Static Electricity and Chemical Safety

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Static Electricity and Chemical Safety

Presentation Outline

- Introduction
- A Systematic Approach to Electrostatic Hazard Assessment
- Control of Electrostatic Hazards
- Discussions

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Fire Triangle

- **Fuel** - A gas, liquid vapor, mist, or solid material capable of being oxidized
- **Oxidant** - A material that may cause or enhance the combustion of other materials, usually oxygen in air
- **Ignition source** - An energy source capable of initiating a combustion reaction

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Hazard Management

Ensuring Safety Through Prevention & Protection

- Elimination of fuel
- Elimination of oxidant
- Elimination of ignition sources
- Explosion protection

NFPA 77, Recommended Practice on Static Electricity (Ref. NFPA, 1 Batterymarch Park, Quincy, MA 02169)

- **Purpose** - Provide assistance in controlling the hazards associated with the generation, accumulation, and discharge of static electricity

- **Contains:**
  - A basic understanding of the nature of static electricity
  - Guidelines for identifying and assessing hazards of static electricity
  - Techniques for controlling the hazards of static electricity
  - Guidelines for controlling static electricity in selected applications

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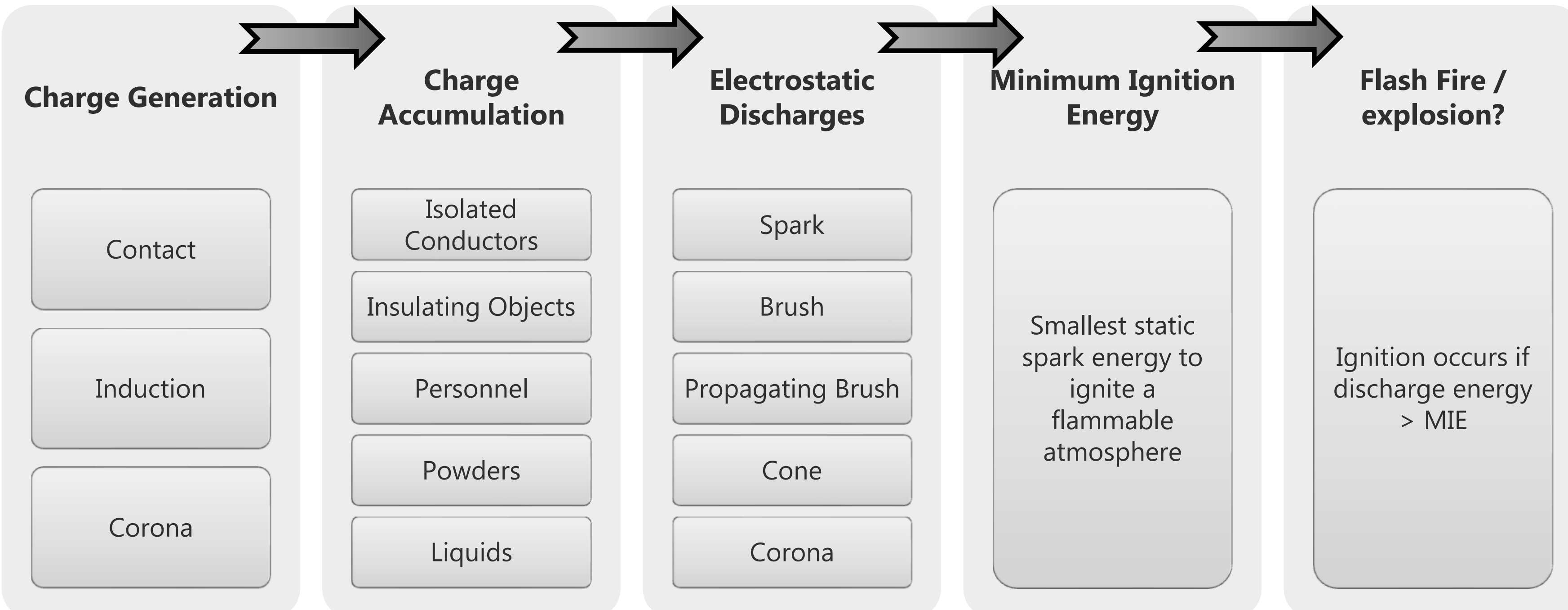
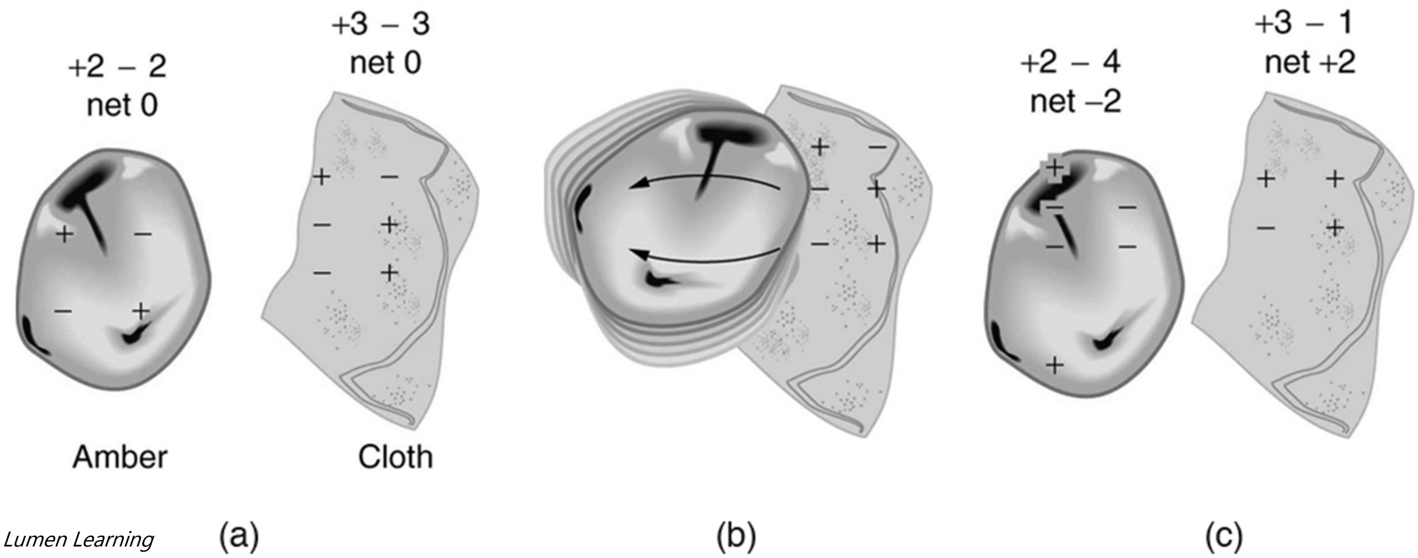
Electrostatic Hazard Assessment - Systematic Approach



Charge Generation - Contact Charging

- Electrostatic charge is usually generated when any two materials make and then break contact, with one becoming negative and the other positive



Picture Ref. Lumen Learning

- Build up of the charge on electrically isolated conductors and/or on insulating materials, can give rise to electrostatic discharges
- Ignition is expected if discharge energy is greater than Minimum Ignition Energy (MIE) of the flammable atmosphere

Electrostatic Charge Generation - Examples

- **Personnel**
  - Walking on insulating flooring
  - Removing coveralls while wearing insulating shoes
- **Powders**
  - Sieving
  - Pouring
  - Auger or screw-feed transfer
  - Grinding
  - Micronizing
  - Pneumatic conveying
- **Liquids**
  - Liquid transfer in hoses & pipes
  - Mixing / Agitation
  - Filtration
- **Movable Items**
  - Metal carts with rubber/plastic wheel

Electrostatic Data / Properties

Proper assessment of electrostatic hazards requires certain information on properties of plant and the materials handled/processed, such as:

