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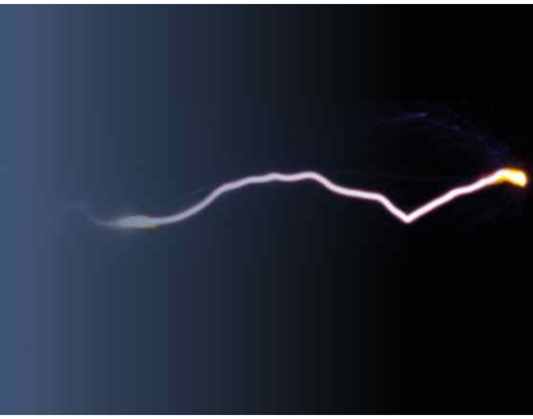

TECHNICAL ARTICLE

Static electricity and its role as a potential ignition source in hazardous areas

Static electricity can be described in a number of different ways, but it is, essentially, electricity stuck in one place. In a normal electrical circuit, charges that form an electrical current move through a closed circuit in order to do something beneficial, like power a computer or the lighting in your house. In these circuits, the charge always returns to the source from which it has been supplied. Static electricity is different. Because it is not part of a closed circuit static electricity can accumulate on plant equipment ranging from road tankers/tanker trucks to flexible intermediate bulk containers.

Static electricity as a hazard

Although static electricity is generally regarded as a nuisance, in the hazardous process industries it can become an ignition source. Discharges of static electricity have been identified as the ignition source in a broad range of processes. It is as potent as sparks resulting from mechanical and electrical sources, and yet, it is often underestimated, either due to a lack of awareness of the risks it poses or because of neglect and/or complacency.

Legislation concerning static electricity in hazardous area process industries

The ignition risk posed by static electricity is addressed in North American and European legislation.

In the US, the **Code of Federal Regulations** that addresses hazardous location activities, **29 CFR Part 1910 "Occupational Safety and Health Standards"**, states that all ignition sources potentially present in flammable atmospheres, including static electricity, shall be mitigated or controlled.

Section 10.12 of **Canada's Occupational Health and Safety Regulations (SOR/86-304)** states that if a substance is flammable and static electricity is a potential ignition source that the employer ***"shall implement the standards set out in the National Fire Protection Association, publication NFPA 77, Recommended Practice on Static Electricity."***

In Europe, **Annex II** of the **ATEX Directive 2014/34/EU** within **Section 1.3.2** states ***"Hazards arising from static electricity: – Electrostatic charges capable of resulting in dangerous discharges must be prevented by means of appropriate measures"***. Thus, "electrostatic discharges" are a known potential ignition source and must be considered as part of the explosion risk assessment.

Industry Code of Practice

NFPA 77 "Recommended Practice on Static Electricity" is one of a number of industry codes of practice that addresses the ignition hazards of static electricity. In recognition of the ignition risks posed by static electricity these publications are produced and edited by committees of technical experts that participate in the hazardous process industries. The following publications are dedicated to helping QHSE professionals and plant engineers identify and control electrostatic ignition sources.

All information provided is in line with **NFPA 77 "Recommended Practice on Static Electricity"** and **IEC TS 60079-32-1 "Explosive atmospheres – Part 32-1: Electrostatic hazards, guidance"**. This information is readily available in the public domain; contact www.NFPA.org and www.IEC.ch.

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List of industry codes of practice designed to prevent ignitions caused by static electricity

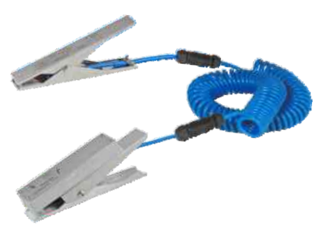
Publisher	Title	Metal grounding circuits	FIBC Type C
International Electrotechnical Commission	IEC TS 60079-32-1: Explosive Atmospheres, Electrostatic Hazards Guidance	10 Ω	1×10^8 Ω
National Fire Protection Association	NFPA 77: Recommended Practice on Static Electricity	10 Ω	1×10^8 Ω
American Petroleum Institute	API RP 2003: Protection against Ignitions Arising out of Static, Lightning and Stray Currents	10 Ω*	N/A
American Petroleum Institute	API 2219: Safe Operation of Vacuum Trucks in Petroleum Service	10 Ω	N/A
International Electrotechnical Commission	IEC 61340-4-4: Electrostatic classification of Flexible Intermediate Bulk Containers	10 Ω	1×10^8 Ω

**API RP 2003 states that 10 Ω is 'satisfactory'*

Note: *Always check for and read the latest version of the International Standards and/or Recommended Practices.*








The basics of the hazard

When a high resistivity liquid, gas or powder becomes electrostatically charged during process operations, it could charge electrically isolated conductive plant, equipment and materials that are in direct contact with it, or in close proximity to it.

