Static Electricity Regulations, Standards & Recommended Practice

Newson Gale
HOERBIGER Safety Solutions

Static Electricity: Mitigation and Control from Newson Gale

We empower people to understand and control electrostatic ignition hazards

About us

Providing our customers with static control solutions globally

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Static Electricity: An Unseen Hazard

Static electricity is with us at every moment

Regulations, Standards & Recommended Practice

- *'DIRECTIVE 1999/92/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 December 1999 on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres (15th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC)'* **(Commonly known as the ATEX 137 Directive)**

Assessment of explosion risks

1. In carrying out the obligations laid down in Articles 6(3) and 9(1) of Directive 89/391/EEC the employer shall assess the specific risks arising from explosive atmospheres, taking account at least of:
   - the likelihood that explosive atmospheres will occur and their persistence,
   - **the likelihood that ignition sources, including electrostatic discharges, will be present and become active and effective,**
   - the installations, substances used, processes, and their possible interactions,
   - the scale of the anticipated effects.

Assessing Electrostatic Hazards

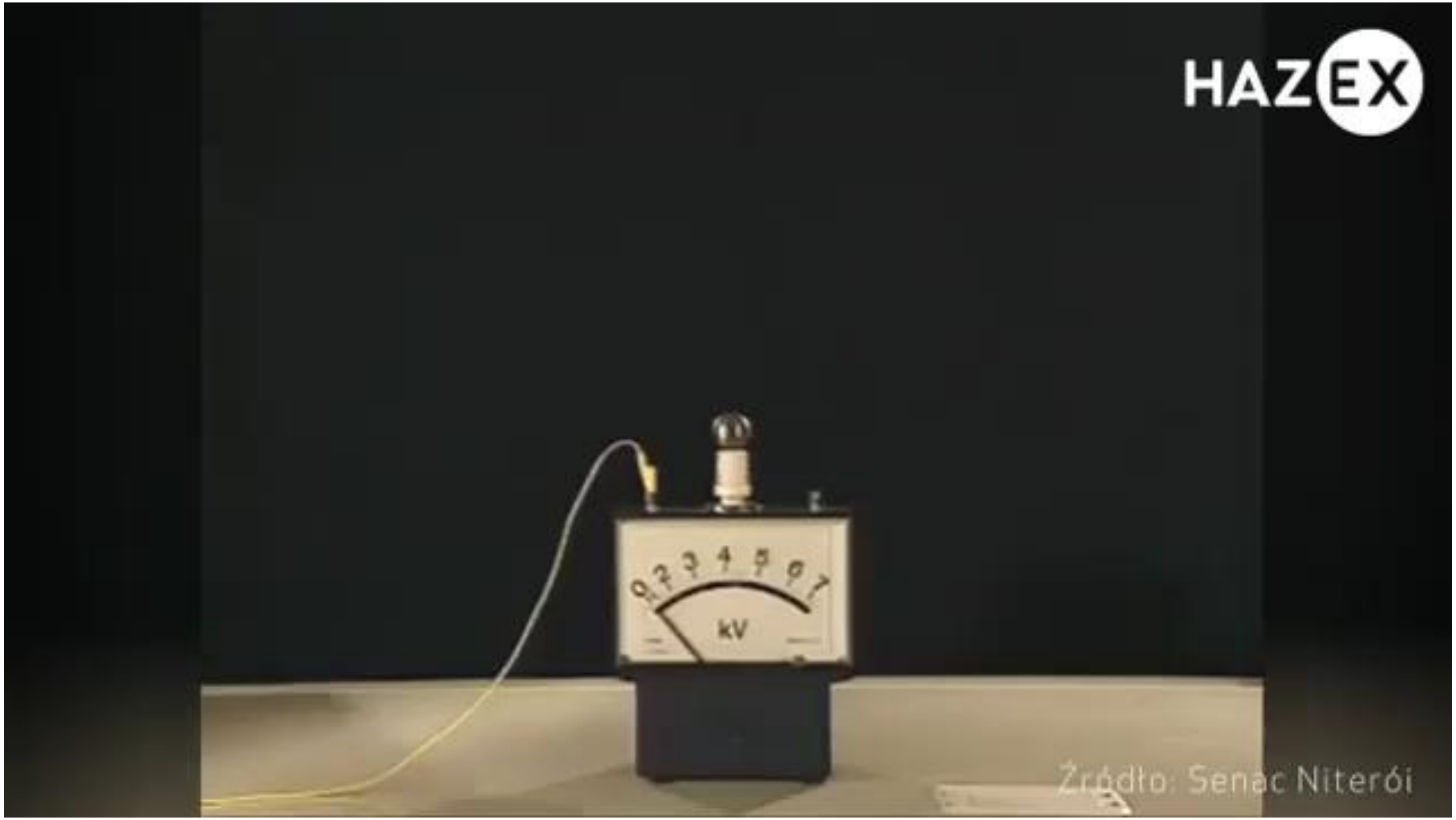
- Could there be a flammable atmosphere?
- Can charge be generated?
- Can charge accumulate?
- Could there be a spark risk?
- Could the spark have enough energy to ignite a flammable atmosphere?

Assessing Electrostatic Hazards

Could there be a flammable atmosphere?