- **Minimum Ignition Energy** of flammable atmospheres*
- **Resistance-to-Ground** of conductive (metal) plant and objects**
- **Resistance-to-Ground** of operators' footwear and floors**
- **Volume Resistivity** of powders*
- **Volume Resistivity** of hoses*
- **Conductivity** of liquids*
- **Surface Resistivity** of containers and liners*
- **Electrostatic Chargeability** of powders and liquids*/**

***** Laboratory Measurement

****** On site measurement

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Typical Minimum Ignition Energy Values

Flammable Atmosphere		Minimum Ignition Energy (mJ)
Gas / Vapor (ref. NFPA 77, 1 Batterymarch Park, Quincy, MA 02169)	Carbon Disulfide	0.009
	Hydrogen	0.016
	Acetylene	0.017
	Methanol	0.14
	Acetone	0.19
	Methane	0.21
	Ethyl Acetate	0.23
	Propane	0.24
Dust Cloud[1] (ref. various sources)	PVC	1,500
	Zinc	200
	Wheat Flour	50
	Polyethylene	30
	Sugar	30
	Sulphur	15
	Aluminum	10
	Epoxy Resin	9
	Zirconium	5

1. *Values quoted in this table must not be used for the determination of explosion prevention and/or protection measures. Factors such as test method, composition, particle size, moisture content may affect the results. Test data from a representative sample from your own process must be used*

Controlling Electrostatic Hazards - Metal Plant

- Accumulation of static charges can be prevented by grounding isolated conductors
- Grounding - The process of bonding one or more conductive objects to the ground, so that all objects are at zero (0) electrical potential (voltage); also referred to as earthing
- A resistance $<10^6$ ohms is generally adequate
- All metal system, resistance in continuous ground paths typically is <10 ohms
- Effective bonding & grounding requires:
    - Identification of conductive equipment and objects within a process
    - Periodic inspection and testing of bonding and grounding systems

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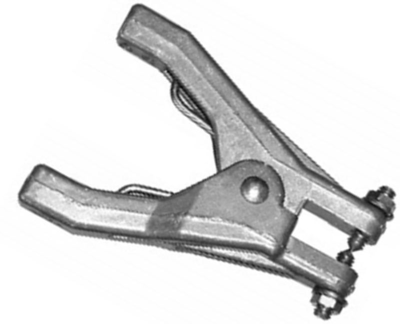
Controlling Electrostatic Hazards - Metal Containers

- Ensure grounding at all times during filling and emptying operations
- Apply grounding clamp prior to commencing filling and emptying operations
- Use grounding clamp with hardened steel points that will penetrate through paint, corrosion, and material buildup



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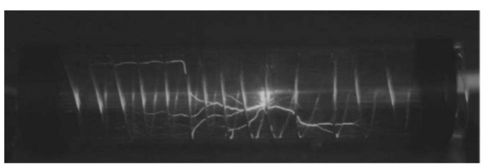
Controlling Electrostatic Hazards - Fiberboard Containers

- Uncoated fiberboard (including paper & wood) is static dissipative
- Ensure grounding through the metal chime at all times during filling and emptying operations
- Apply grounding clamp prior to commencing filling and emptying operations



Controlling Electrostatic Hazard

- **Insulating Hoses with Imbedded Metal Spiral Wire**
  - Ground metal wire at both ends of the hose
  - Propagating Brush discharges are still possible from inside surfaces of the hose
  - Use “conductive” or “static dissipative” hoses

Controlling Electrostatic Hazards - Personnel

- Human body is an electrical conductor and can accumulate static charge if insolated from ground
- During normal activity, the voltage (potential) on the human body can typically reach 10kV to 15kV. At a capacitance of about 200pF the accumulated energy available for a spark can reach 10mJ to about 30mJ
- A person insulated from ground can accumulate a significant charge by:
  - Walking on an insulating surface
  - Manual pouring of powders and liquids from one container to another while wearing insulating footwear or standing on insulating flooring
  - Touching an already charged object such as a Type A, B, and D FIBCs (supersacks) during filling and emptying
  - Brushing against surfaces while wearing insulating footwear
- Electrostatic sparks from human body have been responsible for numerous flash fire and explosion incidents

