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Static Electricity

Grounding & Bonding

Federal Regulations, Standards and Recommended Practice.

Typical Applications

Operator Training
Static Electricity

What is it?
Think of electricity as the movement of charge
“Normal” Electricity
Static Electricity

Liquid or Powder flow
Static Electricity
Section 5.2.1 of NFPA 77 “Recommended Practice on Static Electricity” states that it takes the transfer of just one electron out of a total of 500,000 atoms to setup a situation that could lead to an incendive static spark discharge!
### Non-conductive liquids and powders

<table>
<thead>
<tr>
<th>Non-Conductive liquids</th>
<th>Non-Conductive powders</th>
</tr>
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<tbody>
<tr>
<td>Benzene</td>
<td>PTFE</td>
</tr>
<tr>
<td>Diesel</td>
<td>Polyethylene</td>
</tr>
<tr>
<td>Gasoline</td>
<td>PMMA</td>
</tr>
<tr>
<td>Light crude</td>
<td>Wood</td>
</tr>
<tr>
<td>Crude / Gas condensates</td>
<td>Polyurethane</td>
</tr>
<tr>
<td>Jet fuel</td>
<td>PVC</td>
</tr>
<tr>
<td>Kerosene</td>
<td>Pyrex</td>
</tr>
<tr>
<td>Toluene</td>
<td>Neoprene</td>
</tr>
<tr>
<td>Xylene</td>
<td>Nylon</td>
</tr>
<tr>
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<td>Polypropylene</td>
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<tr>
<td>Heptane</td>
<td>Polystyrene</td>
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Discharges of static electricity
Discharges of static electricity
Discharges of static electricity
What causes a static spark?
Primary Factors behind a static discharge
Capacitance

The capacitance of an ungrounded object is a measure of how much charge it can hold, or “store”, over its surface area.

Unit of measure = FARAD

\[ C_1 = 2 \, \text{F} \quad C_2 = 6 \, \text{F} \]
## Capacitance

### Real World Capacitance

<table>
<thead>
<tr>
<th>Object</th>
<th>Capacitance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trucks</td>
<td>Over 1000 pF</td>
</tr>
<tr>
<td>Plant equipment</td>
<td>100 to 1000 pF</td>
</tr>
<tr>
<td>Medium sized containers</td>
<td>50 to 300 pF</td>
</tr>
<tr>
<td>Human body</td>
<td>100 to 200 pF</td>
</tr>
<tr>
<td>Small containers</td>
<td>10 to 100 pF</td>
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<tr>
<td>Small scoops</td>
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Table 5: Equipment at risk of static charge accumulation and what can cause electrical isolation.
Voltage

In electrical circuits **VOLTAGE** is the electromotive force (a.k.a the EMF) that forces electrons to flow in the circuit.

Unit of measure = VOLT

Voltage across object \( (V) \) = electrical current flowing through object \( (I) \) x object’s resistance \( (R) \)

\[
V = R \times I
\]

Voltage of object \( (V) \) = total quantity of charge on object \( (Q) \) ÷ capacitance of object \( (C) \)

\[
V = \frac{Q}{C}
\]
Resistance

Resistance is a measure of the opposition of the movement of electrons through an object. The resistance of an object is a by-product of its molecular configuration. The property intrinsic to an object’s resistance is described as its “resistivity”.

Unit of measure = OHM

\[
\text{Resistance} = \frac{\text{material resistivity} \times \text{cross sectional area of object}}{\text{length of object}}
\]

\[R = \frac{\rho A}{L}\]
Streaming current

An electrical current is the movement of electrons from one point to another point in a circuit. On a battery circuit it is the movement of electrons from the anode terminal to the cathode terminal through wires and components that require energy to do something.
Typical 110 V electrical circuit will supply a current of 10 to 14 amps to a standard hairdryer.

Unit of measure = AMP
Streaming current

Static charging currents can range from 0.01 micro-amps to 100 micro-amps.

MUCH SMALLER than regular electrical current.

Unit of measure = AMP
Static spark energies

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<th>Product</th>
<th>Minimum Ignition Energy</th>
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<tr>
<td>Benzene</td>
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Case Study: Sucking toluene from a tank sump.
Case Study: Sucking toluene from a tank sump.