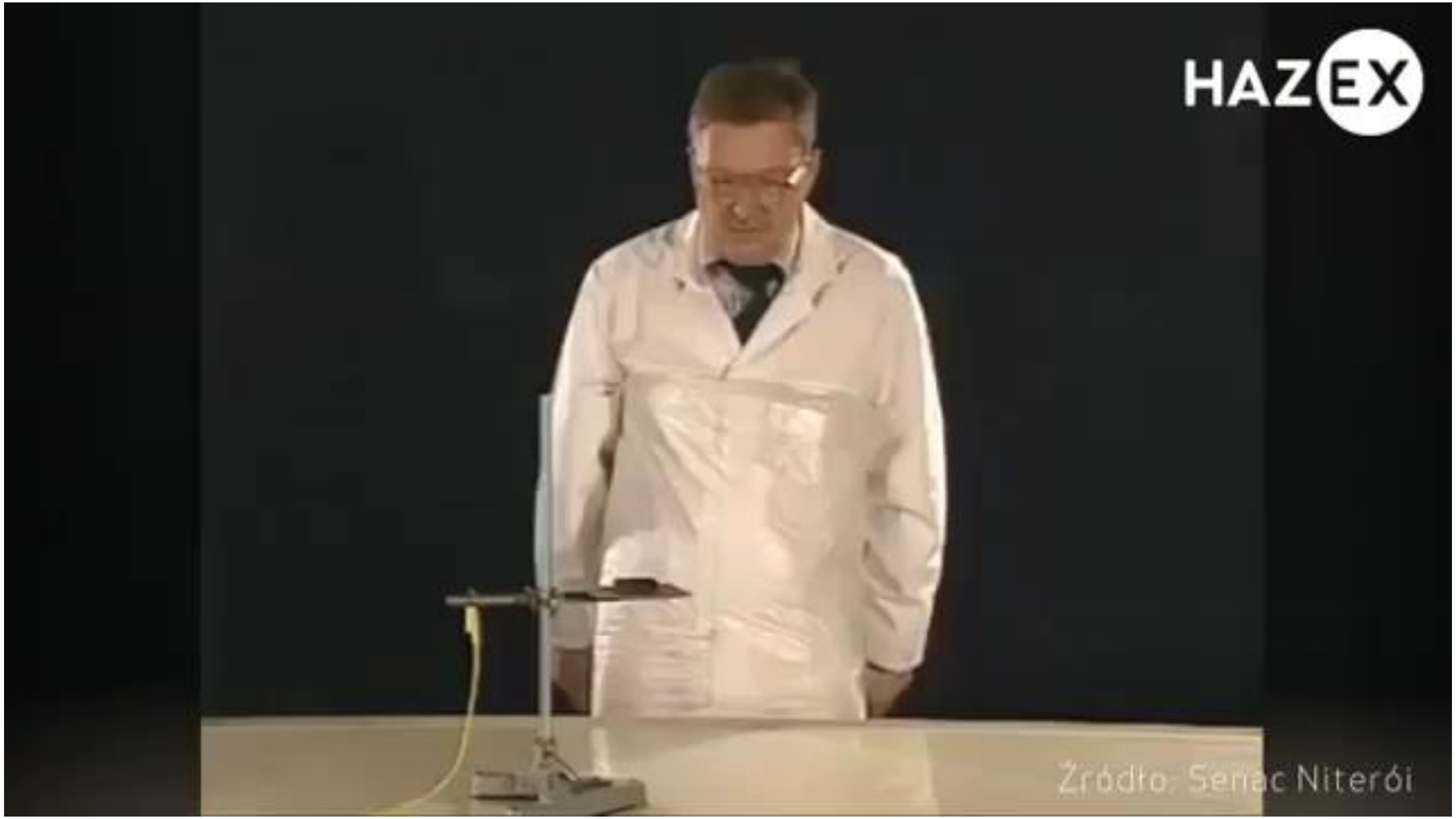
Assessing Electrostatic Hazards

Can charge be generated?



Assessing Electrostatic Hazards

Can charge be generated?



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Assessing Electrostatic Hazards

Can charge accumulate? Could there be a spark risk?

Assessing Electrostatic Hazards

Could the spark have enough energy to ignite a flammable atmosphere?

Examples of Minimum Ignition Energies

The Minimum Ignition Energy (MIE) is the lowest energy required to ignite flammable materials. Table 2 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
Aluminium	50 mJ
Cellulose Acetate	15 mJ
Sulphur	15 mJ
Polypropylene	50 mJ

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

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IEC TS 60079-32-1

Explosive atmospheres. Electrostatic hazards, guidance

https://webstore.iec.ch/publication/60166

(Accessed 30 April 2024)

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IEC TS 60079-32-1 – (Not exhaustive List):

5. General

6. Static electricity in solid materials

7. Static electricity in liquids

8. Static electricity in gases

9. Static electricity in powders

11. Static electricity on people

13. Earthing and bonding.

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10 Ω

13.2.2 Practical Criteria

Metallic items in good contact with earth should have a resistance to it of less than 10 Ω. Although a value of up to 1 MΩ is acceptable for static dissipation, values above 10 Ω may give an early indication of developing problems (e.g. corrosion or a loose connection) and should be investigated. It is important that all connections are reliable, permanent and not subject to deterioration.

13.4 The establishment and monitoring of earthing systems.

Where the bonding/earthing system is all metal, the resistance in continuous earth paths typically is less than 10 Ω. Such systems include those having multiple components. A greater resistance usually indicates that the metal path is not continuous, usually because of loose connections or corrosion. An earthing system that is acceptable for power circuits or for lightning protection is more than adequate for a static electricity earthing system.

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Temporary Earthing

IEC TS 60079-32-1:2018 13.4.1 state:

Temporary connections can be made using bolts, pressure-type earth (ground) clamps, or other special clamps. Pressure-type clamps should have **sufficient pressure to penetrate any protective coating**, rust, or spilled material to ensure contact with the base metal with an interface resistance of less than 10 Ω.

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Passive or Active Grounding?

Passive Grounding

Passive grounding clamps and cables are suitable if the metallic object to be grounded has a bright clean surface. This allows even a poorly designed passive grounding clamp to make a low resistance connection to the metal object.

Active Grounding

Active grounding systems contain intrinsically safe circuits that measure the resistance from between the teeth of the clamp and the local site ground point to 10 ohms or less.

