2nd Chemical Process Safety Sharing (CPSS)

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Awareness of Static Electricity

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Process Technology

What is Electrostatic Discharge ?

Courtesy: Petroleum Equipment Institute

Did you know?

- A spark of static electricity can measure up to 3,000 volts.
- Static electricity is the prime culprit for at least two serious fires or explosions in industry worldwide every day of the year, according to the NFPA and the U.K.'s Institution of Chemical Engineers.
- A review of 310 accidents by the Japanese chemical industry found that improper grounding caused 70% of all accidents involving static electricity.
- Charge of 20,000 to 40,000 volts can build up when pumping petroleum products
- Humidifying the air helps cut down static electricity. A thin layer of water molecules coats most surfaces, which allows electrons to flow more freely and makes almost everything conductive and static-free.

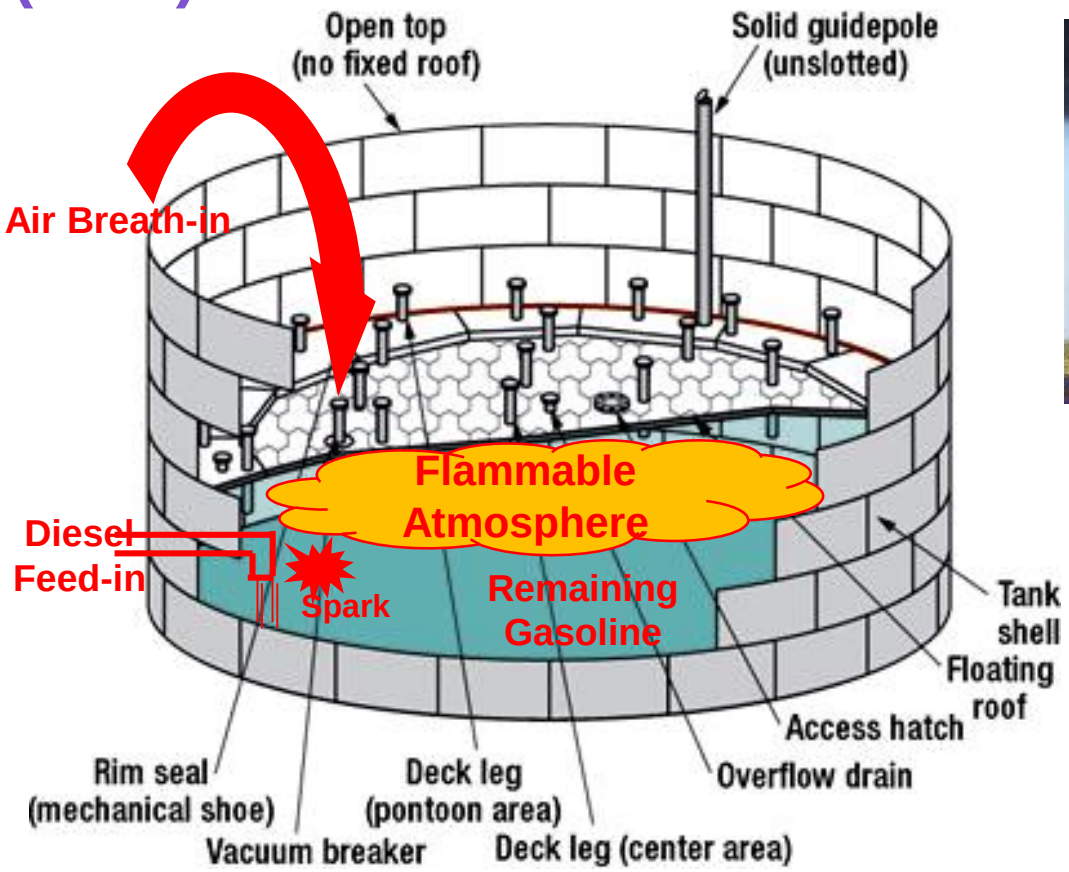
Source : TATA AIG Insurance

Did you know?

STATIC HAZARDS POORLY UNDERSTOOD !

Case Study#1

Oil Tank Fire Caused by Static Discharge in Oklahoma (2003)

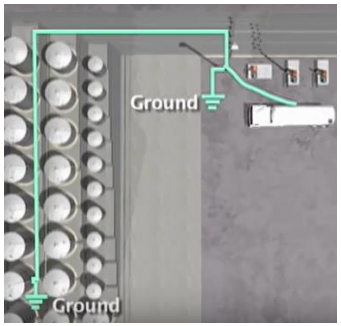


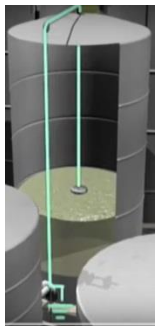
Adobe Acrobat Document

Case Study#2

Static Sparks Explosion in Kansas (2007)

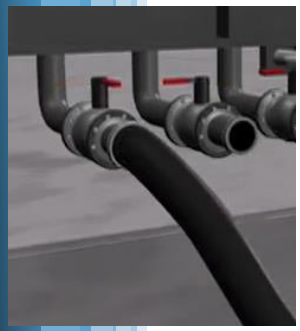
https://www.csb.gov/barton-solvents-explosions-and-fire/





