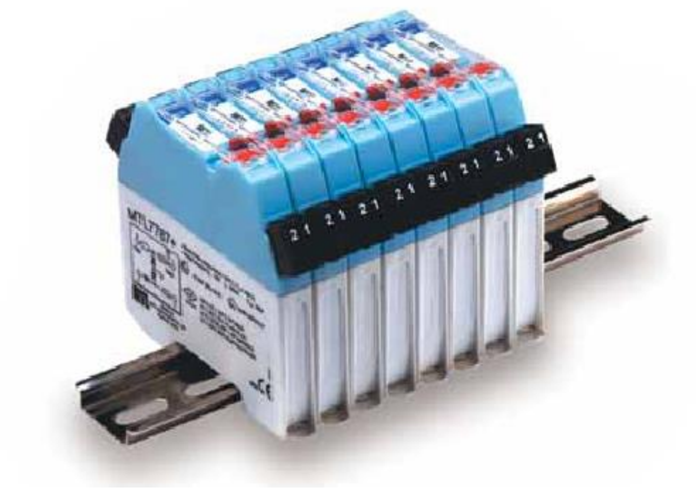
Methods of Protection

Intrinsic Safety

Prevention

DIN rail mounting safety barriers

MTL7700 SERIES



Methods of Protection

Intrinsic Safety (Exi_)

- Prevention
  - Temperature Ignition
  - Accidental Panel-sourced ignition
  - Build-up of electrical energy in device

- **All Classes**
- **All Divisions and Zones**
- **Only approved solution for Zone 0**
- **Any wiring practice (easy)**

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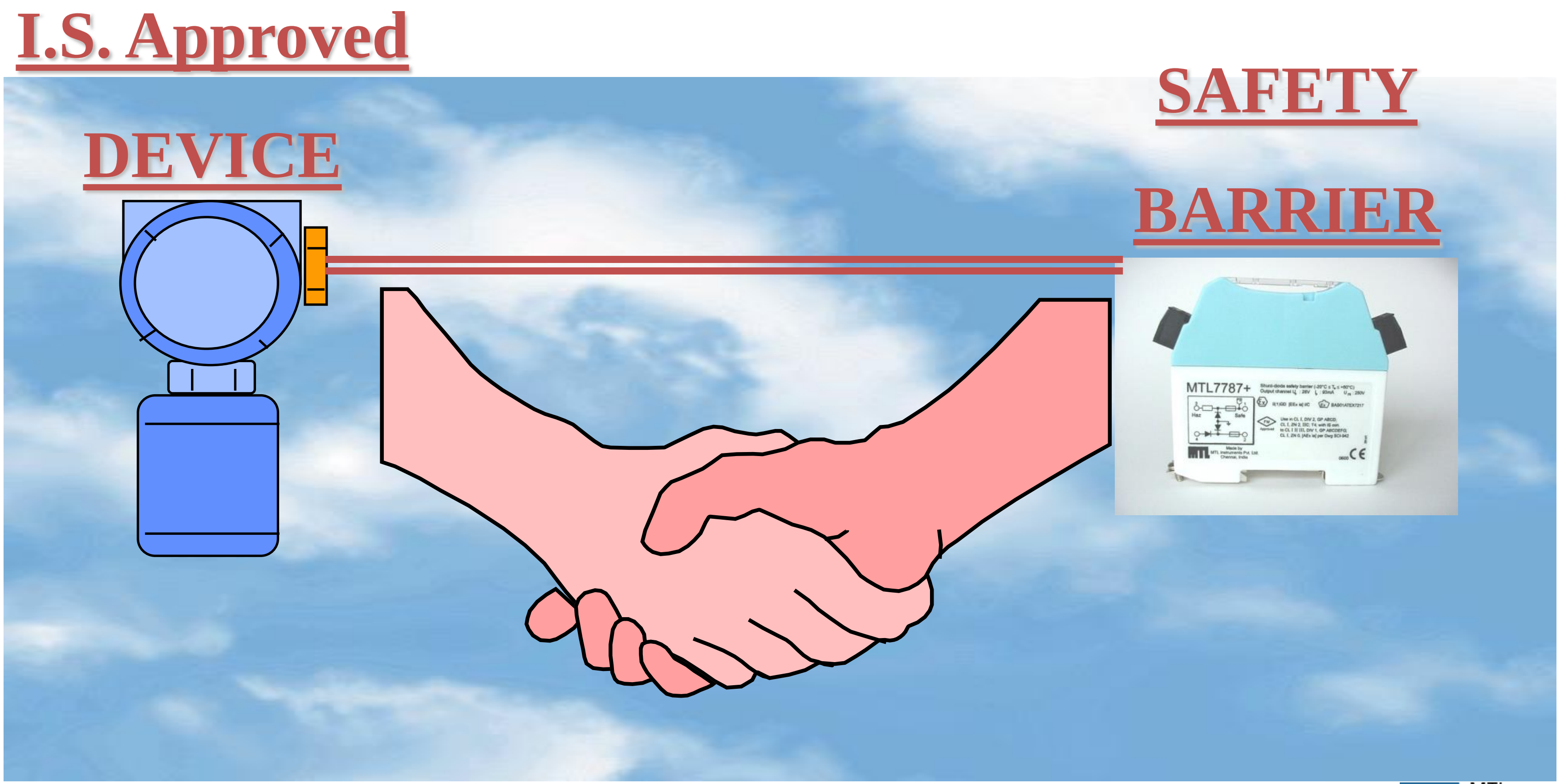
DEFINING “I.S.”

