Grounding & Bonding Applications

Controlling static electricity in hazardous areas

Issue 3

Leading the way in hazardous area static control

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Newson Gale
HOERBIGER Safety Solutions

Headquartered in Nottingham in the heart of the United Kingdom, we develop and manufacture a range of hazardous area hardware solutions dedicated to mitigating the accumulation of static electricity on process equipment.

Newson Gale® is a company committed to mitigating the ignition hazards of static electricity.

ATEX IECEx SIL 2 INMETRO

Controlling static electricity in hazardous areas

This Grounding and Bonding Handbook highlights some of the processes that can be susceptible to static charge accumulation.

Various guidelines referred to in the Handbook can provide more detail on these processes. It should be noted, however, that not all processes at risk of electrostatic discharges can be highlighted in a single document. For professional advice on electrostatic hazard identification please refer to specialist consultants or internal hazardous process experts within your company. Newson Gale does not provide such services and focuses solely on providing customers with grounding and bonding hardware solutions for applications that have been identified at site.

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Static electricity as a hazard

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 to flexible intermediate bulk containers.

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 European and North American legislation. In Europe, Annex II of the ATEX Directive 2014/34/EU states the following:-

Section: 1.3.2 Hazards arising from static electricity:- Electrostatic charges capable of resulting in dangerous discharges must be prevented by means of appropriate measures so “electrostatic discharges” are a known potential ignition source and must be considered as part of the explosion risk assessment.

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 United States National Fire Protection Association, Inc. publication NFPA 77, Recommended Practice on Static Electricity.”

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Industry Codes 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.

Leading the way in hazardous area static control

Publisher	Title	Metal Grounding Circuits	FIBC Type C
International Electrotechnical Commission	IEC 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	1×10^7 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	N/A	1×10^8 Ω

Table 1: List of industry codes of practice designed to prevent ignitions caused by static electricity
* 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.

It is 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 ionisation 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*, ionisation 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 drum 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

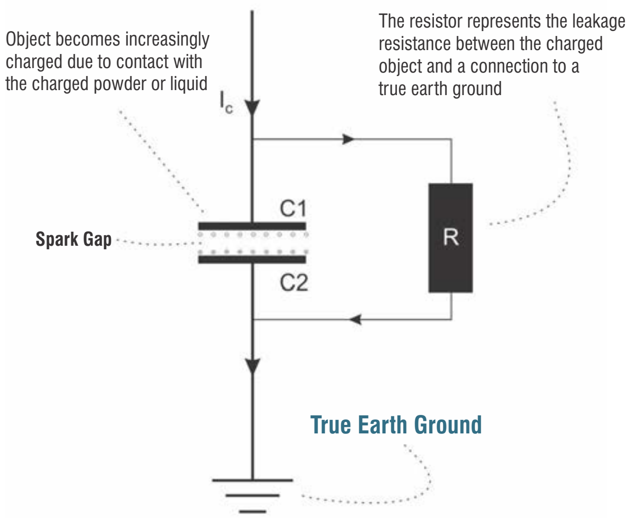

Figure 1: Basic model of why objects can accumulate static electricity.
Ref: IEC 60079-32-1, Figure A.1

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 (ref: NFPA 77, 7.4.1.3.1).

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 Minimum Ignition Energy (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? Table 3a and 3b provides examples of equipment that can become isolated and the reasons for it.

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

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 particle	10^{-7}

Table 3a: Examples of Capacitance
IEC 60079-32-1: Table A.2
NFPA 77: Table A.3.3.5

Causes of Capacitance

Objects	What causes capacitance?
Portable drums	Protective coatings, product deposits, rust
Road Tankers	Rubber tyres
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.

Grounding and Bonding Applications

The following pages identify the most common processes that require static grounding and bonding.

References from the various industry codes of practice listed in the Contents page of this Handbook are provided alongside a brief explanation of the electrostatic ignition hazard behind individual processes.

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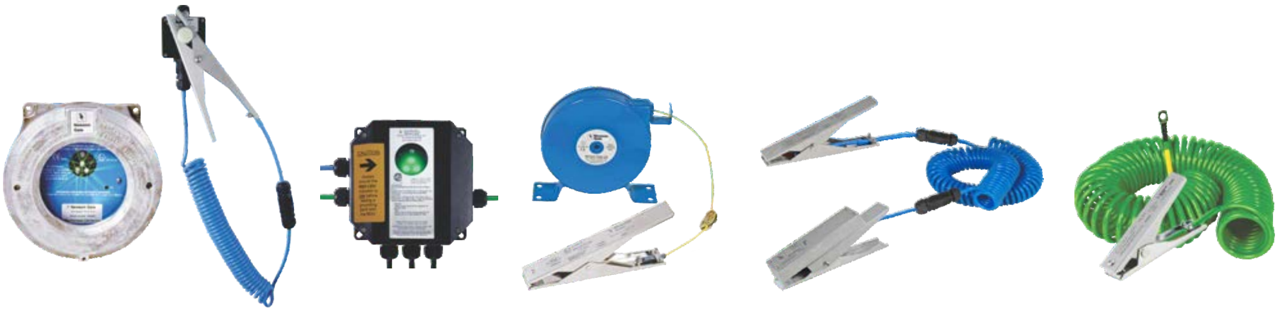

Operator Training

Operator training is essential and should not be overlooked. Operators working in EX/HAZLOC 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.

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 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 earthing of electrical circuits and lightning protection circuits are more than adequate for static electricity (NFPA 77, 7.4.1.3.1).