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Controlling Electrostatic Hazards - Personnel

- Static dissipative footwear used together with conductive or static dissipative flooring provides a practical means to control and dissipate static charges from the human body
  - Resistance to earth through static dissipative footwear and conductive or static dissipative flooring should be between **10^6 ohms** & **10^8 ohms**
- Grounding wrist straps can also be used but may not be practical where personnel need to move around

Illustration of static dissipative footwear tester (Source: Neilson-Gail.com

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Electrostatic Hazards - Insulators

- Examples - plastic hoses, bags, liners, drums
- Surface Resistivity $>10^{11}$ ohm/square
- Grounding of insulating objects would not typically result in relaxation of charge to ground
- Build up of static charge
- Insulating containers prevent the relaxation of static charge from their contents (powders and liquids) to ground

Controlling Electrostatic Hazards - Insulators

- Consider conductive or static dissipative materials with a Surface Resistivity $<10^{11}$ ohm/square

Controlling Electrostatic Hazards - Plastic Liners

- Depending on breakdown voltage of the liner and product charge density there is a possibility of “propagating brush” discharges
- Use antistatic or conductive liners with Surface Resistivity <10^{11} ohm/square
- In the absence of flammable vapor atmospheres insulating liners may be used if breakdown voltage of liner is <4kV

Controlling Electrostatic Hazards - Liquids

- Electrostatic charge generation can arise in various liquid handling operations such as filling, sampling, filtration and mixing
- Electrostatic charge can accumulate on:
    - Low conductivity liquids
    - Liquids in non-conductive containers and vessels
    - Liquid mist regardless of liquid conductivity



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Controlling Electrostatic Hazards - Liquids

- **Use Electrically Grounded Conductive (Metal) Plant**
  - All plant items such as pipes, vessels, containers etc. should be electrically conductive and/or static dissipative and grounded
- **Increase Liquid Conductivity**
  - Where a conductive and a nonconductive liquid are to be blended, add conductive liquid first
  - Adding a conductivity-enhancing agent (antistatic additive
    - Antistatic additives normally are added in parts-per million concentrations

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Controlling Electrostatic Hazards - Liquids

- **Control of Liquid Entry to Vessel**
  - Design inlet to minimize jetting of highly charged product to the surface and to minimize the disturbance of the vessel contents
  - Avoid splash filling through bottom filling or by using an inlet dip pipe extending close to the tank bottom
  - Where the process requires top filling use a fill pipe directed toward the inner wall of the tank

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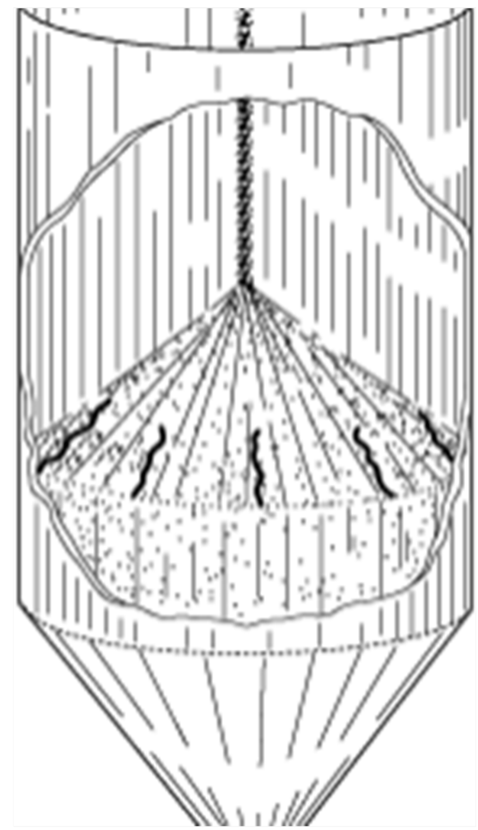
Insulating Containers for Liquids

- How about these items?