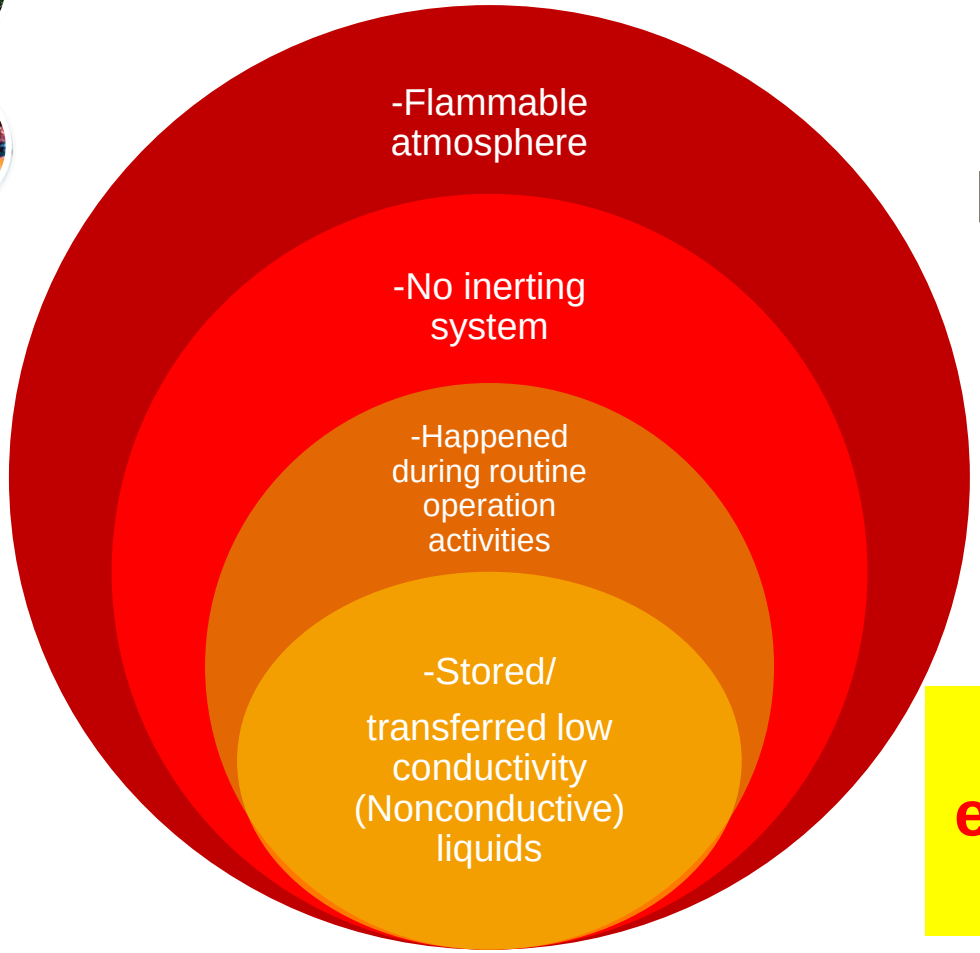
Properly Bonds and Grounds

What went wrong?



Learning from Case Study

Both cases have :



Bond and ground all conductive equipment ?

Always assess electrostatic hazards by asking 5 questions !