For the resistance between the object that is being grounded via the verified true earth ground (e.g. installed bus-bar network) 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, 7.4.1.3.1 and IEC 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 – 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 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 earthing 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 both 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"* 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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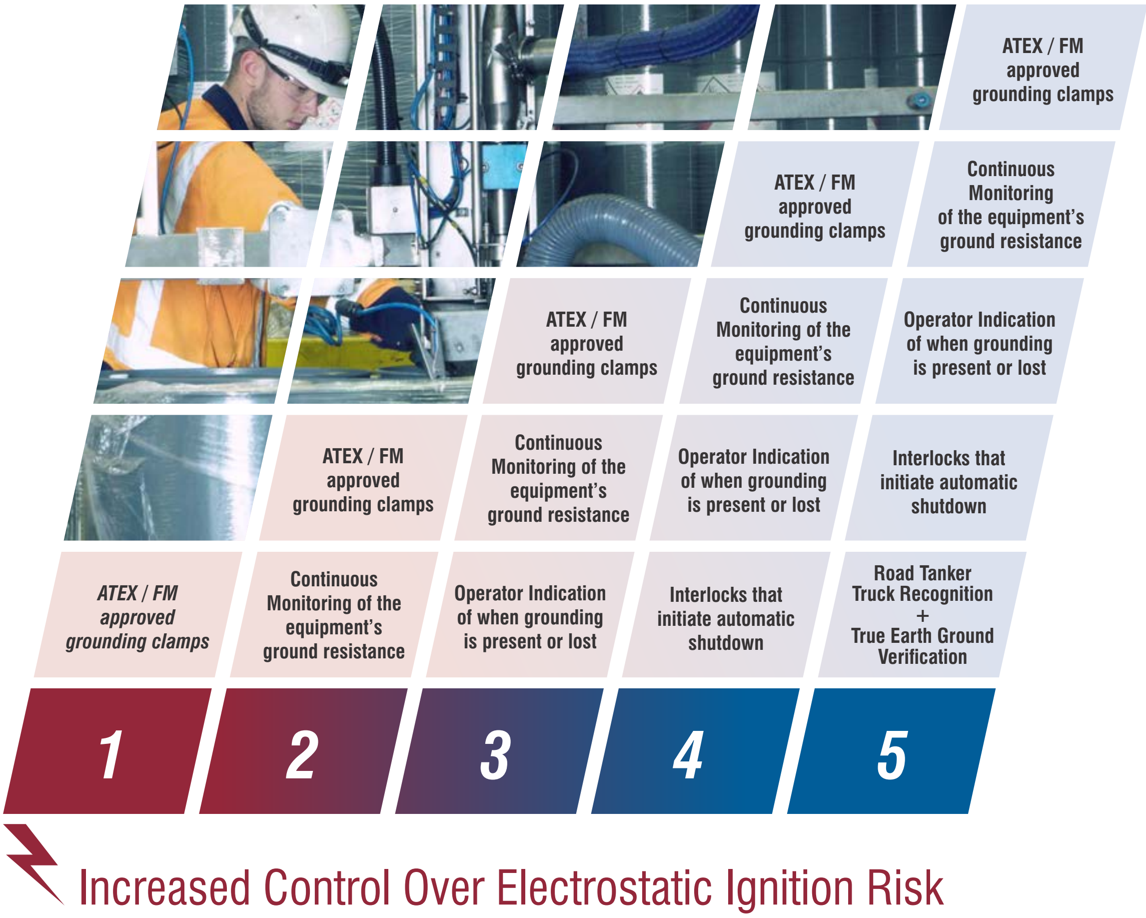

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Earth-Rite® Range

Static Ground Monitoring & Interlock Systems

The Earth-Rite range of static grounding and interlock systems provide an optimum level of control for mitigating against the risk of static charge accumulation.

All Earth-Rite systems feature electronics that continuously monitor the ground path resistance between the grounded object and a verified grounding point, operator displays with LED indicators and internal relays that can be interlocked with the liquid or powder transfer equipment.

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Earth-Rite® II RTR™

Road Tanker Truck and Railcar flammable product transfer

Earth-Rite® II MGV

Truck Mounted Static Earthing Verification

Earth-Rite® II PLUS™

Filling, mixing and blending of flammable / combustible materials in Drums, IBCs, Totes, Portable Containers and Mobile Tanks

Earth-Rite® MULTIPOINT II

Multiple grounding of potentially isolated conductive components of manufacturing and processing systems

Earth-Rite® II FIBC

Filling or discharging Type C FIBCs in flammable or combustible atmospheres

Earth-Rite® OMEGA II

Compact panel mounted static grounding module

Grounding a road tanker with system interlocks and indication

When an ungrounded road tanker is being filled/emptied with a liquid or powder, the road tanker could accumulate enough static to pose a discharge risk.

To counteract this risk, it is important to ensure that the road tanker does not have the capacity to accumulate static electricity. The most practical and comprehensive way of achieving this is to make sure that the road tanker is at earth potential, especially before the transfer process starts.

This is because the general mass of the Earth has an infinite capacity to balance charges which in turn minimises the accumulation of static in the road tanker, and mitigates the generation and presence of voltages on the road tanker.

Using a grounding system can increase the safety and efficiency of the loading/unloading process by reducing the need to physically measure the bond between the earth bar and the road tanker to ensure it is in good condition.

Having a simple display coupled with education of the drivers/operators that they attach the grounding clamp as the primary function ensures repeatable reliability of use. When using a grounding system to ground and monitor the road tanker, a permissive state can clearly be indicated to the driver/operator by GREEN flashing LEDs whilst utilising interlock relays can assist in improving the safety of the loading/unloading process.

IEC 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.

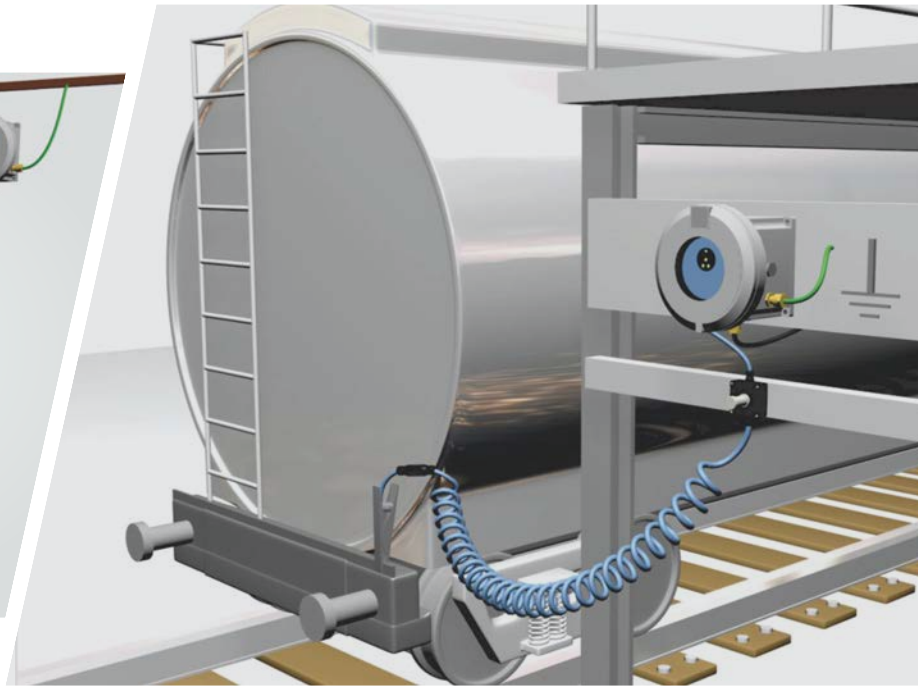
Grounding railcars, IBCs and drums with system interlocks and indication

Isolated conductive metal objects like railcars, LACT units, skids and IBCs that come into contact with electrostatically charged liquids can accumulate high levels of electrostatic charge.