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Movable Metal Items

IEC TS 60079-32-1, 13.3.1.4

“Movable metal items” states:

Portable conductive items (e.g. trolleys equipped with conductive rollers, metal buckets etc.) are earthed through their contact with dissipative or conductive floors.

However, in the presence of contaminants like dirt, or paint on the contact surface of either the floor or the object the leakage resistance to earth may increase to an unacceptable value resulting in possible hazardous electrostatic charge on the object. Where such situations are expected, the object should be earthed by an alternative means (e.g. earthing cable).

A connection resistance of 10 Ω between the cable and the item to be earthed is recommended. Earthing and bonding need to be continuous during the period that charge build-up could occur and cause electrostatic hazards.

IEC TS 60079-32-1, 13.4.1

“The establishment and monitoring of earthing systems” states:

Where the bonding/earthing system is all metal, the resistance in continuous earth paths typically is less than 10 Ω. Such systems include those having multiple components. A greater resistance usually indicates that the metal path is not continuous, usually because of loose connections or corrosion. An earthing system that is acceptable for power circuits or for lightning protection is more than adequate for a static electricity earthing system.

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Road tankers

IEC TS 60079-32-1, 7.3.2.3.3
“Precautions for road tankers” states:

1) Earthing and bonding
   a) The bonding resistance between the chassis, the tank and the associated pipes and fittings on the truck should be less than 1 MΩ. For wholly metallic systems, the resistance should be 10 Ω or less and if a higher value is found further investigations should be made to check for possible problems of e.g. corrosion or loose connection.
   b) An earthing cable should be connected to the truck before any operation (e.g. opening man lids, connecting pipes) is carried out. It should provide a resistance of less than 10 Ω between the truck and the gantry's designated earthing point and should not be removed until all operations have been completed.
   c) It is recommended that the earth cable required in b) be part of a static earth monitoring system that continuously monitors the resistance between the truck and a designated earthing point on the gantry and activates interlocks to prevent loading when this resistance exceeds 10 Ω.

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Earth-Rite® II RTR™

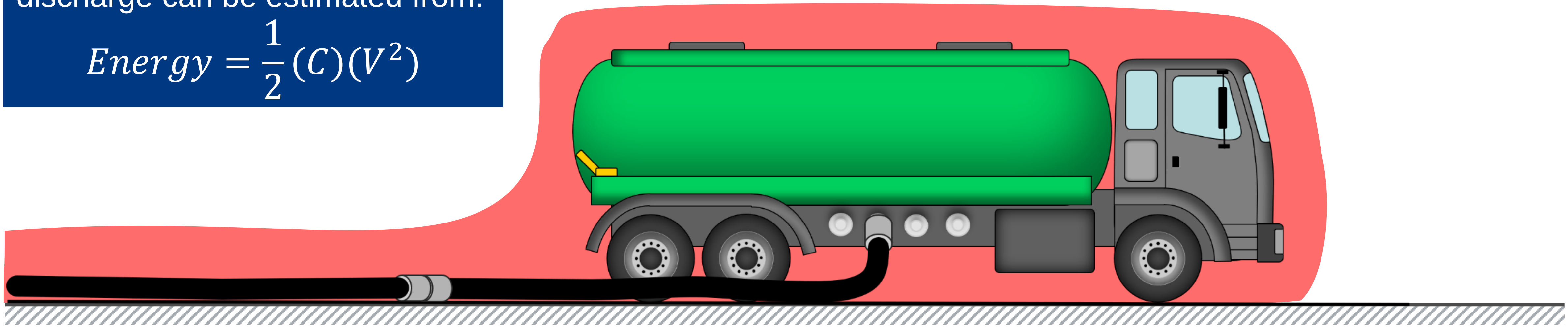
Road Tanker Transfers Risk

A typical road tanker when it is being filled with a liquid at recommended flow rates, but is **without electrostatic grounding protection**, could have its voltage raised to between **10,000 volts and 30,000 volts within 15 to 50 seconds**.

For example, a truck with a capacitance of 1000 pico-farads that is electrified to 30,000 volts has 450 milli-joules of potential spark energy. Given that most hydrocarbon vapours and gases have MIEs of less than 1 milli-joule and most combustible dusts have MIEs of less than 200 milli-joules, it's easy to see why road tankers that do not have static grounding protection in place can be a **major ignition source in a hazardous area**.

The total energy prior to discharge can be estimated from:

$$Energy = \frac{1}{2}(C)(V^2)$$



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Vacuum trucks

IEC TS 60079-32-1, 8.8.4 Vacuum trucks states:

“Vacuum trucks should be connected to a designated site earth before commencing any operations. In areas where site earths are not present, i.e. where portable earthing rods are required, or there is doubt regarding the quality of site earths, the resistance to earth should be verified prior to any operation.

When the truck is connected to a verified earth, the connection resistance between the truck and verified earth should not exceed 10 Ohms for pure metallic connections or 1 Meg-Ohm for all other connections.”

This requirement should be verified with a truck mounted earthing system or portable ohmmeter.

The electrostatic suitability of the hoses used should also be verified in accordance with 7.7.3 or 9.3.3.

