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RE-Konnect

Risk Engineering Bulletin

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In Focus:

Electrostatic Hazards in Flammable Liquids' Handling

Editor's Note

Fire and explosion as results of electrostatic ignition are a common hazard in industries. A variety of operations may generate static electricity leading to such fires and explosions. This requires adequate preventive and protective measures against this hazard. The electrostatic spark is the most important phenomenon to be controlled and proper evaluation of a plant for electrostatic hazard potential is necessary to protect the industry from fires and explosions. In this issue of RE-Konnect, we provide you a brief overview on electrostatic charge, static charge ignition and ways to reduce its hazards.

Catastrophes

Terrifying fireballs as alcohol distillery goes up in flames

On November, 2012, in morning hours, a fire and series of explosions occurred at in West Midlands, England. A huge blaze at the alcohol distillery caused a series of terrifying fireballs to shoot across the sky.

The HSE investigation found that the most likely source of ignition was a discharge of static electricity generated by the transfer of the liquid. A 21-year-old worker was transferring ethyl acetate – a highly flammable solvent – from a bulk storage tank to an intermediate bulk container when the liquid caught fire.

Explosion & Fire rocked Iowa chemical factory

On October 29, 2007, a fire and series of explosions occurred at an Iowa, chemical distribution facility. Flames and clouds of black smoke soared above the facility, and exploding barrels could be seen jetting into the sky. It was caused by a static electrical spark resulting from inadequate electrical bonding and grounding during the filling of a portable steel tank, the U.S. Chemical Safety Board (CSB) determined.

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 National Fire Protection Association (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.
- Charges of 20,000 to 40,000 volts can build up when pumping petroleum products.

- When you reach for a positively charged doorknob, electrons flee and you get zapped. From the impact of your voltage, the air between your hand and the knob grows extremely hot and instantly turns to *Plasma, the fourth state of matter*.
- 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.

Static Ignition - Conditions

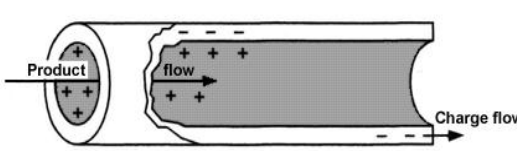
Static electricity is the electrical charge produced on two dissimilar materials through physical contact and separation caused by the imbalance of charges between the two. If the charge is unable to bleed off to ground when the electric field exceeds the insulating properties of the atmosphere, a static discharge can occur. In industries, flammable vapours and dust may be present during normal operations and a discharge of static electricity has the potential of causing fires and explosions.

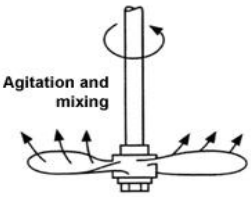
There are 4 conditions that must be present for static ignition to occur:-

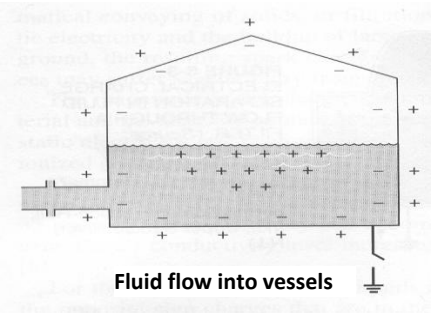
1. Static Charge Generation

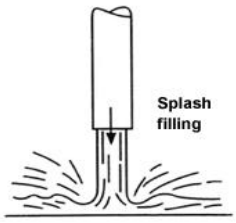
An electrostatic charge is normally **generated** by contact and separation between surfaces of dissimilar materials. Examples include:

- Fluid flowing through a pipe or hose.
- Fluid flowing through a filter.
- Splash filling.
- Fluid flow into vessels
- Bubbling or agitation.
- Steaming.
- Two-phase flow (liquid and gas or liquid and solid).
- Sand or grit blasting.
- Conveyor, roller or belt motion.





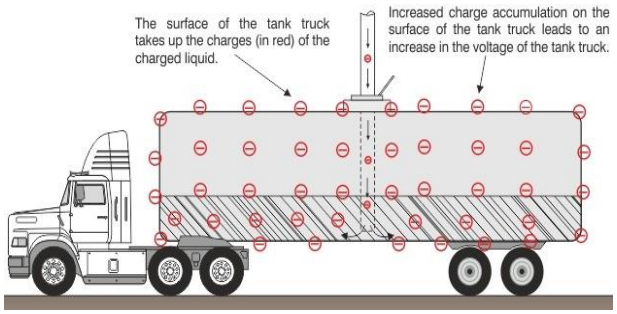




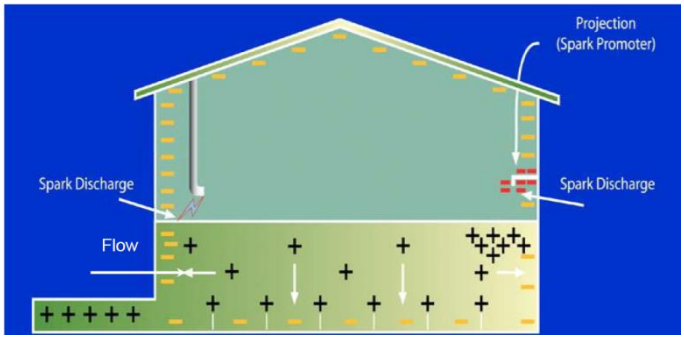
2. Static Charge Accumulation

An electrostatic charge may accumulate when:

- The charge does not dissipate due to low conductivity of product.
- Inadequate time is given for charge to dissipate.
- The container is nonconductive or inadequately grounded.
- An ungrounded, conductive object accumulates the charge.