If an ungrounded object is allowed to accumulate electrostatic charges, the voltage present on the object rises dramatically in a very short space of time. Because the object is at a high voltage, it is seeking to find ways of discharging this excess energy and the most efficient way of doing this is to discharge the excess charge in the form of a spark.

Grounded objects that are in close proximity to charged objects are potential targets for electrostatic discharges.

If the transfer system is not grounded, the electrostatic voltage of objects like railcars can build up to hazardous levels in a short time period.



IEC 60079-32-1, 13.3.1.4
"Movable metal items" states:

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.

NFPA 77, 12.4.1 & 12.4.2.
"Railroad Tank Cars" states:

In general, the precautions for railroad tank cars are similar to those for tank vehicles specified in Section 12.2*.

*Section 12.2:

Many tank cars are equipped with non conductive bearings and nonconductive wear pads located between the car itself and the trucks (wheel assemblies). Consequently, resistance to ground through the rails might not be low enough to prevent accumulation of a static charge on the tank car body. Therefore, bonding of the tank car body to the fill system piping is necessary to protect against charge accumulation.

Tank trucks should be bonded to the fill system, and all bonding and grounding should be in place prior to starting operations. Ground indicators, often interlocked with the filling system, frequently are used to ensure bonding is in place.

Truck mounted static ground verification with system interlocks and indication

Normally, road tankers (tank trucks) load/unload at a fixed point in a factory. However, vacuum trucks can work anywhere from main roads/highways to refineries/chemical plants and require a different grounding solution.

Continuity between all metal parts on the vacuum truck is essential. Every metal item must be bonded to the chassis and tank with caution towards paint, coatings and hose trays.

The most crucial aspect of safety concerning vacuum trucks is the education of the operator that on arrival at site they attach the grounding clamp first and get a GREEN flashing LED that clearly shows that the truck is grounded before any other operations are started e.g. attaching hoses.

The second most crucial part is to remove the clamp after all other operations have been completed and equipment packed away - clamp on first and clamp off last.

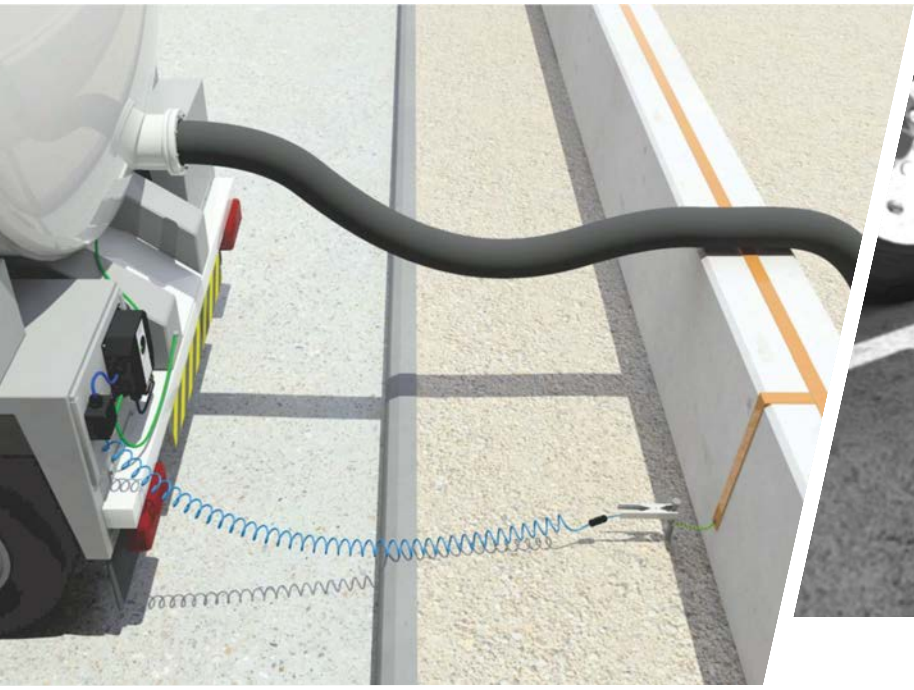
A lot of users fit a simple hand wound or retractable cable reel and clamp to protect vacuum trucks and road tankers. The advantage to installing a monitored grounding system will alert users of the following dangers:

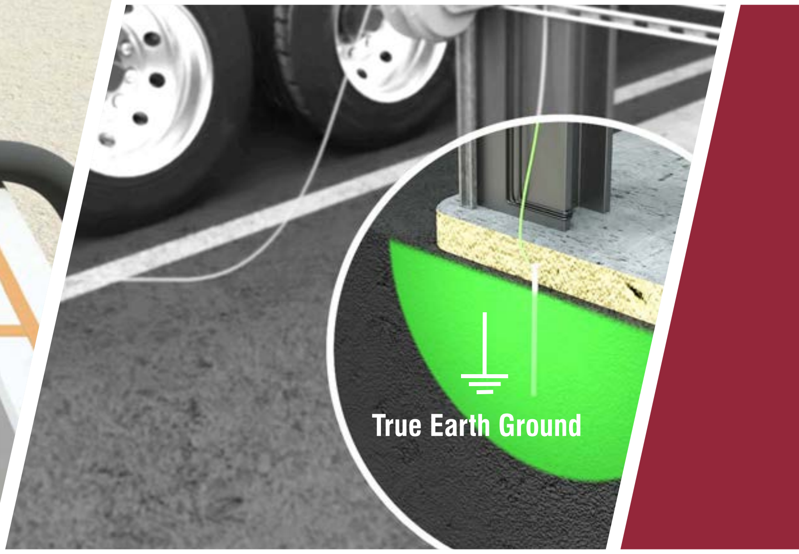
> The grounding system will provide a visual indication of a GOOD or BAD ground connection.

> The grounding system will provide true earth verification e.g. is the system connected to an earth that is capable of dissipating static electricity.

> The grounding system is a monitored circuit and will automatically shut down the product transfer if the ground connection is lost. However, the product itself would need to stop moving in order to prevent any further charge generation.

The grounding system complies with International Standards e.g. <10 Ohms metal to metal loop resistance between the teeth of the clamp and the chassis/tank of the vacuum truck.





The installation of a truck mounted grounding system requires an experienced EX/HAZLOC electrical engineer who will be able to complete a satisfactory installation that complies with EX/HAZLOC approval requirements and code.