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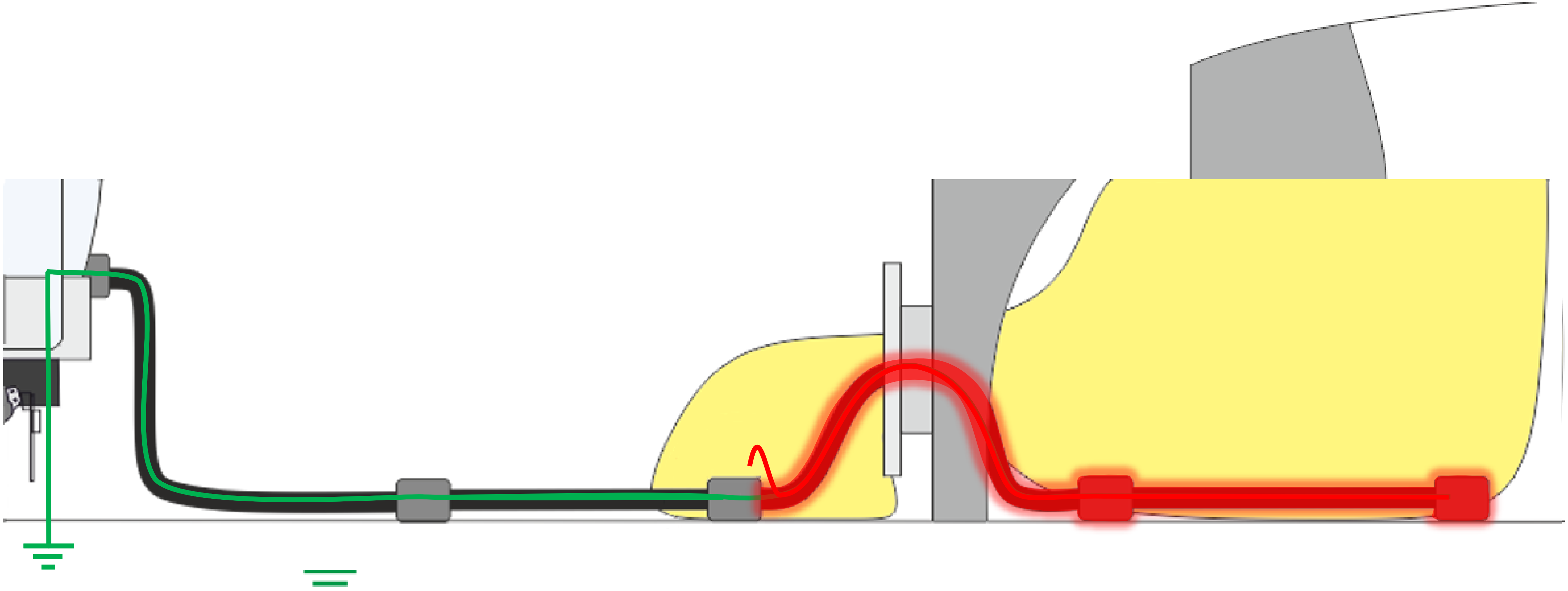
Hoses



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Hoses

IEC TS 60079-32-1

7.7.3.3.1 “End-to-end electrical bonding (continuity).”

End-to-end electrical bonding is usually provided by reinforcing helix wires embedded in the hose wall, or braided metal sheaths bonded to conductive end couplings. It is important that each bonding wire or reinforcing helix is securely connected to the end couplings.

Connections between bonding wires and couplings should be robust and the resistance between the end couplings should be tested periodically. The frequency and type of testing will depend on the application and should be determined in consultation with the manufacturer.

*IEC TS 60079-32-1, Table 16 of 7.7.3.4 “Practical hose classifications” recommends a maximum end-to-end resistance of 100 Ohms for conductive hoses.

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FIBC type C

IEC 61340-4-4 (2018) 'Electrostatics – Part 4-4: Electrostatic classification of flexible intermediate bulk containers 7.3.1. Type C FIBC states:

A Type C FIBC intended for use in the presence of flammable vapours or gases, or combustible dusts with ignition energies of 3 mJ or less (see Annex E) shall have a resistance to groundable point of less than **$1{,}0 \times 10^8\ \Omega$**

IEC TS 60079-32-1:2013/AMD1:2017. Part 32-1 Explosive atmospheres: Electrostatic hazards, guidance, specifically refers to IEC 61340-4-4 (2018) regards FIBC Type C bag resistance.

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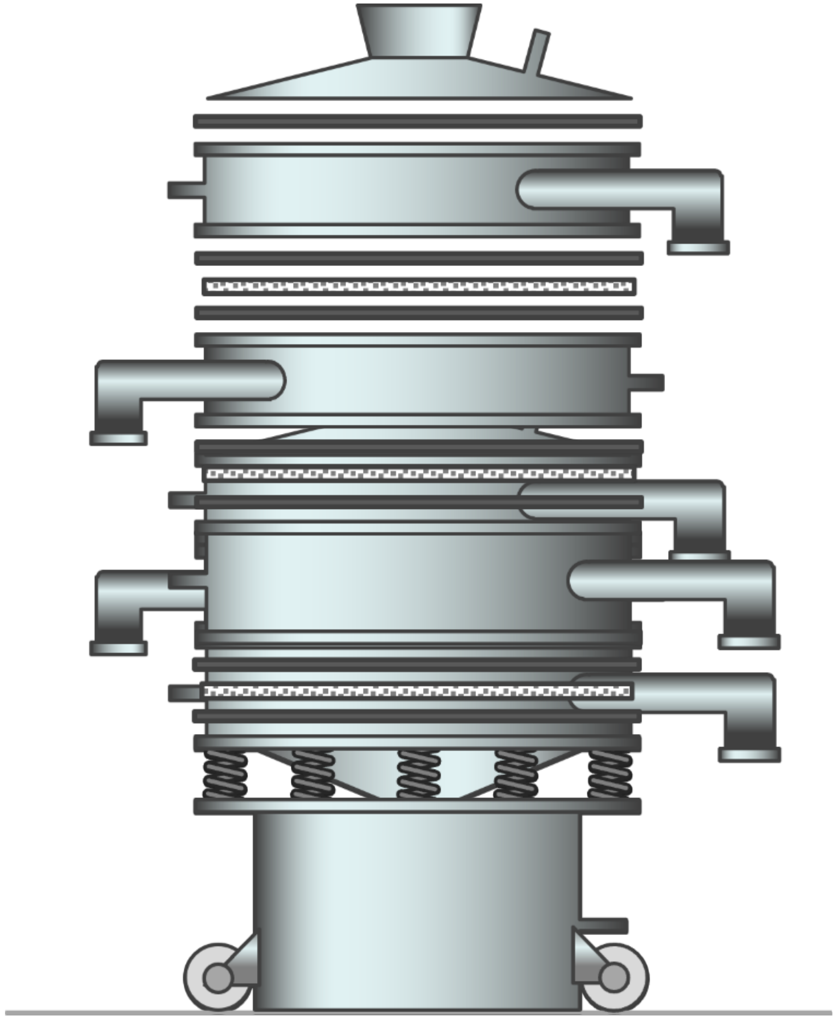
Powders