3. Static Discharge



Electrostatic discharge is the transfer of charges between bodies at different potentials caused by direct contact or induced by a charged field. The spark associated with static electricity is caused by electrostatic discharge, or simply static discharge, as excess charge is neutralized by a flow of charges from or to the surroundings.

A hazardous electrostatic discharge occurs when an accumulated static charge is released in the form of a spark with sufficient energy to cause ignition. Spark discharge usually occurs between a grounded object and a surface that has accumulated a charge.

4. Flammable mixture

Fire occurs when there is an ignitable vapor-air mixture and a source of ignition, such as a static electric spark. At normal handling temperatures, flammable storage tanks, like those containing gasoline, may contain vapor-air mixtures that typically cannot be ignited by a static electric spark because the vapor-air mixture is too rich to burn. Other flammable liquids (e.g., many NFPA Class IB Flammables), may form ignitable vapor-air mixtures inside tanks at normal handling temperatures.

Common Static-Accumulating Flammable Liquids That May Form Ignitable Vapor-Air Mixtures

- VM&P naphtha
- Cyclohexane
- n-Heptane
- Benzene
- Toluene
- n-Hexane
- Xylene
- Ethyl benzene
- Styrene

Some examples of situations in which Flammable mixtures can occur are:-

- Handling material at temperatures close to or above their flash point.
- Switch loading: loading low-vapor-pressure material (such as diesel) into a container having flammable vapors from a previous product (such as gasoline).
- Tank cleaning operations.
- Application of a protective coating inside a tank.
- Relief drums or other light stock pumped into heavy oil.

An Example of Static Ignition

Courtesy: Petroleum Equipment Institute

The customer started fueling. She put it on automatic and returned to sit in the car. The nozzle shut off. She topped off the tank. As she grabbed the nozzle to remove it, a flash fire occurred.

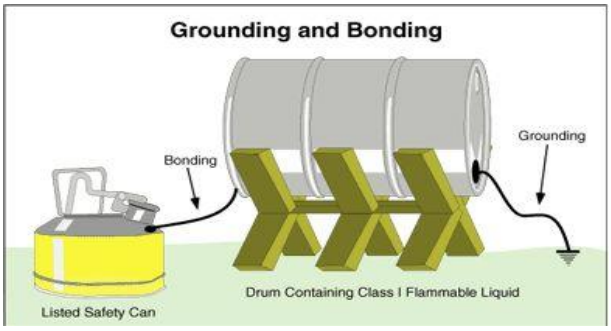
Minimizing Static Ignition Hazards

1. Limit Static Charge Generation

- Control flow rates. Avoid splash filling or misting operations.
- Avoid pumping or flowing hydrocarbons with dispersed water or solids.
- Minimize the need for jet and propeller blending.
- Avoid free-falling or dropping of liquid through the surface of a stored liquid.
- Minimize water droplets or other particulate matter from settling through the liquid body.
- Avoid the use of free-flowing steam to "inert" a potentially flammable vapor space; carbon dioxide has similar properties when "snow" is formed at the nozzle.

2. Limit Static Charge Accumulation

- Use **bonding** and **grounding** to prevent buildup of potential differences on isolated conductive parts of a system.
- Allow sufficient **residence time*** downstream of filters and pumps.
- Allow sufficient **relaxation time**** after filling containers, trucks, railcars and tanks.
- Add static dissipater additives to refined oils.



*Residence time is the amount of time material remains in a grounded conductive delivery system.
**Relaxation time is the time it takes for a charge to dissipate.

3. Eliminate Static Discharge (Static Spark)

Static sparks generally occur between the surface of a liquid that accumulates a charge and a conductive surface or object that is grounded. Here are some basic guidelines to follow:

- Wait before gauging or testing a newly filled tank.
- Eliminate spark promoters projecting into a tank.
- Use bonding to provide a conductive path across possible spark gaps, for example:
  -At the top opening of a tank truck.
  -A hose nozzle and the wall of a tank being cleaned.
  -A metal container and a fill pipe or sample connection.

4. Avoid Flammable Mixtures

There are three methods to avoid flammable mixtures when handling flammable chemicals:-

a) **Inerting** – Adding inert gas to reduce the oxygen concentration below the limiting oxygen concentration (LOC)*.
b) **Dilution** – Removing vapor to dilute the volume percent vapor in air below the lower flammable limit (LFL)**.
c) **Enriching** – Adding combustible gas to increase the volume percent above the upper flammable limit (UFL)***.