Most importantly read the manual and install the EX/HAZLOC truck mounted grounding system as per the manufacturer's instructions and the approval control drawings for the best operational results and safety.

The side and rear of the vacuum truck are the typical positions where the grounding system can be sited. This allows the driver to see the GOOD or BAD grounding signal whilst using the other controls of the truck. The side and rear of the vacuum truck are usually Ex zoned areas.

Always choose a grounding system with an intrinsically safe (ia) signal out to the clamp for the upmost safety.

Depending on construction, grounding clamps supplied by an intrinsically safe (ia) signal can go anywhere in a hazardous area/location (Zone 0 / Class I, Div. 1).

Depending on construction, grounding clamps supplied by an intrinsically safe (ib) signal can only go into a hazardous area/location (Zone 1, 2 / Class I, Div. 2).

A high intensity coloured light can be placed on the top of the truck and interlocked with the grounding system. This supplements the grounding system and allows the driver and all other team members to clearly see the condition of the grounding system and react accordingly.

If the vacuum truck often visits a remote loading site then it is good idea to get a verified grounding point installed and checked regularly by a responsible person. Rods in the ground are normally a good way of providing this designated grounding point.

If the vacuum truck rarely visits the remote loading site then a fully featured truck mounted grounding system will be required to let the driver test metallic objects installed in the earth near to the transfer point to see if any are suitable for use as a grounding point and therefore protect the product transfer, plant and personnel.

There are a number of International standards and Industry recommendations that relate to the safe use of vacuum trucks and static electricity.

Always check to make sure that you are consulting the latest version of the International Standards and or Recommended Practises.

IEC 60079-32-1, Explosive atmospheres
Part 32-1: Electrostatic hazards, guidance

8.8.4 Vacuum trucks

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.

ADR Volume 2 - Concerning the International Carriage of Dangerous Goods by Road

Chapter 4.5 Use of Vacuum Operated Waste Tanks and: 6.9.2.14.3

All components of the shell shall be electrically connected to each other and to the metal parts of the service and structural equipment in contact with each other shall not exceed 10 Ohms.

Safe Operation of Vacuum Trucks Handling Flammable and Combustible Liquids in Petroleum Service

API Recommended Practice 2219, Sections 3.2, 3.7, 5 to 5.5.3

Protection against Ignitions Arising Out of Static, Lightning, and Stray Currents
API Recommended Practice 2003

Recommended Practice on Static Electricity
NFPA77, Section 12.3 Vacuum Trucks

WJTA - Water Jet Technology Association
(USA & Canada)
Vacuum Truck Safety Practices
Recommended Practices for Industrial Vacuum Services

SIR - Stichting Industriële Reining (Holland & Belgium)

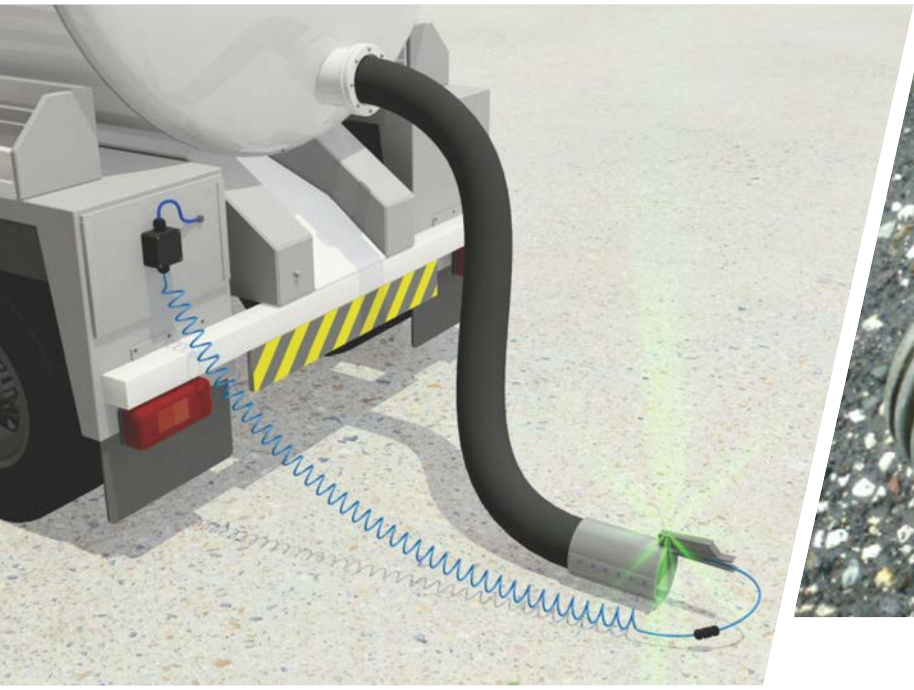
Hose testing and electrical continuity testing with visual indication

Hoses play an important role in hazardous area operations and owing to their direct interaction with moving liquids and powders can be at risk of becoming electrostatically charged. At no point in its structure should the metal components of a hose be permitted to accumulate static electricity.

Examples of metal components that have the potential to accumulate static charge are couplings and metal wire helixes.

Periodic resistance testing of hoses with meters by a responsible person (experienced electrician) helps identify potentially faulty hoses so that they can be removed from service.

Another option is to supply drivers with an easy to use hose continuity tester that provides an LED indicator to indicate a PASS or FAIL test of the hose. It should be emphasised that drivers must be suitably trained as being competent to use such testers.



IEC 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 60069-32-1, Table 16 of 7.7.3.4 “Practical hose classifications” recommends a maximum end-to-end resistance of 100 Ohms for conductive hoses.

There a number of International guidelines that relate to the safe use of hoses and static electricity.

Always check to make sure that you are consulting the latest version of the International Standards and or Recommended Practises.

IEC 60079-32-1 - Section/s: 7.7.3 to 7.7.3.5

API RP 2219 - Section: 5.3 “Conductive and Non-conductive Hose”

OhmGuard®

Grounding interconnected plant assemblies and piping with system interlocks and indication

Powder processing operations can generate large quantities of electrostatic charge via the movement of powder. The most common cause behind the electrostatic charging of powder processing equipment is “tribo-electrification”.

In pharmaceutical operations, equipment like powder conveying systems, micronizers, blenders and sieve stacks all make up multiple component assemblies that can accumulate high levels of electrostatic charge should any of the components be isolated from a true earth ground.

Regular disassembly for cleaning and maintenance can result in bonding connections being missed or not being made correctly when the equipment is reassembled.

Regular flexing, vibration and corrosion can also degrade assembly connections so it is imperative to ensure that no parts in the assembly become isolated from a true earth ground.