NFPA 77, 15.3.1 and 15.3.2 'Mechanisms of Static Electric Charging' states:

Contact static electric charging occurs extensively in the movement of powders, both by surface contact and separation between powders and surfaces and by contact and separation between individual powder particles.

Charging can be expected **any time** a powder comes into contact with another surface, such as in sieving, pouring, scrolling, grinding, micronizing, sliding and pneumatic conveying.



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Hydrogen

ISO 19880-1:2020 Gaseous hydrogen – Fuelling stations – Part 1: General requirements within point **10.2.3 Protection from ignition due to accumulation of static charge** states:

- Hydrogen systems shall be equipotentially bonded and grounded to prevent build-up of electrostatic charge.
- Electrical continuity should be ensured throughout the hydrogen systems.
- The electrical resistance between metallic parts connected or in contact together should be less than 10 Ω.
- All hydrogen delivery vehicles shall be equipotentially bonded to the fixed storage hardware prior to flexible hose connection.
- Grounding devices should be clearly visible or be essential to the correct functioning of the fuelling station, so that any shortcomings are quickly detected.
- Effectiveness of grounding connection should be verified at an appropriate frequency that is consistent with risk assessment.

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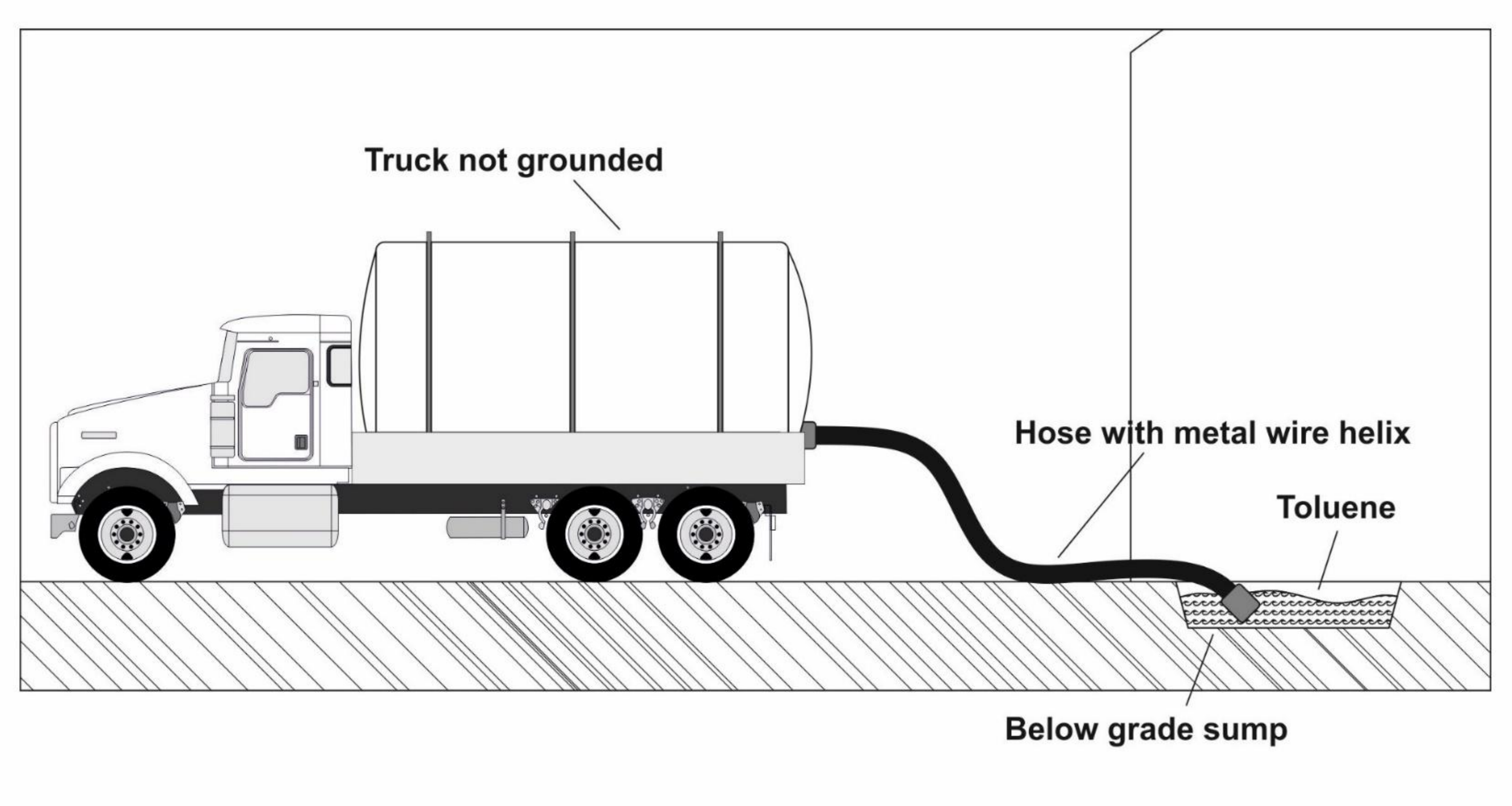
Case Study

Vacuum Tanker – Sucking toluene from a tank sump



Case Study

Vacuum Tanker – Sucking toluene from a tank sump

The facts:

Vacuum truck: 12,000 gallon truck.