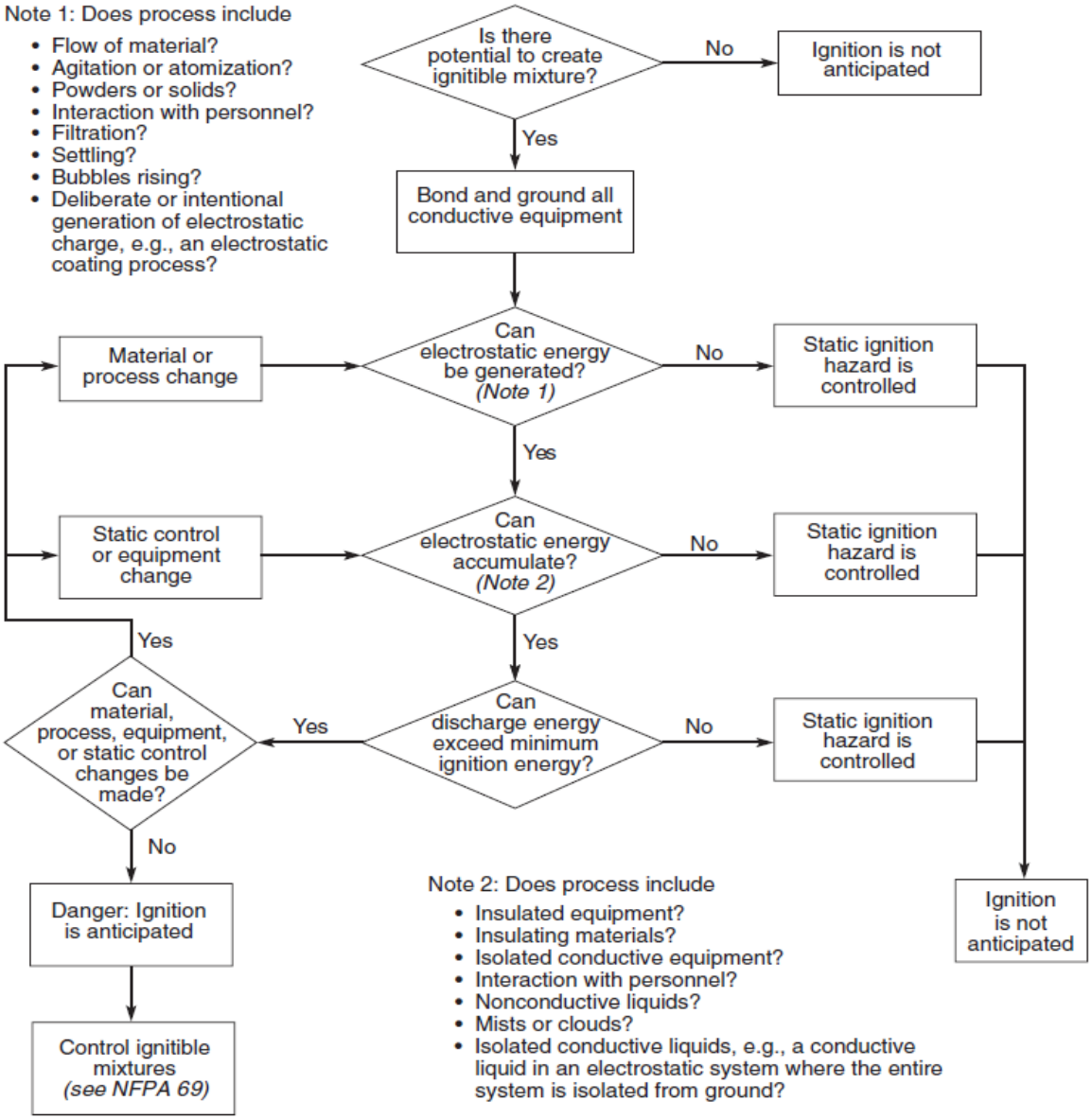
Assessing Electrostatic Hazards

5 Questions to Assess the Electrostatic Hazards

1. Is there potential to create flammable/ignitible atmosphere?
2. Can charge be generated?
3. Can charge accumulate?
4. Spark / Ignition risk ?
5. Enough energy to ignite the flammable atmosphere (exceed MIE) ?

Assessing Electrostatic Hazards

NFPA 77 (2014)



1. Potential Flammable/Ignitible Atmosphere

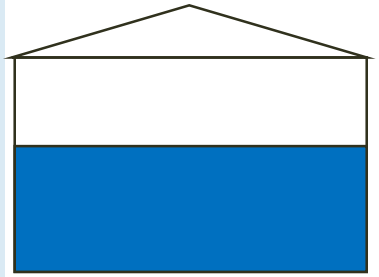
DEP 80.64.10.11

It should be assumed that a flammable atmosphere exists if the temperature of the liquid is within 11 ^{o} C(20 ^{o} F) of the flash point.

NPFA 77

6.10.1 Any combustible solid (dust), liquid (vapor), or gas should be evaluated as an ignitible atmosphere…

9.2.1.2 → Mention same as DEP but use 5 ^{o} C for single-component and 11 degC for mixed liquids



Storage Temp = 35 degC

Flash Point of Liquid = 40 degC

Lower Flammable Range approx. = 29 (40-11) degC

Potential Flammable Atmosphere

1. Potential Flammable/Ignitible Atmosphere

In Summary, flammable atmosphere can occur in numerous situations.

For example:

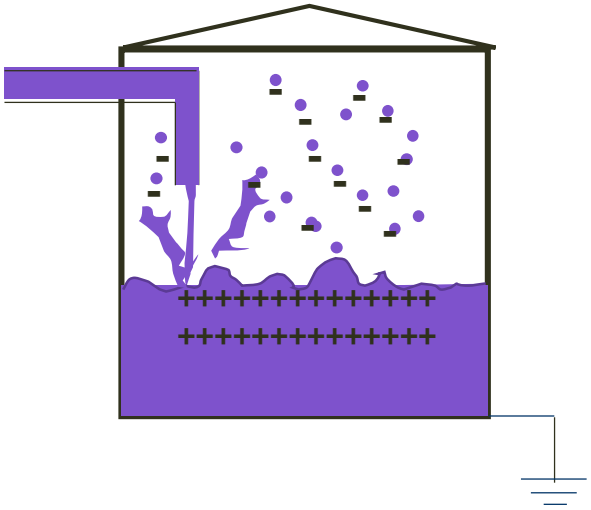
- ❑Handling material at temperature close to or above their flash point
- ❑Switch loading
- ❑Tank cleaning operations
- ❑Relief drums or other light stock pumped into heavy oil

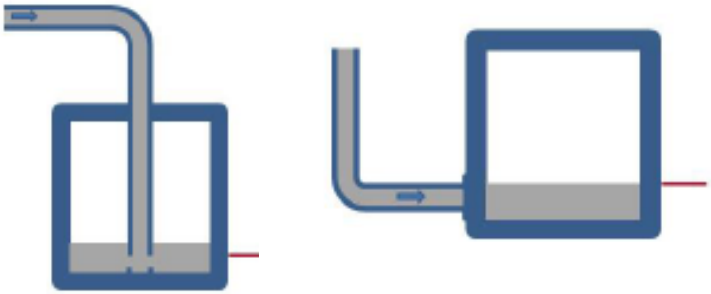
1. Potential Flammable/Ignitible Atmosphere

Preventive Measures

- **Atmosphere Control**
  - Inerting (N2, Flue Gas, Steam)
  - Ventilation
  - Temperature Control
  - Prevent Splash Filling

  (e.g. Dip-leg, Bottom filling)