Powder processing equipment presents more of a challenge compared to standard applications as there are many metal parts that can make up larger assemblies that are potentially electrically isolated from each other. It is therefore important to ensure that multiple components that come into contact with charged powders have a means of being monitored for static grounding protection purposes.

This application scenario is not limited to powder processing equipment. Multiple grounding points in liquid processing applications (e.g. multiple drum filling / railcar loading) can be managed with a single grounding system.

NFPA 77, 15.3.1 & 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.

IEC 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.

Protecting Type C FIBC against static electricity

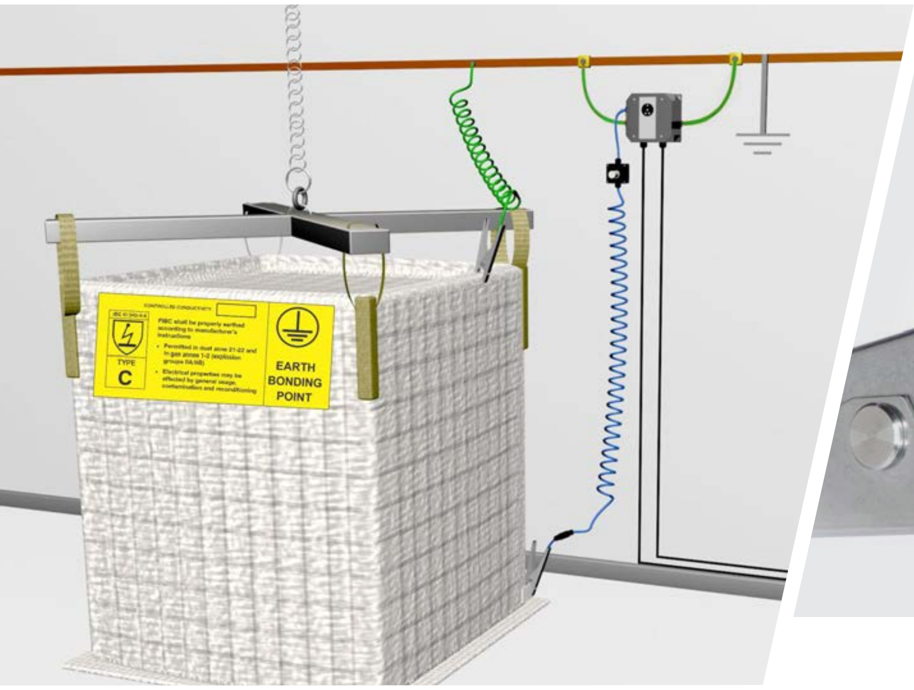
Type C FIBCs are made from conductive fabric or plastic sheet, or interwoven with conductive threads or filaments and designed to mitigate the occurrence of electrostatic discharges, brush discharges and propagating brush discharges.

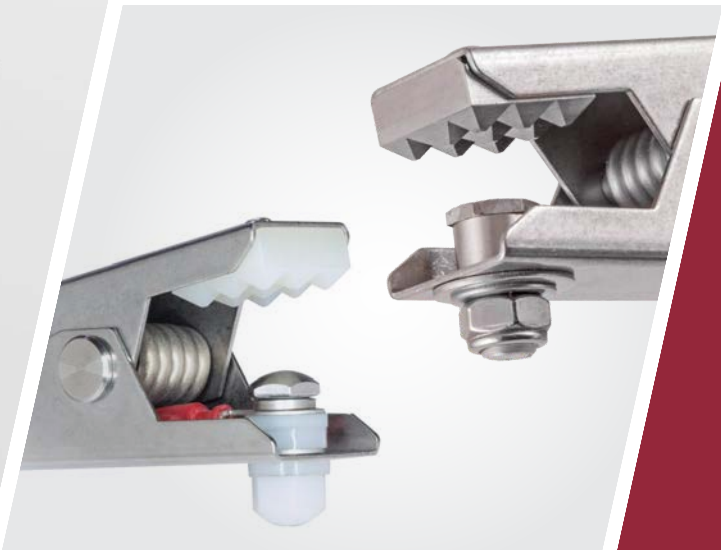
Type C FIBC bags should be provided with grounding tabs (usually sited at the top and bottom of the bag) that are electrically connected to the conductive material or thread and are intended to be connected to a ground point when the FIBC is filled or emptied to ensure static electricity does not accumulate on the bag.

Grounding Type C bags can be achieved with either passive (single pole clamp and cable) or through active means (monitoring systems). A grounding system can indicate if the resistance of the static dissipative threads are within the correct resistance range (100 Meg-Ohm or 10 Meg-Ohm). It does not validate the general condition of the bag, it checks to see if the interwoven conductive threads embedded in the material of the bag are in good electrical contact with the ground connection points.

Type C bags may also be supplied with inner liners. Electrical continuity between the liner and threads of the FIBC are not verified by grounding systems.

The suitability and general condition of the Type C bag is the site owner's responsibility.





The primary standard/s for the electrostatic classification of Type C bags are as follows:

BS EN 61340-4-4 "Electrostatics
Part 4-4: Standard test methods for specific applications – Electrostatic classification of flexible intermediate bulk containers (FIBC)" :

Foreword

a) In light of experimental evidence, the maximum resistance to ground for Type C FIBC, and corresponding resistance limits for inner liners used in Type C FIBC has been increased from 1.0×10^7 Ohms to 1.0×10^8 Ohms (100 Meg-Ohm)

7.3.1. Type C FIBC
"Resistance to groundable point of less than 1.0×10^8 Ohms (100 Meg-Ohm)

NFPA 77, Recommended Practice on Static Electricity

16.6 Flexible Intermediate Bulk Carriers (FIBC's)
16.6.6.3, "Type C FIBC"
The resistance between the conductive elements in the FIBC and the grounding tabs should be less than 1.0×10^7 (10 Meg-Ohm)

Panel mounted grounding with system interlocks

There are applications where electrical contractors may need to provide a static grounding solution as part of a specialised instrumentation/automation project. To satisfy the requirements of bespoke projects designers are often limited by standard “off-the-shelf” static grounding solutions that cannot be customised to provide a good “fit” for their specific application design requirements. A suitable design trade-off is to specify static grounding relays that can monitor a range of resistance values.

Although installations of this type are limited by not having ground status indication provided at the point of grounding, the normal application for such relays is to monitor the ground status of permanent fixed equipment connections or rotating machinery and using an internal relay to provide outputs to PLCs or customised HMI panels or panel mounted indication.