Controlling Static Hazards - Powders

- Bulking of highly charged insulating powder in containers causes a partial surface discharge over the top of powder pile that appears as a luminous, branched channel flashing radially from the wall toward the center of the pile - “Bulk”/”Cone” Discharge
- Discharge energy depends on powder “Volume Resistivity”, “Electrostatic Chargeability”, “particle size”, and “vessel dimensions”
- Bulk/Cone discharges have been attributed to explosions of dusts having MIEs less than 20mJ



Controlling Electrostatic Hazards - Powders

- Assessment of ignition hazards caused by Bulk/Cone discharges:
  - **Powder Volume Resistivity <10^9 ohm.m**

    No electrostatic charge accumulation and hence no "Bulk" discharge if powder is handled in grounded conductive plant
  - **Powder Volume Resistivity >10^9 ohm.m <u>and</u> Minimum Ignition Energy >20mJ**

    Even if Bulk/Cone discharges are present, no static ignition hazard in grounded conductive plant
  - **Volume resistivity > 10^9 ohm.m <u>and</u> Minimum Ignition Energy <20mJ**

    For sufficiently high electrostatic charging (high chargeability) conditions possibility of Bulk/Cone discharges cannot be ruled out. Consider:
    - ✓ Inert gas blanketing, or
    - ✓ Explosion protection, or
    - ✓ Reduction of electrostatic charges (ionization)

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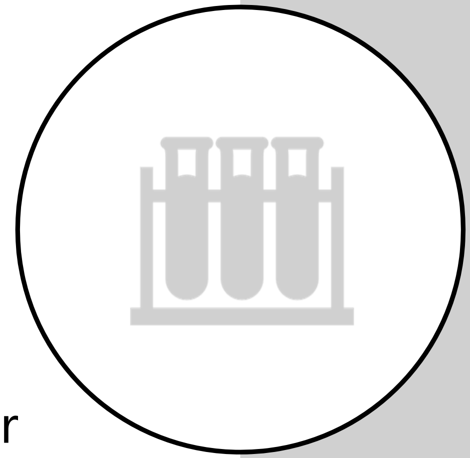
Controlling Electrostatic Hazards

- **Effect of Humidity on Charge Accumulation**
  - Water vapor - if present in air - absorbs onto surfaces and forms a slightly conducting surface layer
  - Factors affecting the extent of water absorption onto the surface include:
    - Chemical properties of the surface, and
    - Quantity of moisture content (humidity) in air
  - Maintaining the relative humidity level higher than about 65% can reduce electrostatic charge accumulation



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Controlling Electrostatic Hazards

- **Effect of Humidity on Charge Accumulation**
  - Electrostatic Voltages Resulting from (Contact) Triboelectric Charging at Two Levels of Relative Humidity (RH) *(Ref: NFPA 77, 1 Batterymarch Park, Quincy, MA 02169)*

Situation	Electrostatic Voltages (kV)	
	RH 10% - 20%	RH 65% - 90%
Walking across a carpet	35	1.5
Walking across a vinyl floor	12	0.25
Working at a bench	6	0.1
Vinyl envelopes for work instructions	7	0.6
Poly bag picked up from bench	20	1.2
Work chair padded with polyurethane foam	18	1.5

IEC 61340-4-4, Edition 3.0, 2018-01

Standard Test Methods for Specific Applications –

Electrostatic Classification of Flexible Intermediate Bulk Containers (FIBCs)

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IEC 61340-4-4, Edition 3.0, 2018-01