2. Charge Generation

Charge profile in truck loading system

Source : API RP 2003

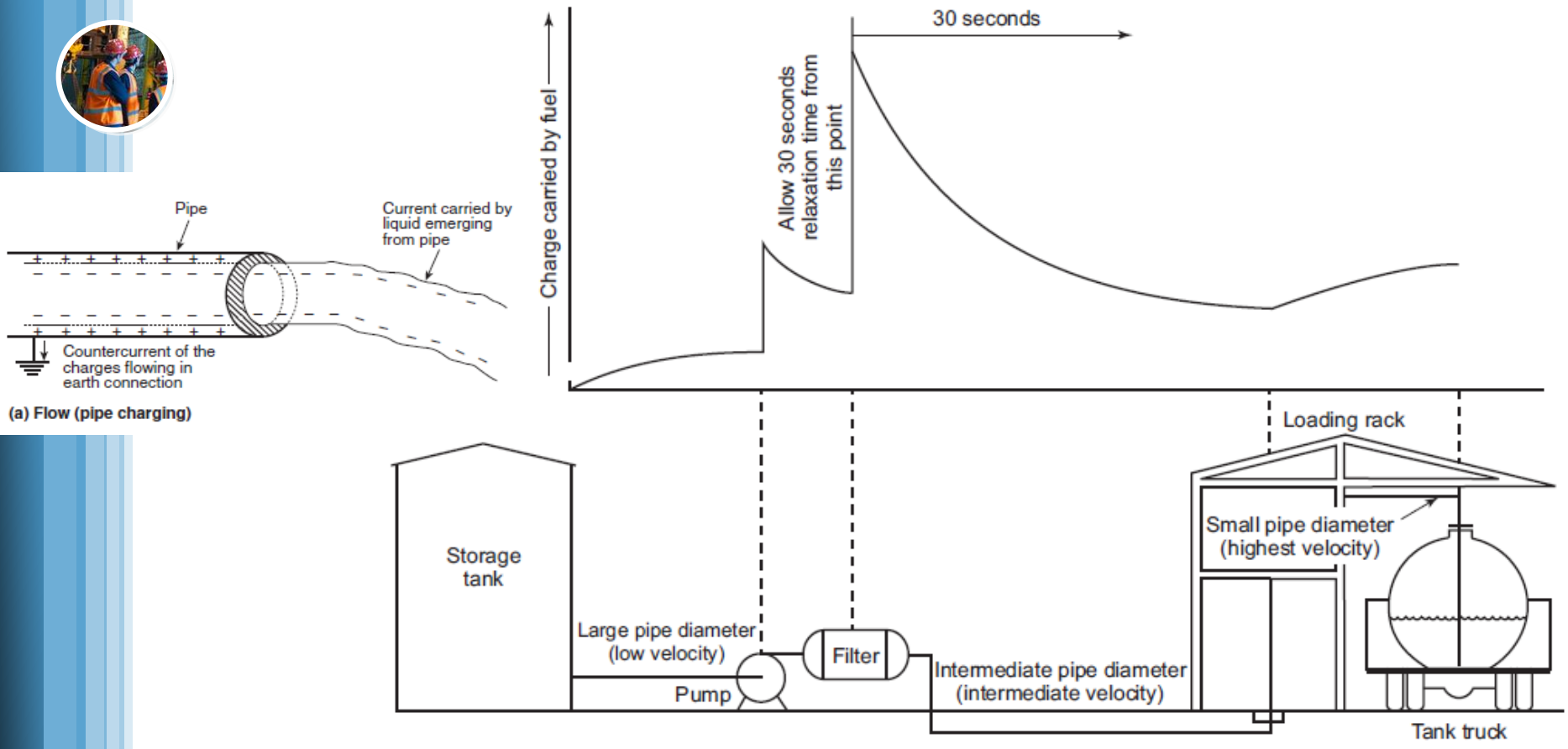
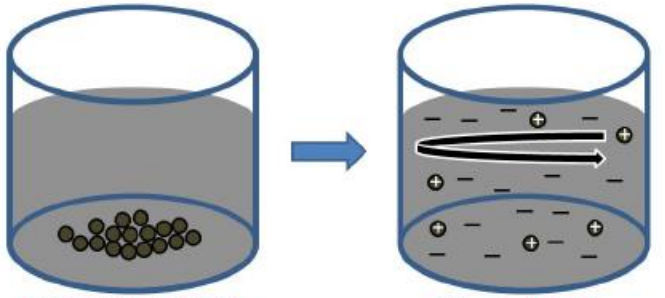


Figure 9—Electrostatic Charge Generation During Tank Truck Loading Update Using Clear Copy

2. Charge Generation

Typical charging mechanisms - Liquids

- ✓ Flow through pipes/hoses
- ✓ Pouring from containers
- ✓ Splash filling
- ✓ Bubbling/Agiation
- ✓ Filtration
- ✓ Settling of 2-phase mixtures



Typical charging mechanisms - Powders

- ✓ Sieving/Mixing/Grinding
- ✓ Pneumatic transfer
- ✓ Pouring from sacks
- ✓ Filing or emptying bags or kegs
- ✓ Pouring powders via chutes

Source : ABB Awareness of Process Safety in Design

2. Charge Generation

Preventive Measures

- ❑ Minimize charge generation-Liquids
  - ➢ Restrict flow velocities
    - ○ Type of liquid, clean or contaminated
    - ○ Depending on tank size
  - ➢ Limit power input
  - ➢ No rubbing of insulating materials
  - ➢ Prevent splash filling
- ❑ Minimize charge generation-Powders
  - ➢ Restrict powder flow into vessels – Use rotary valves, screw feeder
  - ➢ Avoid charge chutes above 3 m long

See more details in NFPA 77

2. Charge Generation

Example of Flow Velocity Limitation

See more details in NFPA 77

Table 12.1.4.4 Summary of Precautions for Filling Large Conductive Tanks with Low-Conductivity Liquids

Precautions	Applicability to Tank	
	With Floating Roof or Internal Cover	With Fixed Roof, No Floating Cover
Keep flow velocities below 1 m/s.	Essential until the roof or cover is afloat.	Essential during the initial filling period and when loading a contaminated or two-phase liquid or a liquid with a substantially lower density than that already in the tank.
Keep flow velocities below 7 m/s.	Not essential when the roof or cover is afloat. NOTE: A flow rate limit will often be needed to avoid damaging the roof by too rapid movement.	Recommended in all cases in which the 1 m/s limit does not apply.
Ensure adequate residence time between strong charge generators (e.g., microfilters) and the tank.	Essential until the roof or cover is afloat. NOTE: The residence time can be calculated using a velocity of 1 m/s in this instance.	Essential.
Avoid disturbing water bottoms with incoming product or entrained air or by blowing out lines with gas.	Essential until the roof or cover is afloat.	Essential.
Avoid charging low density liquids into tanks containing substantially higher density liquids.	Unnecessary.	Recommended as far as practicable. If unavoidable, keep the flow velocity below 1 m/s (see Row 1).