Due to the design of bearings, etc. a good method of providing ground continuity is to use a non-hazardous area mounted ground monitoring relay to test the ground connection to the drum or impeller via a pair of carbon brushes or a slip ring, acting on the shaft.

Relays that have a range of resistance settings are normally mounted on DIN rails inside electrical panels installed in non-hazardous areas.

Using a compact panel mounted static grounding module that can monitor a range of resistances with an output relay to interlock with control circuits or motor starters can assist with improving the safety of processes.

Bond-Rite® Range

Self testing clamps with visual indication and monitoring

The **Bond-Rite**® range provides a "middle ground" between earthing systems and basic clamps.

Bond-Rite provides operators with a 10 Ohms (or less), connection to a verified earth*. This 10 Ohm (or less) connection is indicated via a continuously flashing green LED indicator. Equipment specifiers have the option of specifying an LED indicator mounted earthing clamp or utilising a wall mounted indicator station. All Bond-Rites continuously monitor the resistance between the object requiring static earthing protection and the site verified earth for the duration of the operation.

**Bond-Rite EZ can be used to bond or ground metal items.*

ATEX IECEx CSA C US

Bond-Rite® CLAMP

Self-testing earthing clamp with visual indication

Bond-Rite® REMOTE

Self-testing earthing clamp with mounted monitoring module

If you want to discuss a particular application or product feel free to

Contact Us >

Full details are also provided on the back cover.

Bond-Rite® EZ

Self-testing earthing clamps with visual indication

Bond-Rite® REMOTE (EP)

Externally powered self-testing earthing clamp

Grounding and bonding drums and containers with visual indication

A static grounding system with visual indication is the best solution for simple day to day manufacturing processes where there isn't interlocking capability.

Operators are unable to confirm a good earth connection before the process begins if using a simple grounding clamp and cable assembly.

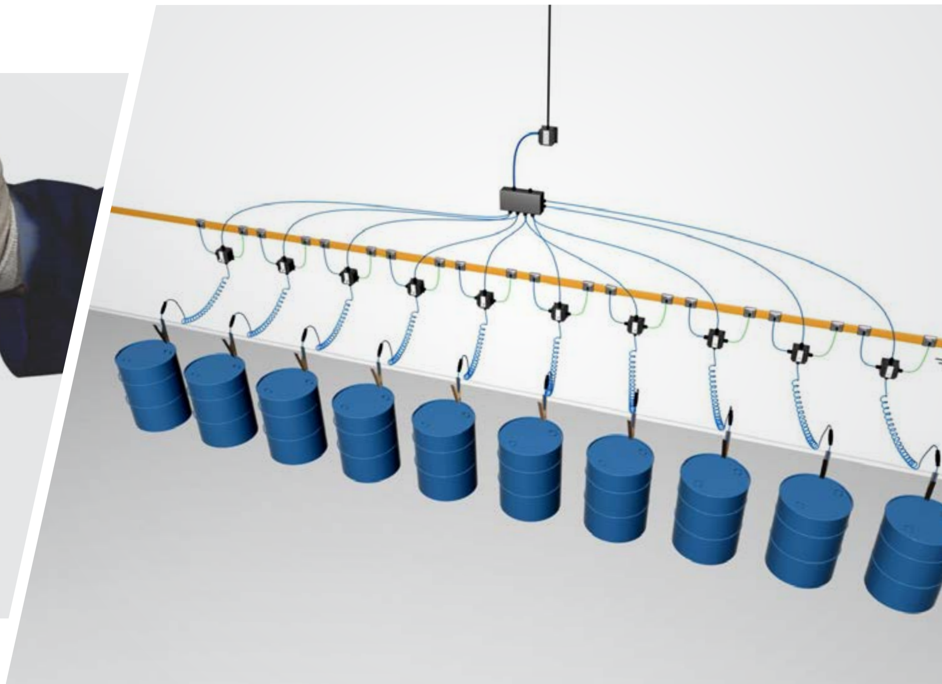
Grounding systems with visual indication (high intensity flashing Green LED) are intrinsically safe (Ex ia) and monitor the resistance between the equipment that they are attached to and the true earth ground connection (or they can bond metal plant items together such as drums, IBCs or tank trucks).

This provides the operator and their colleagues with confidence that the process is reliably grounded and continuously monitored to 10 Ohms (or less) before the process starts.

Bond-Rite REMOTEs with visual indication can be battery or mains powered depending on the duration of use each day (<6 hours battery OR >6 hours mains powered).

The visual indication can be hand held or wall mounted, the clamp is normally made from stainless steel and the wall mounted version from either GRP or stainless steel to suit the process.

Bond-Rites can be used with retractable cable lengths from 3 m up to 30 m to suit the process and application.



IEC 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.

NFPA 77, 7.4.1.3.1, "Bonding and Grounding" states:

Where the bonding/grounding system is all metal, resistance in continuous ground paths typically is less than 10 Ohms. Such systems include those having multiple components. Greater resistance usually indicates that the metal path is not continuous, usually because of loose connections or corrosion.

Cen-Stat™ Range

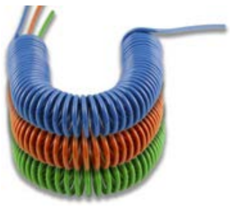
Static earthing clamps and cables, personnel safety equipment

The **Cen-Stat**™ range of ATEX and FM approved static earthing clamps are designed to operate in the harshest EX/HAZLOC areas.

The certifications achieved by our Cen-Stat range of clamps and cables benchmark their ability to establish and maintain good electrical contact with equipment requiring static earthing and bonding protection.

Static Earthing Clamps

Static earthing clamps



Cen-Stat™ Cable

Hytrel® anti-static coated cable

Static Earthing Reels

Static earthing retractable cable reels

Testers

Sole-Mate™ II

Static Dissipative Footwear Test Station

Personnel Grounding Strap

Personnel Grounding

Grounding drums and containers

If sites determine that ground monitoring status capability is not a requirement, basic grounding clamps with cables or cable reels can be specified.

Wherever the object requiring grounding is covered in product deposits or coated surfaces it is important to ensure the clamp teeth have penetrated to the base metal of the object. In addition cables should have a high mechanical strength to provide a reliable and repeatable connection.

Electrical continuity checks should be performed on a routine basis to check for wear and corrosion of metal parts and connections.

Factory Mutual tested grounding clamps can be specified in such situations. It is the ultimate responsibility of the end-user / site operator to ensure that solid and stable connections to the object(s) requiring grounding or bonding are made.