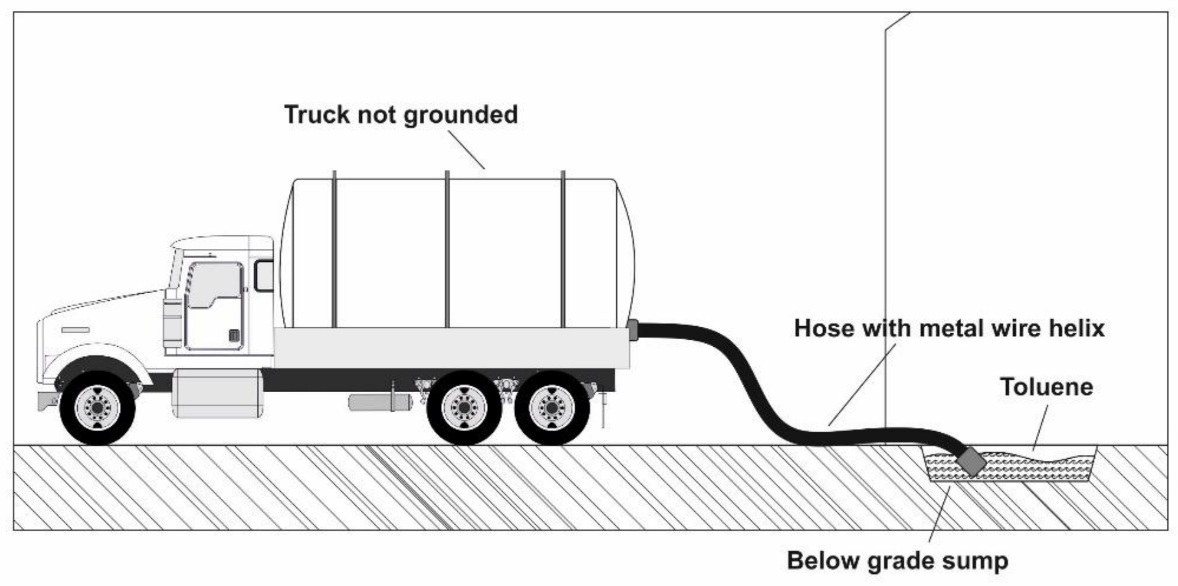
Hose: 4 in. diameter neoprene hose with internal metal wire helix.

Suction rate: 500 gallons per min.

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

Material being vacuumed: Toluene with a resistivity of 1 x10^{12} Ω.m → static accumulator.

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

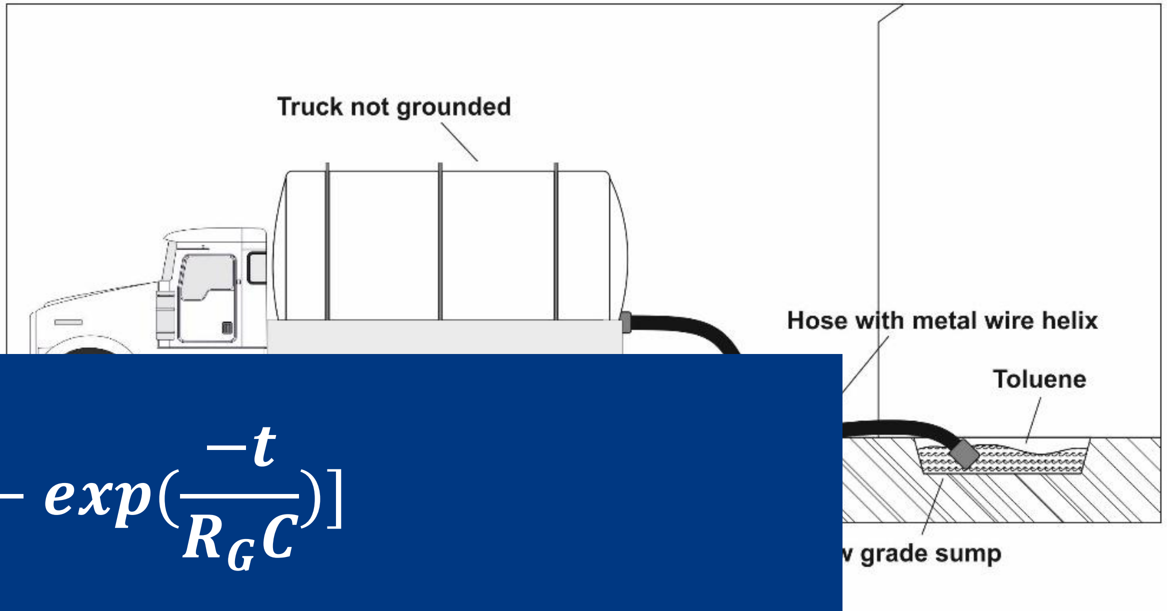


Case Study

Vacuum Tanker – Sucking toluene from a tank sump

Calculate the truck's voltage at:

5 seconds, 10 seconds, 15 seconds etc



Using:

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

Where:

- V_T= the voltage of the truck and hose (volts) = **?**
- R_G = resistance to ground = **1 x10^{11} Ω.**
- I_S = the charging current carried by the material (amps) = **4 x 10^{-6} amps.**
- **C** = the capacitance of the truck (farads) = **3.5 nF (nano-farad).**
- **t** = the period of time charge is allowed to electrify the truck (seconds).