2. Charge Generation

Summary of Velocity Limit for Filling Large Tanks with Low Conductivity Liquids

	Tank with Inert Gas	Tank with floating roof or cover	Tank with fixed roof, no floating cover and no Inert Gas
Normal operation with clean liquids	No limit	No limit	7 m/sec
Operation with contaminated liquids	No limit	No limit	1 m/sec
At a product interface	No limit	No limit	1 m/sec
At the start of filling	No limit	1 m/sec	1 m/sec

Note 1. This table relates only to electrostatic hazards. There might be other reasons to restrict the velocity.

2. Where no velocity limit is necessary, it may nevertheless be useful to keep velocities below 7 m/sec as an additional safeguard.

Do we still need to limit the velocity if anti-static additive is added ?

3. Charge Accumulation

Classification of Liquids

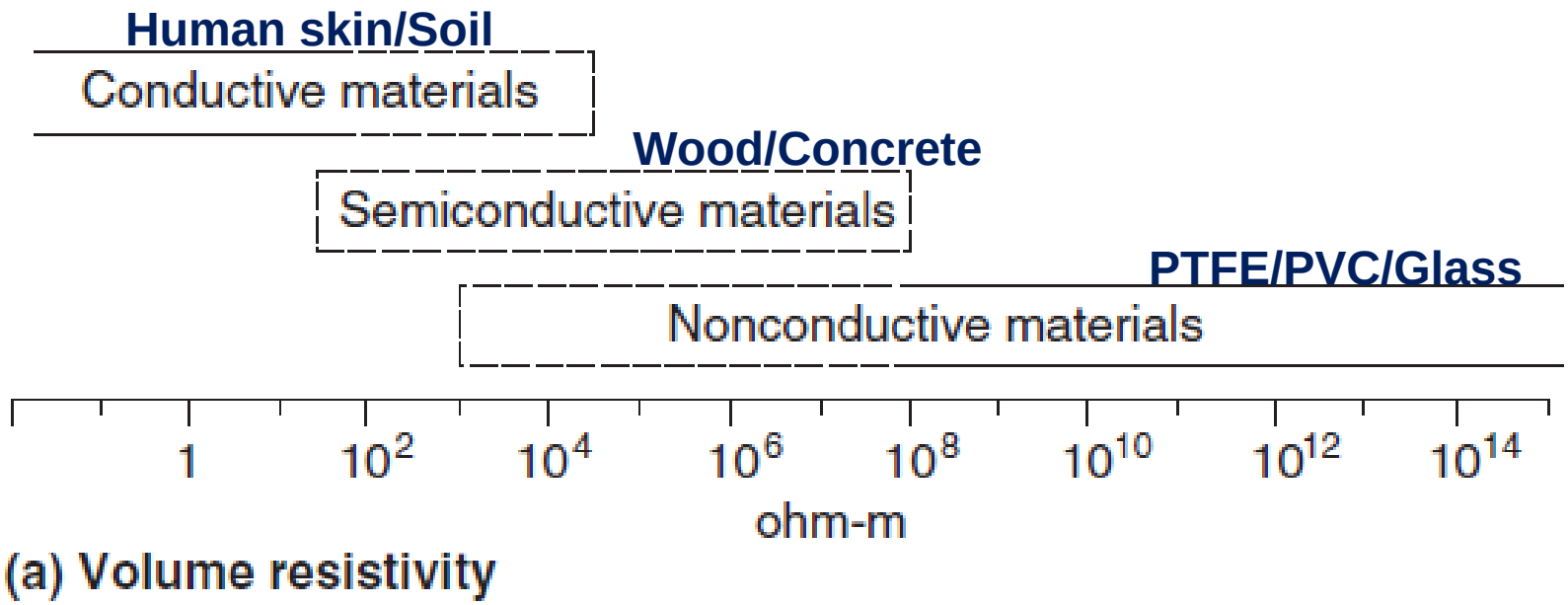
Risk	Conductivity	Examples	Hazard	Remark
High	< 50 pS/m	Gasoline (straight run/unleaded) Diesel Toluene Benzene Xylene	Retains charge easily, most incidents with these substances	Low conductive/Nonconductive liquids
Medium	50 - 1,000 pS/m	Gasoline (leaded) Trichloroethylene Ethylene Dichloride	Requires vigorous operations for charge to be retained	Medium conductive/ Semiconductive liquids
Low	> 1,000 pS/m	Ethylene Oxide Pure Water Methanol, Ethanol	Safe in normal operations in process industry	Conductive liquids

See more details in NFPA 77

Source : ABB Awareness of Process Safety in Design

3. Charge Accumulation

Classification of Solids



(a) Volume resistivity

See more details in NFPA 77

3. Charge Accumulation

In Summary, charge can be accumulated in :

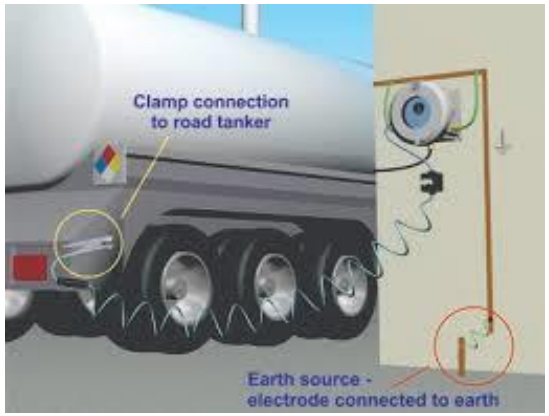
- ✓ Accumulation in Liquids
- ✓ Accumulation on Insulated Conductors
- ✓ Accumulation on Insulating Solids
- ✓ Accumulation on Gaseous Suspensions

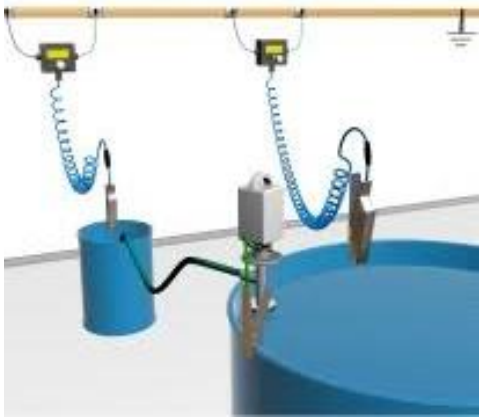
What's about tank with internal coating ?