- **Type A** - Constructed from insulating fabric or plastic sheet with no provision for controlling any type of static discharge
  - Must not normally be used in presence of flammable atmosphere with MIE ≤1,000mJ
- **Type B** - Constructed from insulating fabric or plastic sheet designed to prevent “Sparks” and “Propagating Brush Discharges”
  - Safe for use in dust environments with ignition energies greater than 3mJ. There must be no flammable vapors/gases present
- **Type C** - Constructed from fully inter-connected conductive threads
  - Relies on grounding to prevent electrostatic hazards (shall have a resistance to groundable point of $<1.0\text{x}10^8\ \Omega$)
  - Safe for use in the presence of flammable vapors, gases, or dusts with MIE ≤3mJ
- **Type D** - Constructed from fabrics with special static protective threads and/or properties
  - Controls discharge incendivity without requiring earthing
  - Safe for use where flammable vapors, gases, or dusts with MIE ≤3mJ are present

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Use of Different Types of FIBC

Bulk Product in FIBC	Surroundings		
MIE of Dust	Non Flammable Atmosphere	Dust Zones 21 – 22 1000mJ > MIE > 3mJ	Gas Zones 1 – 2 or Dust Zones 21 – 22 MIE ≤ 3mJ
MIE > 1,000mJ	A, B, C, D	B, C, D	C, D
1000mJ > MIE > 3mJ	B, C, D	B, C, D	C, D
MIE ≤ 3mJ	C, D	C, D	C, D

- Additional precautions are usually necessary when a flammable gas or vapor atmosphere is present inside the FIBC, e.g. in case of solvent wet powders
- Non-flammable atmosphere includes dusts having a MIE >1000mJ
- Use of Type D FIBCs shall be limited to atmospheres with MIE ≥0.14mJ

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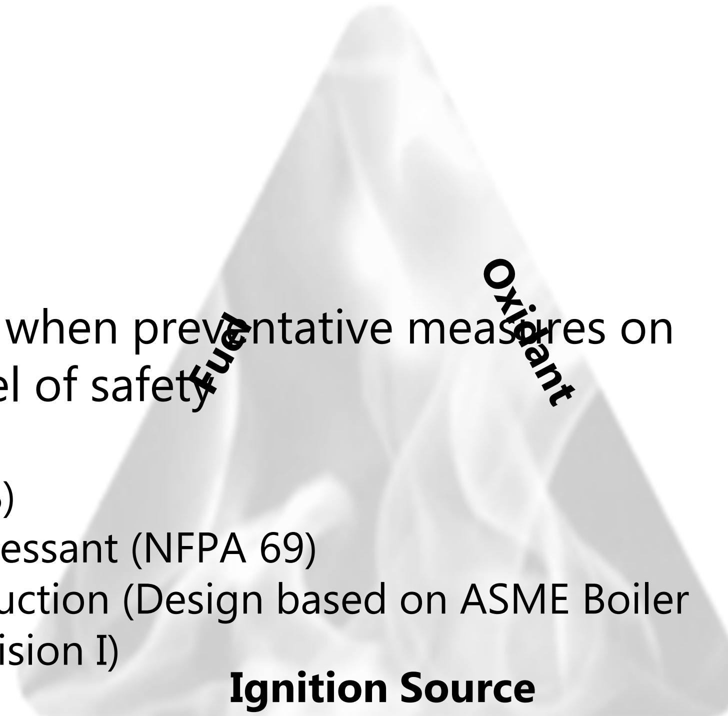
Explosion Protection

Ensuring Safety Through Prevention & Protection

- **Explosion Prevention**
  - Elimination of Fuel
  - Elimination of Oxidant
  - Elimination of Ignition Sources

- **Explosion Protection**
  - Protection measures must be considered when preventative measures on their own may not ensure acceptable level of safety
  - Explosion protection measures include:
    - Explosion venting to a safe place (NFPA 68)
    - Explosion suppression by injecting a suppressant (NFPA 69)
    - Containment by explosion resistant construction (Design based on ASME Boiler and Pressure Vessel Code, Section VIII, Division I)



Thank You

We partner with our clients in the process industries to help them identify, assess, prevent, and control fire, explosion, and accidental loss of containment hazards in their operations.

We would like to hear from you. Please contact us!

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