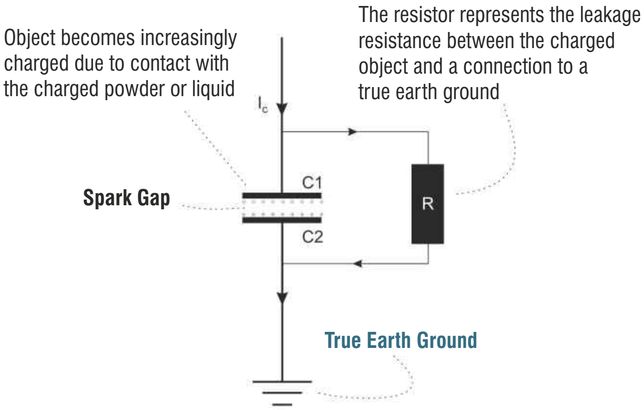


Figure 1: Basic model of why objects can accumulate static electricity. Ref: IEC TS 60079-32-1, Figure A.1

It i scenarios where the hidden increase in the voltage of the charged object presents the static ignition risk. This is because static sparks are caused by the rapid ionization of the atmosphere between the charged object and objects that are at a lower voltage. When the voltage of the object hits a critical level that exceeds the breakdown voltage of the medium present in the gap between the charged object, C1, and uncharged object, C2, ionization occurs, which presents a conductive path for the charges to pass through the gap in the form of a spark. The total energy available for discharge is based on the voltage (V) of the object and its capacitance (C) based on the formula shown below:

$$V = \frac{Q}{C}$$

Where:

V = voltage of charged object (Volts)
Q = total quantity of charge on the object (Coulombs)
C = capacitance of charged object (Farad)

Source: NFPA 77: 6.3.1

Examples of Minimum Ignition Energies

The Minimum Ignition Energy (MIE) is the lowest energy required to ignite flammable materials. *Tables 2a* and *2b* highlights various materials and their MIE values.

Liquid/Gas	MIE
Methanol	0.14 mJ
MEK	0.53 mJ
Ethyl Acetate	0.46 mJ
Acetone	1.15 mJ
Benzene	0.20 mJ
Toluene	0.24 mJ

*Table 2a**: List of* ***flammable liquids and gases*** *and their corresponding Minimum Ignition Energies*

Powder	MIE
Magnesium Stearate	03 mJ
Polyethylene	10 mJ
Aluminum	50 mJ
Cellulose Acetate	15 mJ
Sulfur	15 mJ
Polypropylene	50 mJ

*Table 2b**: List of* ***combustible powders*** *and their corresponding Minimum Ignition Energies*

***The figures listed in Tables 2a and 2b are indictive examples of the MIE. Confirmation of the actual product MIE should be sought from the product supplier.*

Real world scenarios

As described in *Figure 1* the objective of grounding is to mitigate electrostatic voltage increase during the process. Charge accumulation is likely to occur if there is a high enough resistance present between the equipment and general mass of earth.

Connections to the mass of the earth should be provided by high integrity earth grounds present on the site. These high integrity earth grounds will normally be providing paths to ground for lightning and electrical fault currents and should be suitable for dissipating static electricity.

The performance and condition of high integrity grounding points are the responsibility of the site owner and need to be verified on a regular basis by a site appointed competent electrical person.

Tables 2a and *2b* detail MIE of some common liquids and powders used in process industries. If an object becomes isolated and the static voltage increases on it then the charge on the object can quickly achieve a value above the products MIE and therefore be capable of igniting these flammable materials.

But what can cause equipment to become isolated? *Tables 3a* and *3b* provides examples of equipment that can become isolated and the reasons for it.