If you want to discuss a particular application or product feel free to

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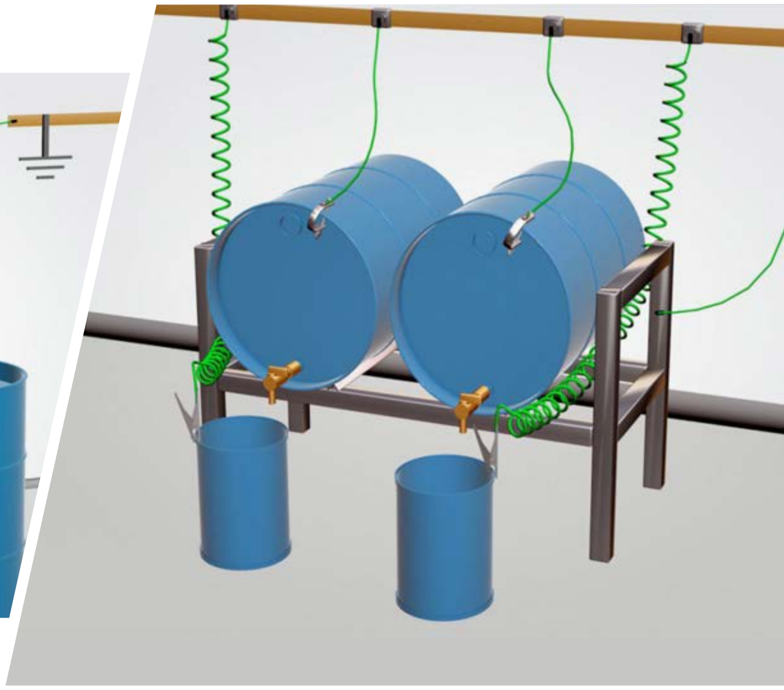
Full details are also provided on the back cover.



Both IEC 60079-32-1, 13.4.1 and NFPA 77, 7.4.1.6 & 7.4.1.4 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*.

Where wire conductors are used, the minimum size of the bonding or earthing wire is dictated by mechanical strength, not by its current-carrying capacity. Stranded or braided wires should be used for bonding wires that will be connected and disconnected frequently.

Personnel footwear tester with visual indication

The recommended range of resistance for static dissipative footwear in:

IEC-60079-32-1 Section 11.3 Dissipative and conductive footwear
NFPA 77 Section 8.2.2.2 Static Dissipative (SD) Footwear

Both documents refer to 1 Meg-Ohm up to 100 Meg-Ohm ($1 \times 10^6\ \Omega$ up to $1 \times 10^8\ \Omega$) resistance through the shoes.

EN ISO 20345, which is another safety footwear standard, specifies a resistance range of 100 Kilo-Ohm up to 1000 Meg-Ohm ($1 \times 10^5\ \Omega$ up to $1 \times 10^9\ \Omega$).

When specifying footwear testers it is important to know what specification the shoes are manufactured to so that the applicable resistance range is tested on entry to the EX/HAZLOC area.

For example, if shoes manufactured in accordance with EN ISO 20345 are tested on a footwear tester designed to test shoes at ASTM F2413, IEC 60079-32-1 and NFPA 77 levels, there is a strong possibility that the tester will fail the shoes.

Footwear testers need to be used in accordance with the manufacturer’s instructions, installed indoors in a safe area, for testing before entering the hazardous zone.

They are not designed to ensure 100% compliance with the relevant footwear standards. They can only indicate if the electrical resistance through the shoes are below the maximum permitted resistance outlined in the relevant standard/s.

It is the site operator's responsibility to ensure adequate levels of training are in place to ensure people use such testers correctly and Standard Operating Procedures (SOPs) are in place so that shoes not in the specified range do not get used in the zoned or classified area.

IEC 60079-32-1, 11.3 “Dissipative and conductive footwear” states:

Resistances can be measured with commercially available footwear conductivity testers which measure the resistance between a hand-held metal bar via body and feet to a metal plate on which the person stands. Alternatively, the resistance between a shoe filled with shot pellets and a steel plate on which the shoe is pressed can be measured according to IEC 61340-4-3.

The resistance of footwear can increase with the accumulation of debris on the footwear, use of orthopaedic insoles, and reduced floor contact area. The conductivity of footwear should be tested frequently to confirm functionality.

NFPA 77, 8.2.2.2
“Conductive and Static Dissipative Flooring and Footwear” states:

Static dissipative (SD) footwear used in conjunction with conductive or static dissipative flooring provides a means to control and dissipate static electric charges from the human body. Resistance to earth through static dissipative footwear and conductive or static dissipative flooring should be between 10^6 Ohms and 10^8 Ohms. For materials with very low ignition energies, the resistance to earth through footwear and flooring should be less than 10^6 Ohms. Resistance should be measured with commercially available footwear conductivity testers.

Sole-Mate™ II

Personnel grounding with grounding straps

The operating requirements of certain processes can cause the loss of direct contact between the operator's static dissipative safety shoes and the static dissipative flooring of the plant or facility.

For example, an operator may need to stand on a ladder to tip powder into a large mixer and in the process of moving to the ladder loses contact with the static dissipative flooring of the plant.

Under limited and controlled circumstances personnel grounding straps may be used.

It should be noted that grounding straps are not a substitute for static dissipative flooring or static dissipative footwear.

Grounding straps should only be used for rare occasions where process operators may lose contact between the soles of their static dissipative footwear and the plant floor.

IEC 60079-32-1, 11.4 "Supplementary devices for earthing of people" states:

The simplest type of commercial device is an earthing bracelet with a built-in resistor typically giving a resistance to ground of about 100 kΩ for shock protection. Wrist straps of this type have the greatest utility at ventilation hoods and at other locations where limitation on the operator's mobility can be tolerated. Breakaway wrist tether systems could be necessary where emergency egress is needed. A hood can be equipped with two external coiled earthing cords with cuff attachments that can be removed and kept by individual users.

NFPA 77 , 8.2.3.2 "Personnel Grounding Devices" states:

Supplementary devices should be selected so that accumulation of hazardous static electrical charge is prevented, while the risk of electrocution is not increased. In most practical situations, grounding of personnel is achieved by ensuring that the resistance from the skin to ground is approximately 10^8 Ohms or less. The need to protect against electrocution via a grounding device imposes a minimum resistance from skin to ground of 10^6 Ohms. Based on skin contact and contact with the floor, especially during activities where the entire sole of the footwear is not in contact with the floor (e.g. kneeling) effectiveness can be compromised.

Personnel Grounding Strap

On-going maintenance of static control procedures and equipment

Once appropriate static control procedures and equipment have been put in place, it is vital that a high level of static awareness is maintained. The three principles of a successful, on-going static control policy are:

I. Regular testing of the equipment used including logging of results.
ii. Frequent awareness training for operators and staff, particularly new employees.
iii. Reference to the standards when changes take place, such as the introduction of new types of plant or materials.