Per NEC504 code and
ISA RP12.6:

INTRINSIC SAFETY IS:
A system, …. intended for use in hazardous areas which is incapable of causing ignition.

Prompted by 1913 Coal Mine Disaster in England – The Senghenydd Colliery Disaster, which killed 440 miners

Intrinsic Safety – A SYSTEM



Intrinsic Safety

Hazardous Location apparatus can be either:

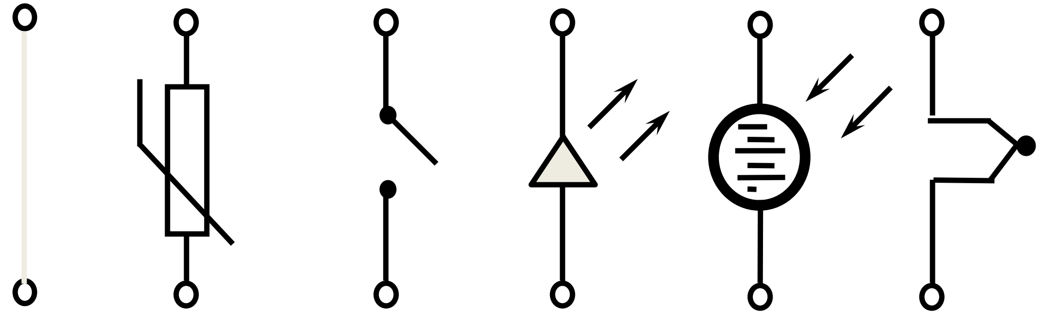
Certified, energy -storing (e.g instruments) or

Uncertified, "non-voltage producing, non-energy storing Simple Apparatus"

Simple Apparatus Definition:

"Devices in which, according to the manufacturer's specifications, none of the values 1.2 V, 0.1A, 20µJ or 25mW is exceeded, *need not be certified or marked "*

Examples:



Simple Apparatus

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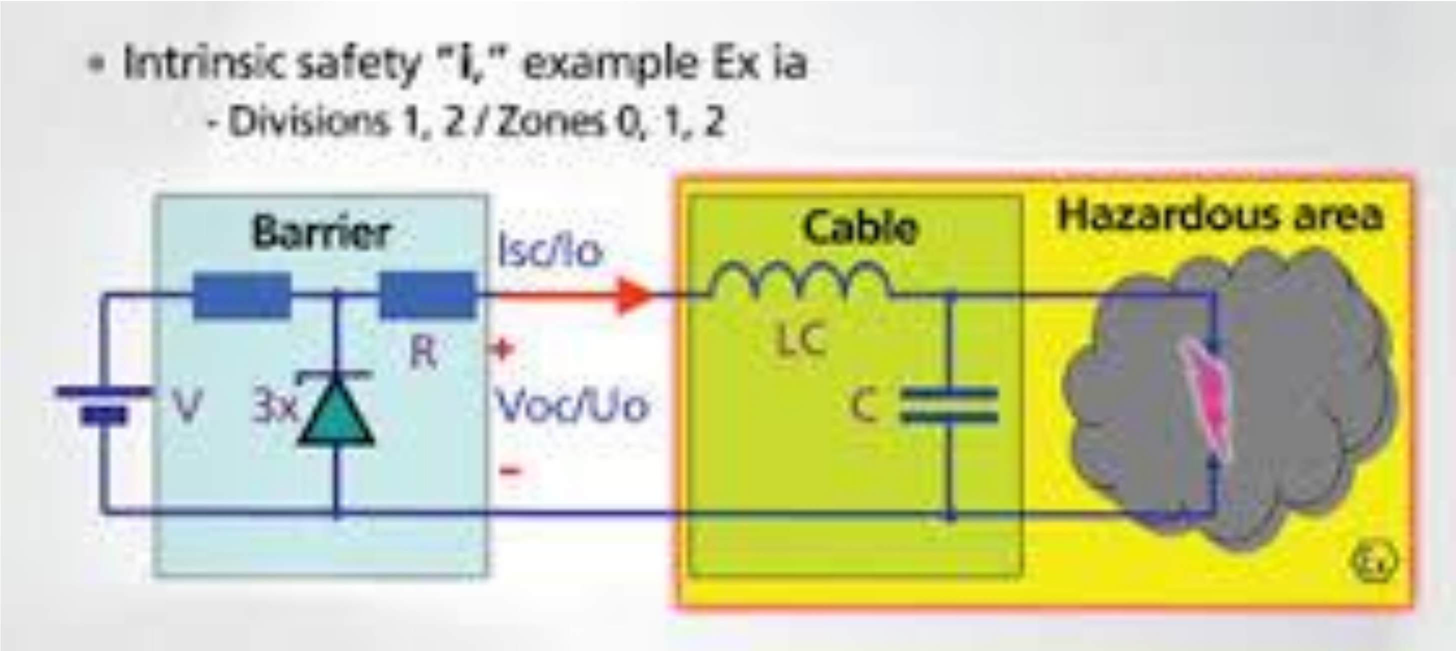
I.S. – Complex Apparatus

- **Designed to operate in accordance to the entity parameters indicated by the manufacturers control drawing**

V_{max}	Maximum allowable open circuit voltage
I_{max}	Maximum allowable short circuit current
C_i	Internal capacitance
L_i	Internal inductance
P_i	Maximum allowable power

I.S. – Evaluation

System Concept (Loop)



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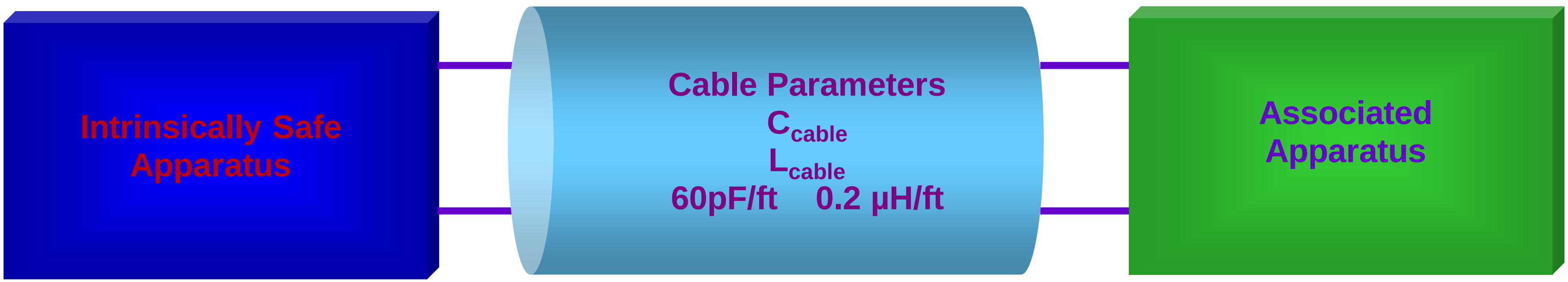
I.S. – Evaluation

Entity Concept (Parametric)

- **Safety is determined by the comparison of Entity parameters of the Apparatus, Associated Apparatus, and interconnecting wires**