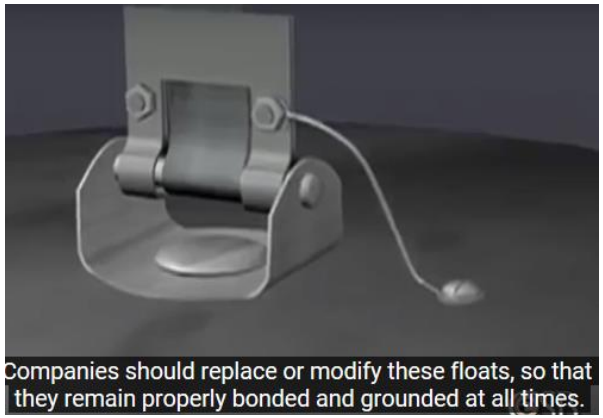
3. Charge Accumulation

Preventive Measures

- Minimize charge accumulation by :
  - Earthing/grounding and bonding of all conductors
  - Increase conductivity (anti-static additives)
  - Use conductive or anti-static materials
  - Provide relaxation time (after filter, before sampling)
  - Humidity (>65% RH)



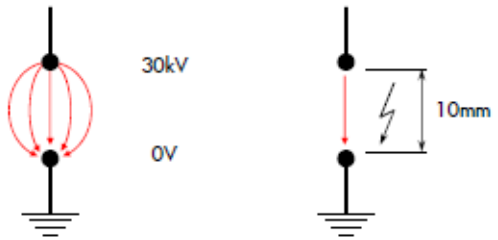


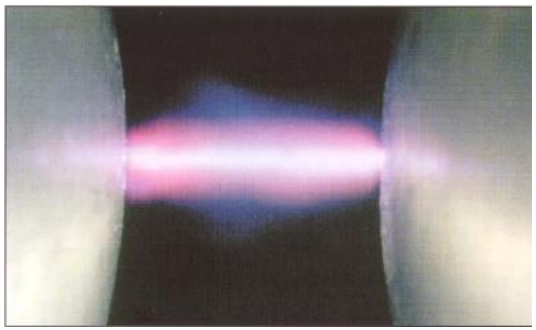


4. Ignition

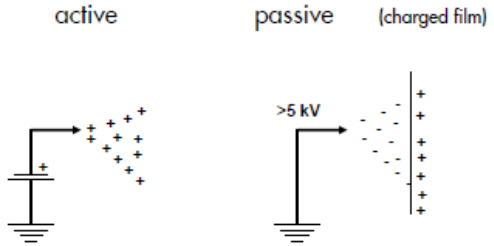
Type of Electrostatic Discharge

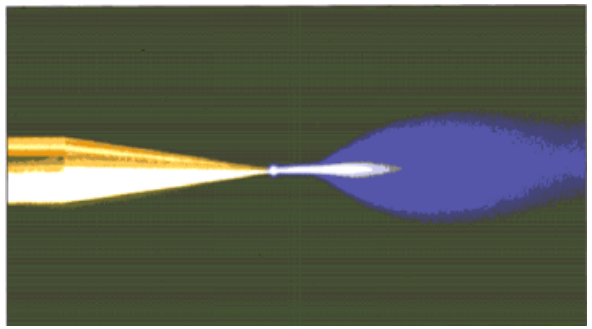
1.Sparks



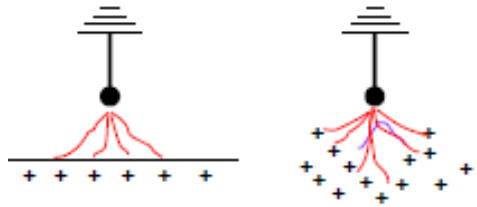


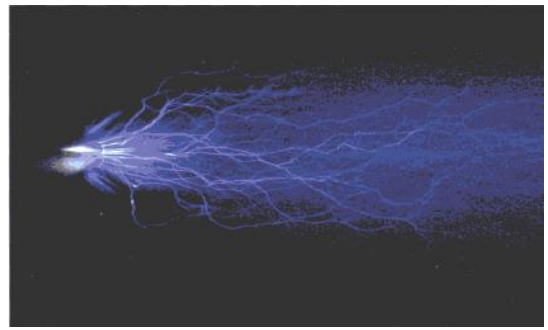
2. Glow Coronas





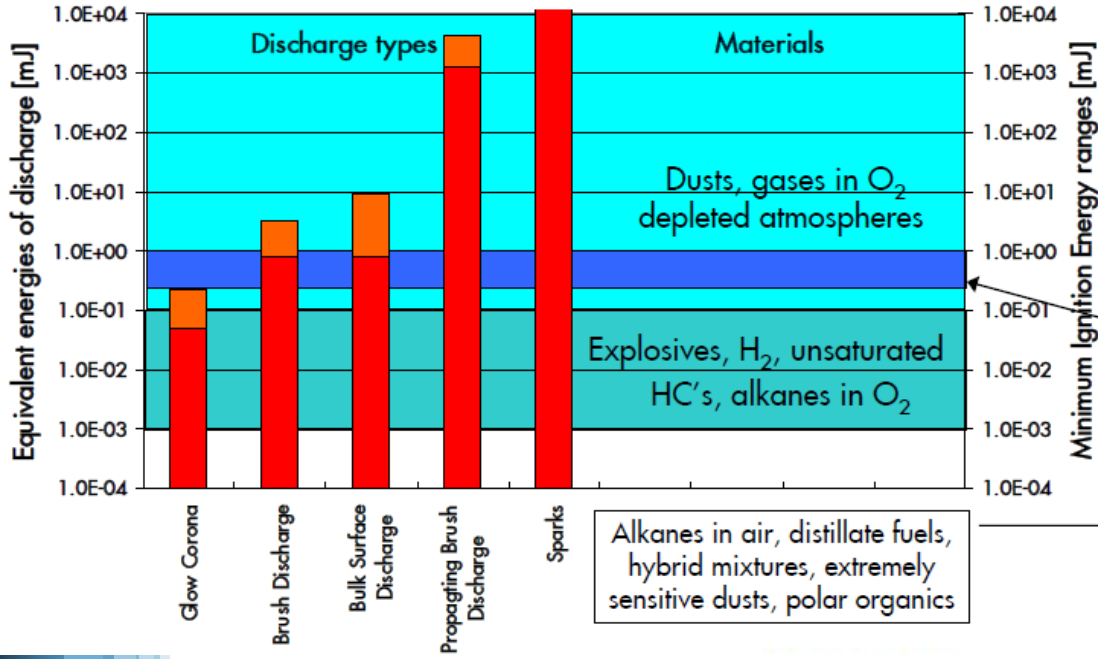
3. Brush Discharges





Source : Shell M123 Safety In Process Design