Case Study

Vacuum Tanker – Sucking toluene from a tank sump

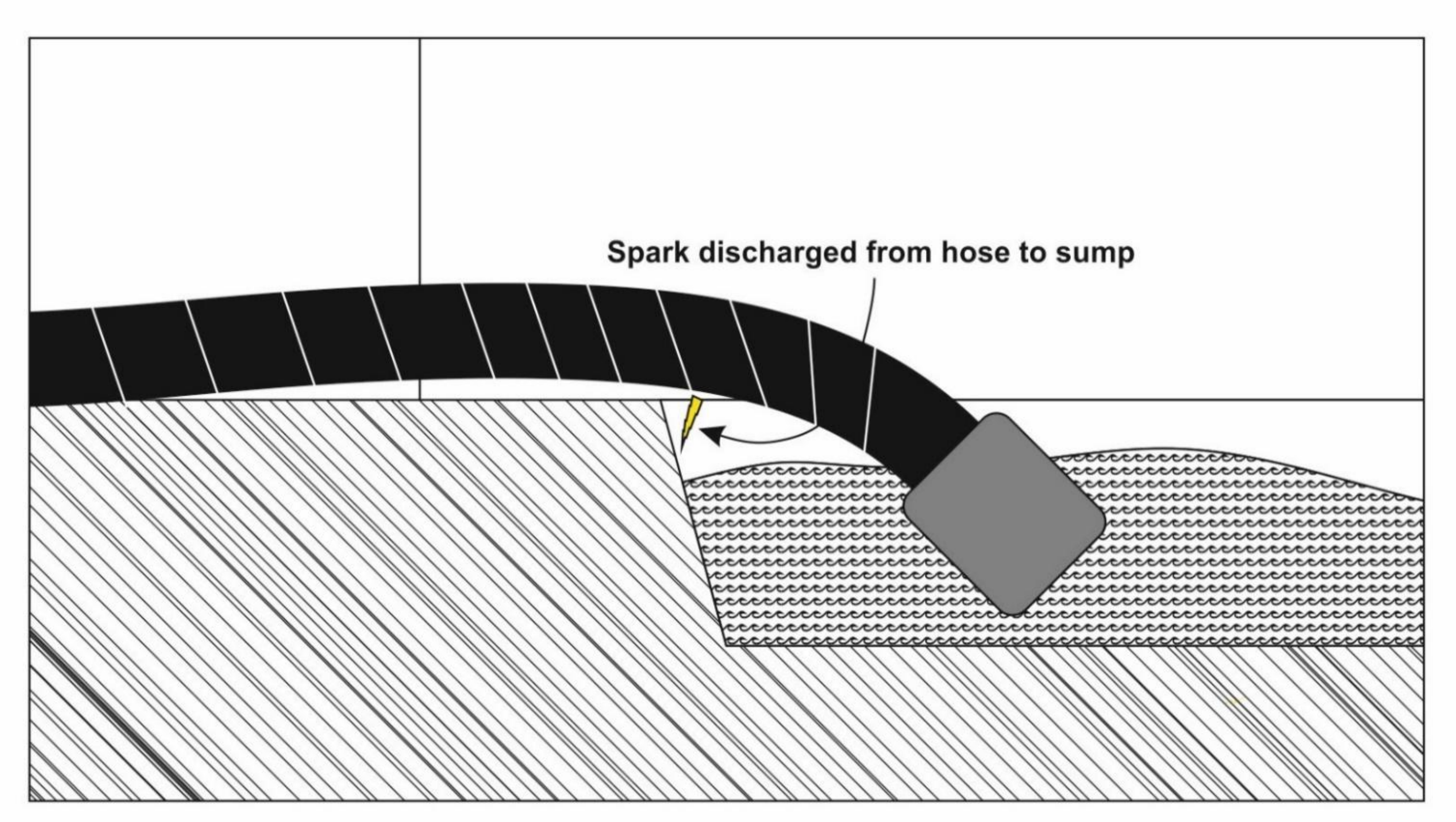
The total energy prior to discharge can be estimated from:

$$Energy = \frac{1}{2}(C)(V^2)$$

Energy available for discharge after 20 seconds:

Energy = $0.5(3.5 \times 10^{-9}).(22216)^2$

Energy = 863 mJ



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Case Study

Vacuum Tanker – Sucking toluene from a tank sump

Product	Minimum Ignition Energy
Benzene	0.2 mJ
Hydrogen Sulphide	0.068 mJ
Pentane	0.28 mJ
Toluene	0.24 mJ
Aluminium	10 mJ
Polyethylene	30 mJ

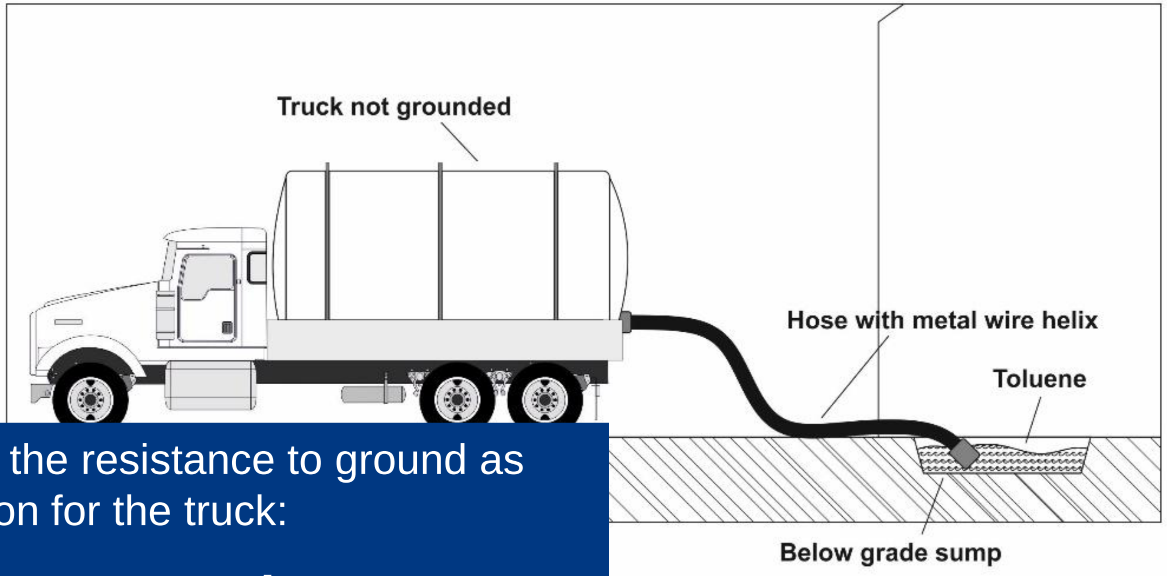
Energy = 863 mJ far exceeds the 0.24 mJ MIE of Toluene