Generally, there are two main elements to the physical side of the static grounding system. These are firstly, the fixed grounding network. This may take the form of a copper strip or bar running along the walls and connected to a number of grounding rods, pits or grids, driven into the ground. This network should be tested periodically, with respect to ground, to ensure that it is maintaining a low (typically less than 10 Ohm) resistance to ground. These tests are fairly specialist, and may be carried out by an outside contractor, often in conjunction with tests on lightning protection equipment.

Source: K, A., 2006. Ground (electricity) - March 2006 [Online] San Francisco: Wikimedia Foundation. Available from: https://commons.wikimedia.org/wiki/File:HomeEarthRodAustralia1.jpg

A typical test period would be every 11 or 13 months (so that over a period of time, the tests cycle through the seasons). A main point to look out for when testing the network, is any significant variation with previous tests, which could show deterioration. This also highlights the need for keeping good records. If the grounding network meets the necessary low resistance, then any metal object connected to it will also be grounded.

The second part of the physical system is the devices used to connect plant and equipment to the grounding network. If a piece of plant is fixed, such as the body of a mixing machine, then a simple strong bonding cable can be used to permanently attach it to the grounding network. However, movable plant, such as the mixer's product bowl, or a 208 litre (55 gallon) drum is harder to ground, and the standards recommend that a cable with strong mechanical strength and a "designed for purpose" clamp are used to make a temporary connection when the item is in use.

These connections can be tested using an intrinsically safe ground lead tester or Ohm meter and the results for each lead recorded. The tester or meter will be used to complete a circuit between the grounding point and the plant item to be grounded; for the purpose of testing clamps and their cables or reels, this may take the form of a clean piece of metal placed in the clamp jaw. The tester or meter leads may then be connected between the piece of metal and the grounding point in order to complete the circuit and obtain a reading.

These types of flexible connector should be tested more frequently than fixed ones; typically once every three months in the case of ground leads and after every re-assembly, in the case of bonds on removable ducting sections. A bond to a fixed piece of plant may be tested on an annual or six-monthly basis.

The on-going training of personnel may be more difficult to maintain, partly because of disruption to production, and also, as it can be difficult to keep things interesting. Training today need not just take the form of a classroom lecture; new interactive learning provides flexible training solutions to accommodate the varying needs of production schedules, shifts and locations. Team leaders can quickly assess the knowledge level of existing or new operators and programme one or two hours per week to bring knowledge levels up.

Today, it is common for companies to use continuous monitoring of ground connections and systems incorporating interlocks that mitigate a static-generating operation from taking place unless the ground is made. Such systems mean that the frequency of lead testing can be reduced, as the systems are providing a continuous test to a pre-determined resistance level. They also mean that the grounding measures are more likely to be remembered during operation, as a visual indication of ground condition, such as the LED in a self-testing clamp, can be incorporated into the company Standard Operating Procedures (SOP).

Equipment commissioning and maintenance service

Our equipment commissioning and maintenance service ensures your Newson Gale static grounding and bonding equipment is installed and maintained in accordance with our system operating and installation requirements.

Our CompEx® certfied engineers will ensure your Newson Gale equipment is installed and maintained in accordance with the equipment's instruction manual.

This is critical to ensuring the equipment has been installed in accordance with the ATEX and IECEx requirements laid down in EN and IEC standards for the safe installation and operation of electrical equipment in EX zoned areas.

In addition to ensuring the equipment is installed in accordance to ATEX / IECEx standards, our engineers will test the functionality of the installed equipment to ensure they are performing at the benchmarked parameters reflected in international guidelines including IEC 60079-32-1: "Electrostatic Hazards - Guidance".

CompEx Supporter

Our CompEx certified engineers commission and service all Newson Gale static grounding and bonding equipment installed at your site.

Safety-Checklist

** This is not an exhaustive list. Local requirements need to be fully assessed by responsible managers.*

Maximise Safety in the Area

> Ensure all operators and managers are trained in safe working with flammable products. It is vital that they understand the characteristics and dangers of flammable products and the principles of static control.

> Ensure all electrical equipment is appropriate for use in the designated flammable atmosphere.

> Ensure lift trucks and other vehicles used in the vicinity are explosion protected to the appropriate standard.

> Ensure **"No Smoking"**, **"Static Hazard"** and **"Ex"** warning signs are clearly posted.

Minimise Charge Generation and Accumulation

> Ensure operators are supplied with static-dissipative footwear. Gloves, if worn, should also be static-dissipative.

> Ensure floors are adequately conductive and are well grounded.

> Ensure static-dissipative footwear is always worn and remains in good condition by use of resistance testing before entry into the combustible area.

> Ensure all containers, pipework, hoses, plant, etc., are conductive or static-dissipative, bonded together and grounded.

> Ensure that sufficient, suitable grounding leads and clamps are provided to enable movable containers to be grounded prior to product transfer or mixing.

> Where practical, pipe liquids directly from storage to the point of use.

> Mitigate or minimise product free-fall distances.

> Where practical, keep pumping speeds low.

> When using plastic materials, such as drums, kegs, liners and hoses in combustible areas, they should be static-dissipative and suitably grounded.

> When using FIBCs bags in combustible areas or with potentially combustible dusts or powders, they should be "Type C" static-dissipative and suitably grounded.

> The use of anti-static additives should be considered in low conductivity liquids if they do not harm the product.

Maintain Safe Working Practices

> Ensure all new operators, managers and maintenance staff are trained in safe working with flammable products.

> Develop a written "safe system of working" for the handling of flammable products.

> Ensure all grounding straps, clamps, wires and monitoring systems are regularly inspected and maintained. The results of inspections should be recorded. Intrinsically safe equipment should be used to test continuity.

> Ensure static-dissipative floors remain non-insulating.

> Ensure all contractors are controlled by strict "permit-to-work" systems.

> Where large, conductive, movable equipment, such as stainless steel IBCs, road tankers or "Type C" FIBCs could become isolated from ground, the use of ground monitoring systems, with suitable interlocks to process equipment, pumps or valves is recommended, to ensure that they cannot pose a static hazard.

Static electricity is an ever-present and significant hazard for operations taking place in flammable, combustible or potentially explosive atmospheres. The uncontrolled build up and discharge of electrostatic charge must be avoided in these environments to protect people, plant, processes and the environment.

Newson Gale's wide range of static grounding solutions can control and mitigate these risks, creating a safer and more productive working environment.

www.newson-gale.co.uk

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