*Limiting concentration of oxygen below which combustion is not possible, independent of the concentration of fuel.
**Lowest concentration (percentage) of a gas or a vapour in air capable of producing a flash of fire in presence of an ignition source
***Highest concentration (percentage) of a gas or a vapour in air capable of producing a flash of fire in presence of an ignition source

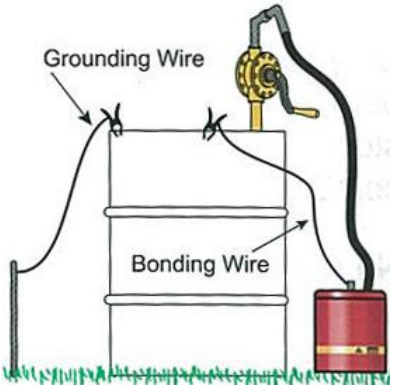
Specific Examples in Industrial Context

1. Road Tankers & Storage Tanks

Static charge from vehicle motion may be generated by the separation of air and dust particles on the vehicle surface, the separation of the tires from the pavement and agitation of intermediate vapor pressure products. Before tank loading begins, the truck is bonded to the loading facility, which in turn is grounded. Splashing or spraying should be avoided by limiting the filling velocity until the loading outlet is submerged. When tank vehicles are unloaded, the truck is first grounded, then bonded to the receiving storage and then the nozzle is bonded before refuelling begins.

There is product movement during filling that can develop a static charge between the liquid surface and tank shell, or metallic fittings, in a non-metallic tank (e. g., manhole). To minimize the risk: avoid splash filling, limit the velocity of the incoming stream, and avoid ungrounded objects in the tank (e.g., gauge floats), don't introduce entrained air, and allow a minimum relaxation time of 30 minutes.

2. Portable Drums and Cans



Single metal containers should be filled with metal spouts that are held in contact with the container or a funnel throughout the filling operation to prevent static accumulation and discharge. However, when transferring into or out of open top containers, the filling stream is broken and splashing occurs. In these operations, a bonding wire should be used to connect the two containers.

Plastic containers are not conductive and can accumulate a static charge on the liquid surface. When filling plastic containers, a grounded conductor should be present in the container being filled throughout the filling process and all conductive elements on the container, such as metal handles, and all nearby metal such as funnels, should be grounded.

3. Purging & Cleaning Tank Vessels

Purging involves removing a fuel vapor from an enclosed space and completely replacing it with air or inert gas. The purging operation can involve static electricity generation if steam jets, or CO_2 jets are discharged into a flammable vapor-air mixture. Both steam and CO_2 can generate static charges on the nozzle and should be avoided.

Vacuum trucks are often used to remove hydrocarbon liquids from vessels that are being cleaned. Ignitions may occur unless suction hoses and conductive pipe wands have electrical continuity.

Refilling of empty vessels when returned to service, should begin at the lowest flow rate to avoid the incoming stream from breaking the liquid surface. And, in the case of floating roofs, the flow should be reduced until the roof is floating off its support legs.

Do continuous monitoring for flammable atmosphere if tank entry is required. Provide a gas-free vapor space, Bond spray nozzles to tank, only use conductive hoses/nozzles; check continuity of system daily. Misting-type operations should be avoided.

Guidelines

- NFPA 77: Recommended Practice on Static Electricity.
- API Recommended Practice 2003: Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents.
- API RP 2219: Safe Operation of Vacuum Trucks in Petroleum Service.
- National Fire Protection Association (NFPA), "NFPA 30: Flammable and Combustible Liquid Code," 2008.
- National Fire Protection Association (NFPA), "NFPA 69: Standard on Explosion Prevention Systems."
- IEC 60079-32-2: 2015 (also EN 60079-32-2: 2015, CENELEC; BS EN 60079-32-1, BSI)

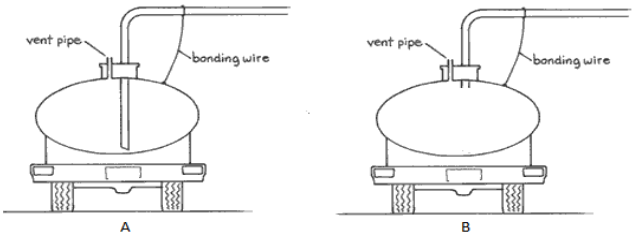
Engage

Answer the following questions to win Amazon coupons worth Rs 500 each. Send the answers to editor.bulletin@tata-aig.com. 5 winners of this quiz will be announced in next issue.

Q. Out of the two trucks being loaded, which is more likely to generate static charge?

a) A

b) B



Q. In the static ignition example shown in Pg – 5, from where did the lady probably acquired the static charge which led to the ignition?
a) From the Car Seat b) From the Fuel Nozzle c) From the surroundings

Q. How will you minimize static charge in plastic drums' filling?
a) Grounding & Bonding the nozzle and the drum b) Using a grounded dip rod

Winners of the previous issue are as follows:

- Amit George, Unison Brokers Pvt. Ltd.

Answers to previous questions: 1. Electric Arc Furnace, 2. Emergency Response Planning, 3. Human Factors

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Figure: Propagating static discharge from a plastic pipe conveying diesel fuel

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