Entity Parameters

V_{max}

I_{max}

C_i

L_i

P_i

Entity Comparison

$V_{max} \geq V_{oc}$

$I_{max} \geq I_{sc}$

$P_i \geq P_o$

$C_i + C_{cable} \leq C_a$

$L_i + L_{cable} \leq L_a$

Entity Parameters

V_{oc}

I_{sc}

C_a

L_a

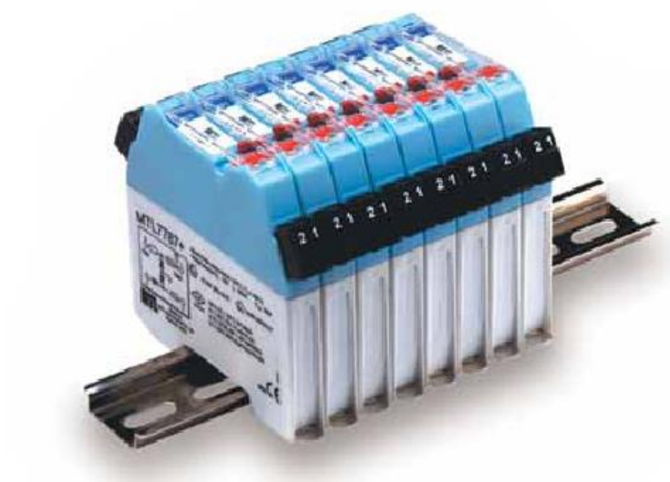
P_o

I.S. – Associated Apparatus

I.S SHUNT DIODE ZENER BARRIERS

DIN rail mounting safety barriers

MTL7700 SERIES



I.S. ISOLATORS, GALVANIC

MTL5500 Series

I.S. – Associated Apparatus

Zener Vs Galvanic

- I.S SHUNT DIODE ZENER BARRIERS
  - Simple and reliable parts
  - High integrity ground required
  - Generic applications
  - inexpensive
  - Requires understanding of the application

- I.S. ISOLATORS, GALVANIC
  - Fairly complex, parts lower MTBF
  - Floating, Isolated
  - Application specific
  - Perceived more expensive
  - ‘Plug and Play’

Strengths of Intrinsic Safety

- ***Good for all Divisions and Zones***
- ***Safest of the methods***
- ***Allows hot-area work on equipment***
- ***Easiest wiring***

Weaknesses of Intrinsic Safety

- ***Somewhat complex electrical calculations***
- ***Barrier failure can be confusing***
- ***Limited to low voltage and DC applications (typically 50 VDC or less)***
- ***Must have low resistance path to ground***

Methods of Protection

Non-Incendive

Prevention and Segregation

Methods of Protection

Non Incendive (Exn)

- **Prevention**
- **Class I, D2 / Z2**
- **ANSI/ISA S12.12, two categories: EXna and Exnl**

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Methods of Protection

NON INCENDIVE (DIVISION 2 ONLY)

ANSI/ISA S12.12 is the Standard
Falls Into two categories:

NON ARCING/NON SPARKING, EXnA

Requires mechanical protection, hermetically sealed contacts.
24VDC or 120VAC may be used

NON INCENDIVE(Energy Limited),EXnL

Similar to intrinsic safety including entity parameters, relaxed ignition curves, approved Div. 2 field devices, but less well defined. Designed to eliminate hot surfaces or incendive sparks under normal operating conditions

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Methods of Protection

Non Incendive (ExnL)

- **Energy limited, D2/Z2 only!**
- **Utilizes entity system**
  - **Capacitance Max**
  - **Inductance Max**
  - **Resistance Max**
  - **Voltage Max**
  - **Temperature Max**
- **Relies heavily on *probability* of no disruption to normal operation**

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Strengths of Non-Incendive

- ***Applicable for Division 2 areas, which companies prefer to have over Division 1 areas***
- ***Less rigorous***
- ***Helps to avoid intrinsic safety, purging, and explosion proof solutions***

Weaknesses of Non-Incendive

- ***Can be complicated and confusing with what code really says, and use of entity parameters***
- ***Still not as safe as intrinsic safety***
- ***Equipment should not be worked on live in Non-Incendive applications***
- ***Mistakes can be made with conduit/cable seals***

Conclusion

- ***Remember to ask the question correctly: “Prove to me that it is safe”, NOT “Prove to me that it is unsafe”.***
- ***Take into account safety, risk factors, costs, and effects on insurance***
- ***Know the rules of each method***
- ***Make sure you triple check both design AND implementation afterward***