4. Ignition



MIE : Minimum Ignition Energy

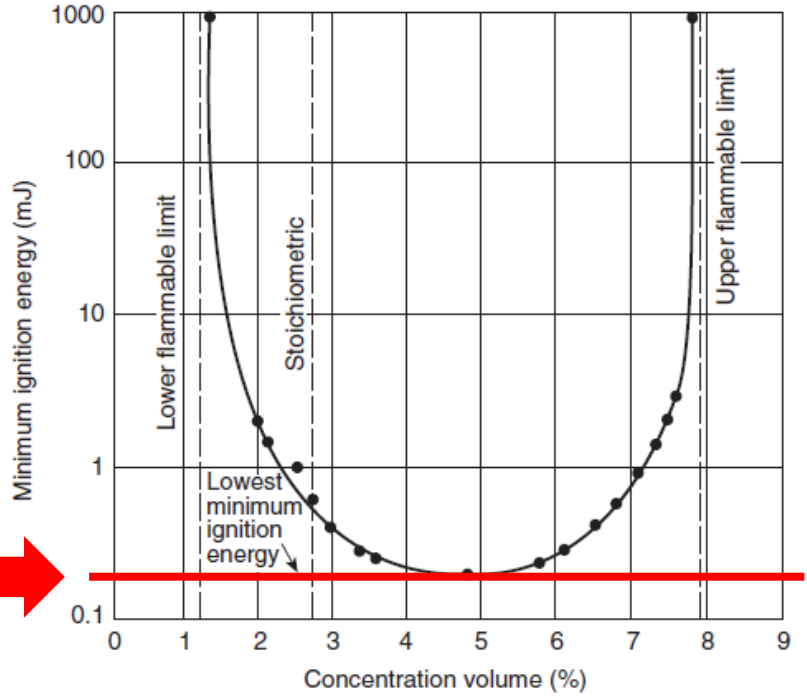


FIGURE 9.2.3 Minimum Ignition Energy (MIE) of Benzene as a Function of Concentration. *(Adapted from L. G. Britton, "Using Material Data in Static Hazard Assessment.")*

Source : NFPA RP 77 & Shell M123 Safety In Process Design

4. Ignition

Ignition from People – Preventive Measures

- Anti-static or conductive clothing
- Anti-static footwear
- Conductive or static dissipative flooring
- Personnel-grounding devices

Summary

- Ask 5 questions to assess a risk of fires or explosions during :
  - ✓ Design Review
  - ✓ HAZOP Review
  - ✓ MOC Review
- Avoid flammable/ignitible atmosphere
- Limit static charge generation
- Limit static charge accumulation
- Eliminate static discharge