The facts:

Vacuum truck: 12,000 gallon truck.

Hose: 4 in. diameter neoprene hose with internal metal wire helix.

Suction rate: 500 gallons per min.

Resistance to ground: estimated to be at least $1 \times 10^{11}$ ohm.

Material being vacuumed: Toluene with a resistivity of $1 \times 10^{12}$ $\Omega \cdot m \rightarrow$ static accumulator.

Truck capacitance: in the range of 1 nF to 7 nF.
Estimate Streaming Current:

Suction rate: 500 gpm.

Liquid velocity: 3.89 m/s

Hose diameter: 4 in. (0.1 m)

Streaming Current, \( I_s = 2.5 \times 10^{-5} v^2 d^2 \)

Where:

- \( I_s \) = the charging current carried by the material (amps).
- \( v \) = material flow velocity (metres per second).
- \( d \) = inner hose diameter (metres).

\[ = 4 \times 10^{-6} \text{ Amps (4 micro-amps)}. \]
Calculate the truck’s voltage:

Calculate voltage at:
- 5 seconds
- 10 seconds
- 15 seconds
- 20 seconds
- 25 seconds

\[ V_T = R_G I_S \left[ 1 - \exp\left( \frac{-t}{R_G C} \right) \right] \]

Where:
- \( V_T \) = the voltage of the truck and hose (volts) = ?
- \( R_G \) = resistance to ground (ohms) = 1 x 10^{11} \text{ ohms.}
- \( I_S \) = the charging current carried by the material (amps) = 4 x 10^{-6} \text{ amps.}
- \( C \) = the capacitance of the truck (farads) = 3.5 \text{ nF (nano-farad).}
- \( t \) = the period of time charge is allowed to electrify the truck (seconds).
Calculate the truck’s voltage:

Breakdown voltage of neoprene across a 2 mm gap.
The total energy prior to discharge can be estimated from:

\[ E = \frac{1}{2} (C)(V^2) \]

Energy available for discharge after 20 seconds:

\[ E = 0.5(3.5 \times 10^{-9}).(22216)^2 \]

Energy = 863 mJ.
# Static spark energies

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$\rightarrow$ 863 mJ
To demonstrate this fact if we put the resistance to ground as 1000 ohms, into the voltage calculation for the truck:

\[ V_T = R_G I_S [1 - \exp\left(\frac{-t}{RC}\right)] \]

Where:
- \( R_G = 1000 \) ohms.
- \( I_S = 4 \times 10^{-6} \) A.
- \( C = 3.5 \times 10^{-9} \) F.

**0.004 volts**

**2.8 \times 10^{-11} \) mJ**
Case Study 2: Tipping powder from plastic drum.

Polyethylene Drum with metal “chime”.

Fixed vessel grounded through plant contact.

NewsonGale
HOERBIGER Safety Solutions
Case Study 2: Tipping powder from plastic drum.

Polyethylene Drum with metal “chime”.

Fixed vessel grounded through plant contact.

Powder:
MIE: 12 mJ.
Dielectric constant: 4.10.
Conductivity: $2.5 \times 10^{-12}$ S/m.
Amount of powder: 18.1 kg.

Charge separation (measured): $3.6 \mu C$.

$Q = \delta_{\text{max}} \times A_{\text{surface area of chime}}$

$Q = 27 \mu C \times 0.0641 \text{ m}^2$

$Q$ transferred to chime = $1.7 \mu C$

Discharge energy =

$Q^2/2C = 20 \text{ mJ} \ [>12 \text{ mJ}]$
Grounding & Bonding
Grounding
Grounding

An object can be prevented from accumulating electrostatic charge, and a voltage, if the object has a direct connection to the general mass of the earth.
# Capacitance

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Table 5: Equipment at risk of static charge accumulation and what can cause electrical isolation.
Bonding

Bonding is the act of connecting two conductors together with a low resistance connection.

Effect of bonding conductors together is that they both share charge.

Because they are at the same voltage sparking between the bonded objects cannot occur.

It does not mean that the bonded objects will not acquire a voltage and discharge a spark to uncharged objects or grounded objects.
Resistance to the general mass of the earth.
Resistance to the general mass of the earth.

The primary factors influencing ground resistance are:

- Soil Resistivity.
- Soil Moisture Content.
- Soil Temperature.
- Ground electrode condition.
- Ground electrode depth.
Resistance to the general mass of the earth.