Operator training

Operator training is essential and should not be overlooked. Operators working in HAZLOC/EX areas should be trained on the basics of static electricity as a potential ignition source as they are, ultimately, the day-to-day users of the grounding and bonding equipment that has been specified and installed at the site.

Examples of Capacitance of various items

Item	Capacitance (pF)
Tank Car	1000
Automobile	500
Person	100 - 300
Oil/Solvent drum	10 - 100
Metal scoop	10 - 20
Needle electrode	1
Dust particule	10^{-7}

Table 3a: Examples of Capacitance
NFPA 77: Table A.3.3.5
IEC TS 60079-32-1: Table A2

Causes of Capacitance

Objects	What causes capacitance?
Portable drums	Protective coatings, product deposits, rust
Road Tankers	Rubber tires
Piping	Rubber and plastic seals, anti-vibration pads and gaskets
Rail Tankers	Grease, vibration pads isolating tank from rails. Rails isolated from loading gantry
Hoses	Broken internal helixes and bonding connectors
FIBC	Non-conductive fabric / damaged static dissipative threads
People	Human bodies
Scoops	Material of construction

Table 3b: Equipment at risk of static charge accumulation and what can cause electrical isolation

They should be trained on the intended function and correct use of the grounding equipment and where the use of the grounding equipment fits within the standard operating procedures of the company. As a basic minimum for most application scenarios (e.g., grounding a metal drum) they should follow the principle of making grounding connections as the first step in the process and to not remove the ground connection until the process is complete.

Operators should be trained to avoid scenarios where, for example, if grounding systems interlocked with the process have their grounding connections removed during the process, thereby initiating an emergency shutdown of the process (e.g., switching off a pump), there could still be movement of material after the machine has stopped, thereby carrying the risk of continued static charge generation.

If operators notice that equipment has been changed or damaged (e.g., fraying cable connections) they should be encouraged to report this to the relevant person at the location (line manager, local QSHE, maintenance personnel) and not use the equipment until a competent person has deemed the equipment safe and appropriate for use.

Not providing training risks incorrect use of the grounding equipment and/or not following company standard operating procedures with respect to static electricity controls.

General static grounding and bonding requirements

Where asset owners deem it necessary to provide static grounding for equipment of metallic construction this can be achieved by connecting the equipment to a verified true earth ground.

The true earth ground provided by the site owner should have a low resistance connection to the general mass of the earth. Verified grounds that provide grounding of electrical circuits and lightning protection circuits are more than adequate for static electricity (**NFPA 77, 7.3.1.6.1**).

For the resistance between the object that is being grounded via the verified true earth ground (e.g., installed bus-bar network) less than 10 ohms is generally regarded as the benchmark for metal-to-metal circuits. This recommendation is based on the idea that indicators of loose connections and corrosion will show electrical resistances higher than 10 ohms. (**NFPA 77, 7.3.1.6.1** and **IEC TS 60079-32-1**).

Options ranging from basic clamps to grounding systems can be specified. Systems with ground status indicators can provide operators with the benefit of a visual indication of a 10 ohm or less connection to the metal object to be grounded. An additional control can be the use of a grounding system with an interlock function. This would require a permissive output from the grounding system's contact with the site owner's process that is controlling the initiation of the process. This supports the principle of ***"Clamp On First, Clamp Off Last"***, so that grounding of the equipment is the first step in the process.

When the grounding system establishes a 10 ohm or less connection between the equipment and verified true earth ground the ground status indicators switch from non-permissive to a permissive state (red to flashing green). Such a grounding system will monitor the resistance between the object requiring grounding and the site verified true earth ground to 10 ohms or less. It should be emphasized that the grounding system is establishing a circuit between the object to be grounded and the site's verified true earth ground network. It is not verifying if the true earth ground network has a connection to the general mass of the earth.

It is the site owner's responsibility to verify that the ground network has a low enough resistance connection to the general mass of earth based on their national electrical grounding and lightning protection standards.

As with any item of equipment it is essential that the grounding system is installed in accordance with the instruction manual. If the system is not installed in accordance with the instruction manual and the hazardous area certificate, hence, the safe operation of the system and the warranty are both invalidated.

Ground connections should never be removed when the process is underway and should never be attached if the operator has not followed the *"Clamp On First, Clamp Off Last"* principle, e.g., where the process has started before the grounding clamp has been attached as this could lead to a static discharge.

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