Case Study

Vacuum Tanker – Sucking toluene from a tank sump

If we want to **prevent** this situation arising we **must ground the truck**.

If we know the resistance to ground is below a certain resistance, e.g. **1000 Ω**, we can establish a **verified static grounding point** that will keep any voltages to extremely low levels that will not pose any spark ignition risk.



To demonstrate this fact if we put the resistance to ground as 1000 Ω, into the voltage calculation for the truck:

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

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

= 0.004 volts

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Case Study

Vacuum Tanker – Sucking toluene from a tank sump

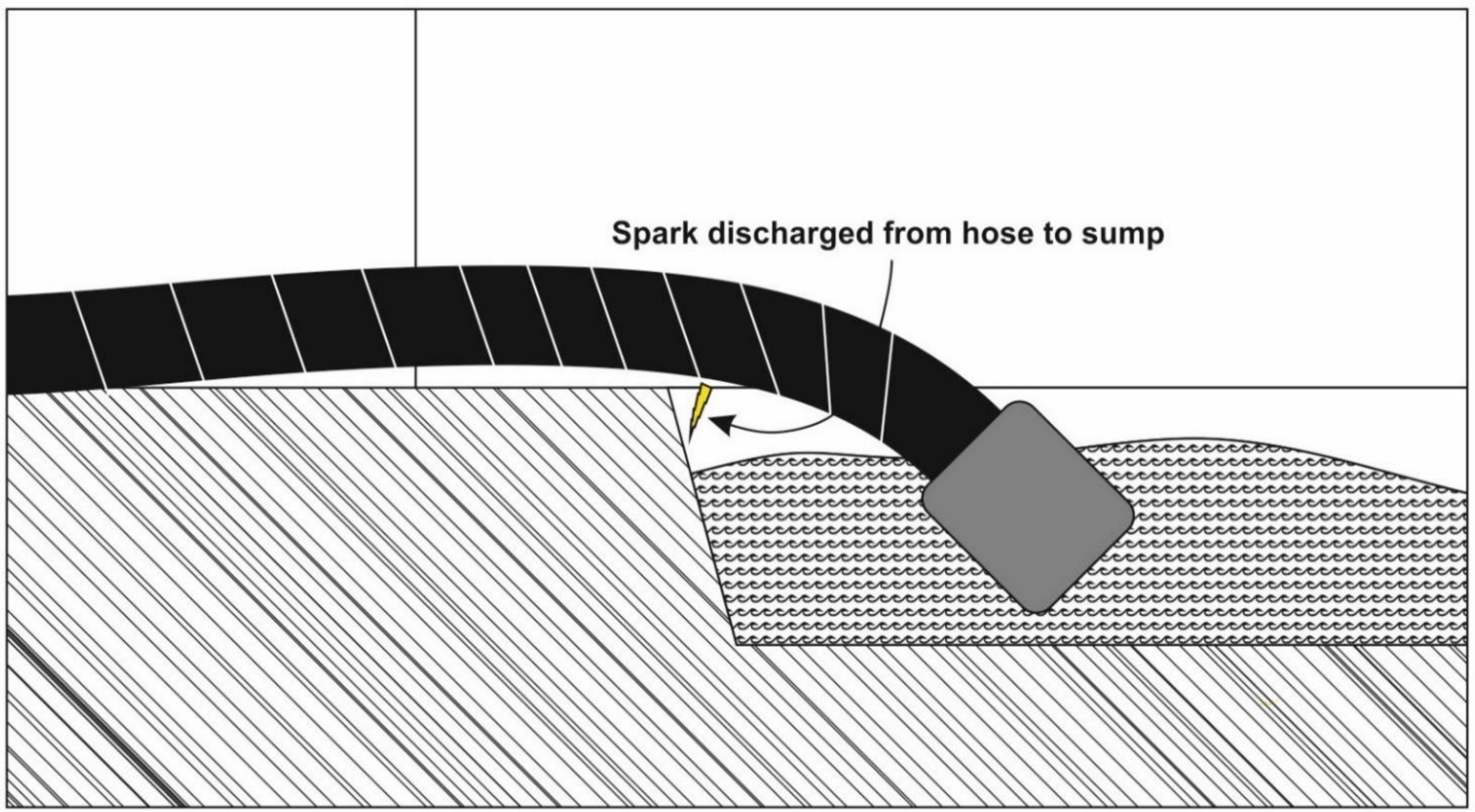
The total energy prior to discharge can be estimated from:

$$Energy = \frac{1}{2}(C)(V^2)$$

Energy available for discharge after 20 seconds:

Energy = $0.5(3.5 \times 10^{-9}).(0.004)^2$

= $2.8\text{x}10^{-11}$ mJ



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Aluminium	10 mJ
Polyethylene	30 mJ

Energy = 2.8×10^{-11} mJ (0.000000000028 mJ)
far below the 0.24 mJ MIE of Toluene

Thank you for listening

Questions & Discussion