Related Standards & References

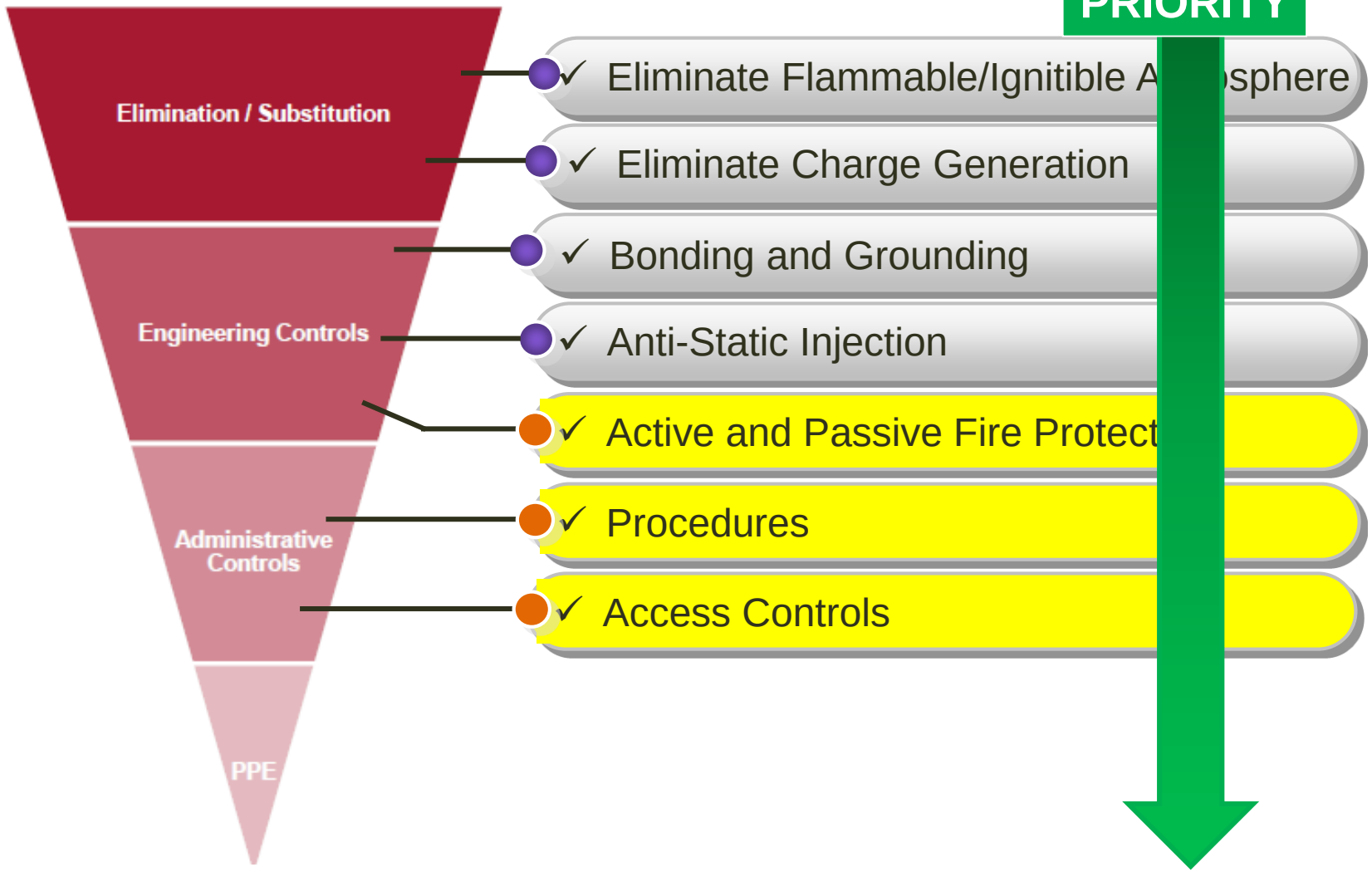
Main Related Standards

- NFPA 77 : Recommended Practice on Static Eletricity
- API RP 2003 : Protection Against Ignitions Arising out of Static, Lightning and Stray Currents

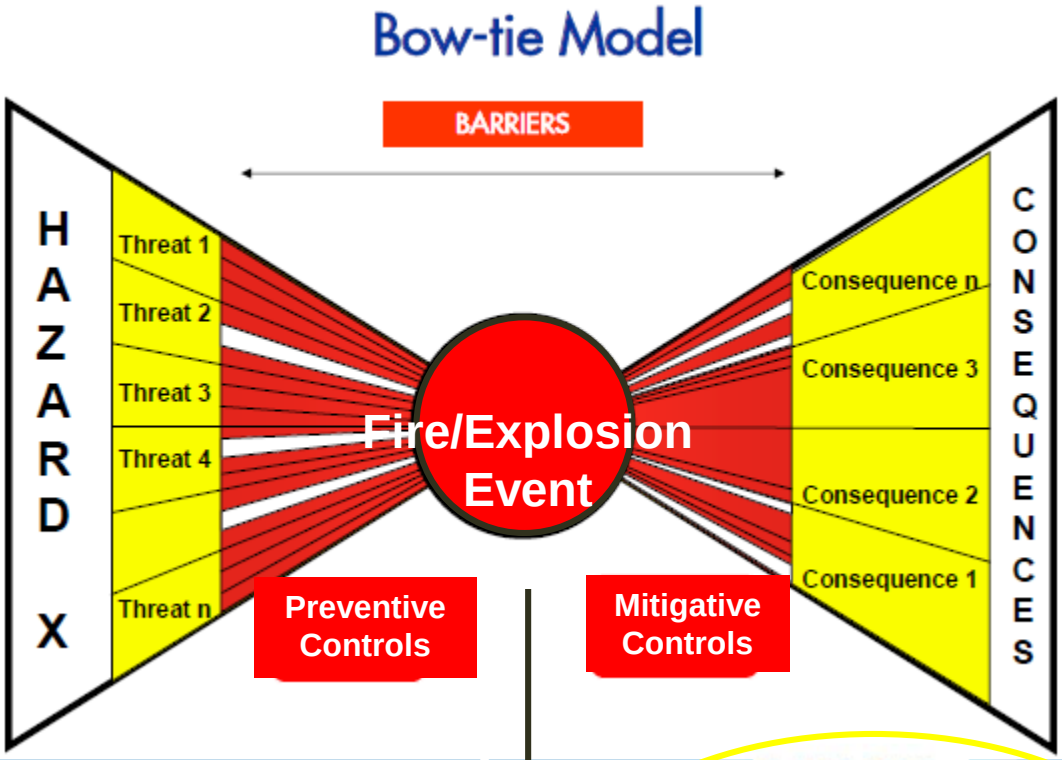
Other Related Standards

- NFPA 69 : Standard on Explosion Prevention Systems
- API RP 2219 : Safe Operation of Vacuum Trucks in Petroleum Service
- API 2015 : Safe Entry and Cleaning of Petroleum Storage Tanks
- NFPA 30 : Flammable and Combustible Liquids Code
- DEP 80.64.10.11 Gen. : Static Electricity
- BS 5958 (1991) Parts 1 and 2
- BS PD CLC/TR 50404 : 2003
- Energy Institute Part 21

Standard Hierarchy of Controls



Bow Tie Diagram For Electrostatic Hazard



- ❑ Design Review/HAZOP/MOC/PSSR
- ❑ Avoid flammable/ignitible atmosphere
- ❑ Limit static charge generation
- ❑ Limit static charge accumulation
- ❑ Eliminate static discharge

- ❑ Fire detection system **Still Required!!!**
- ❑ Fire fighting system
- ❑ Emergency response procedure
- ❑ PPE
- ❑ First aid equipment
- ❑ Evacuation plan

Discussion