For a 10 ft. rod of 5/8 in. diameter buried in soil, 25% of the total resistance to the mass of the earth is normally present in the first 0.1 ft. distance from the rod.

5 ft. of distance from the rod accounts for 86% of the total resistance to the mass of the earth.
Resistance to the general mass of the earth.

Effect of soil temperature on soil resistivity

Soil Resistivity (ohm.cm)

Temperature in °C
Resistance to the general mass of the earth.
Problem with Static Electricity:

“It won’t happen to me”

Can’t Smell it

Can’t Touch it

Can’t See it
Federal Regulations, Standards and Recommended Practice.
Electrostatic Hazards Environment
Federal Regulations, Standards and Recommended Practice.

Occupational Safety and Health Administration (OSHA)

Responsible for ensuring that safe working conditions are in place for private sector workers.

Falls under the administration of the U.S. Department of Labor and is responsible for enforcing the OSH Act which is encompassed in the Code of Federal Regulations – Title 29 “Labor”. 
Occupational Safety and Health Administration (OSHA)

29 CFR Part 1910 “Occupational Safety and Health Standards” is divided into sections called “standards” that describe in detail what safety measures and precautions need to be actioned in the workplace.

Standard number 1910.106 “Flammable Liquids”, which is listed under sub-part “Hazardous Materials”, addresses the removal and control of sources of ignition in such locations, including static electricity.
Standard 1910.106(b)(6) states:

**Sources of ignition.**

“In locations where flammable vapors may be present, precautions shall be taken to prevent ignition by eliminating or controlling sources of ignition. Sources of ignition may include open flames, lightning, smoking, cutting and welding, hot surfaces, frictional heat, **sparks (static, electrical, and mechanical)**, spontaneous ignition, chemical and physical-chemical reactions, and radiant heat.”
Codes of Practice:

International Electrotechnical Commission
National Fire Protection Association
American Petroleum Institute
CENELEC
American Coatings Association
European Solvents Industry Group
Institute of Electrical and Electronic Engineers
Federal Regulations, Standards and Recommended Practice.

The industry codes of practice most applicable to vacuum truck operations are published by the American Petroleum Institute (API), the National Fire Protection Association (NFPA) and the International Electrotechnical Commission (IEC). These are:

- **NFPA 77** “Recommended Practice on Static Electricity” (2014).
- **API 2003** “Protection Against Ignitions Arising out of Static, Lightning, and Stray Currents” (2015).
IEC 61340-4-4

FIBC shall be properly earthed according to manufacturer’s instructions

- Permitted in dust zones 21-22 and in gas zones 1-2 (explosion groups IIA/IIB)
- Electrical properties may be affected by general usage, contamination and reconditioning
Cen-Stat™ is a coating and conductor formula based on Newson Gale's 30 plus years of experience of the rigorous demands of industrial work environments. It combines the features of a well-respected DuPont thermoplastic elastomer that provides a wide operating temperature range, resistance to a wide range of chemical products and enhanced mechanical durability.

Included in our Cen-Stat™ formulation is static dissipative material that prevents the cable from carrying an electrostatic charge and additives that provide protection against exposure to ultra-violet light.

The conductor is composed of multi-stranded galvanized steel threads providing a conductor cross-sectional area of 11 AWG (4 mm²), and with the coating included provides a cable diameter of 0.25” (6 mm). Cen-Stat is supplied in standard retractable spiral le...

Tests the condition of static dissipative footwear prior to entering hazardous areas exposed to potentially ignitable atmospheres. Provides a time efficient and cost effective method of ensuring personnel operating in hazardous areas are wearing static dissipative shoes that are capable of preventing electrostatic charge accumulation on their bodies. Tests the condition of the shoes by measuring the resistance of the electrical loop through the operator and their footwear.

Specifiers can interlock the tester with audible alarms or entry doors into hazardous areas so that personnel not wearing suitable footwear cannot enter the hazardous area.

Units compliant with:

- EN ISO 20345 — 1 x 10⁹ ohm
- IEC 60079-32 — 1 x 10⁸ ohm
- ASTM F2413-05 — 1 x 10⁸ ohm
Operator Training
Booth 1131