White Paper

Verified grounding for safety in hazardous locations

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The generation of static electricity is an inevitable by-product of day to day operations. Processes ranging from drum filling operations, to pneumatic conveying of powders, to mixing operations have the capability to generate huge amounts of static electricity.

When static electricity accumulates on plant equipment like drums, piping, vessels, trucks and flexible intermediate bulk containers there is a very real risk that a spark will be discharged. The only additional factors that will influence an ignition are whether or not a flammable/combustible atmosphere is present in the path of the spark discharge and if the energy in the spark exceeds the minimum ignition energy of the atmosphere.

Static electricity's relevance to the HAZLOC industries.

Static electricity raises the voltage of the object on which it accumulates. The knock-on effect of a continuously increasing voltage is that the potential energy of the static spark rises exponentially. As soon as the voltage of the object exceeds the "break down" voltage of the air between the charged object and a grounded piece of equipment or a person, (or a conductor at a lower voltage), ionization of the air will enable the formation of a conductive channel through which the excess charge can travel in the form of a spark. Over a very short period of time the potential energy of a static spark can rise dramatically.

In the U.S. Code of Federal Regulations titled "Flammable Liquids", 29 CFR Part 1910.106(b)(6) stipulates that static electricity is an ignition risk and that precautions shall be taken to prevent ignitions by controlling or eliminating sources of ignition.

The primary means of ensuring static electricity does not accumulate on people and fixed or mobile equipment is to ensure they are always at ground potential, which can also be described as zero volts.

In effect, this means that any object that is in direct contact with, or in close proximity to, charged liquids, gases or powders will not accumulate a charge. In reality the charge is dissipated to the earth.

Protecting people, plant and products from static ignition hazards.

So how do we ground people and equipment and what codes of practice should we follow to ensure all the relevant benchmarks are achieved? Grounding can be subdivided into three parts that form a chain of protection from electrostatic ignition hazards.

The first part is to identify what processes are at risk from static ignitions and ensure we have the right grounding equipment installed with the appropriate layers of protection in place.

The second part is all about ensuring the bus-bars, bonding straps, conductors and jumper wires that run from the point where static grounding protection is required to the verified static grounding points are in good condition.

The third part is ensuring that ground electrodes or the ground ring to which building structures are connected have a low resistance connection to the general mass of the earth. This connection to the mass of the earth underpins the success or failure of our efforts to ensure static electricity cannot accumulate on people or equipment.

To address the first part of the bigger picture requires us to specify a static grounding protection method, coupled with the appropriate layers of protection over the hazard. Processes that are regularly recognized as being at risk from static sparks in HAZLOC atmospheres include, but are not limited to:

- Tank truck loading and unloading.
- Tank car loading and unloading.
- Vacuum truck loading and unloading.
- Drum and intermediate bulk container (tote) filling and dispensing.
- Mixing, blending and agitation.
- Flexible intermediate bulk containers.
- Pneumatic conveying lines via pipes and hoses.
- People through movement.

Central to ensuring static grounding is in place is the process operator or vehicle driver. They are the people we are asking to ensure the equipment they are operating is grounded before a process has started. Do they need a visual indication of a verified ground connection before they start one of processes listed above? Do we want them to shut down the process or sound an alarm if grounding is compromised after the operation has begun? Do we just rely on basic clamps and cables to do the job and hope that sources of electrical impedance like rust, paint and product deposits have been penetrated permitting the transfer of static electricity from the equipment to ground? What are the benchmark codes of practice we want to follow?

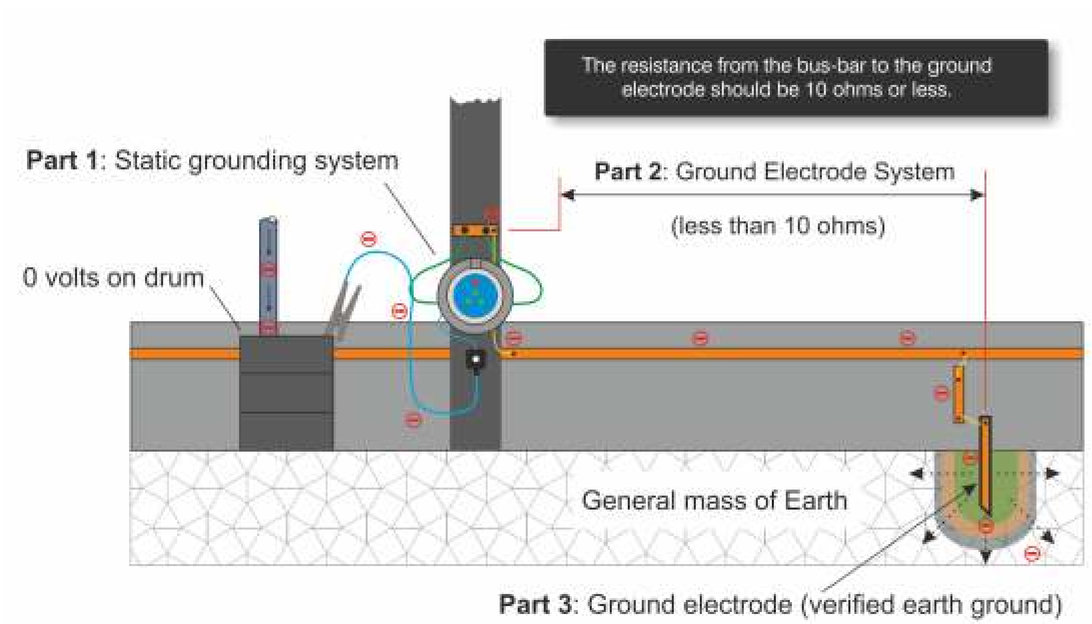

Figure 1: The three parts of the grounding network that ensure static electricity cannot accumulate on equipment.

To answer the last question first, the most comprehensive code of practice is NFPA 77 "Recommended Practice on Static Electricity". This document identifies the processes at risk of discharging static sparks in hazardous locations and recommends that the resistance of static grounding circuits be no more than 10 ohms resistance. This value is based on the fact that if the resistance in the ground loop is higher than 10 ohms it will indicate a fault with the circuit such that a clamp connection has not been made or there are sources of corrosion or loose connections in the ground electrode system. For Type C FIBC constructed with static dissipative threads the resistance through the bag to a ground connection point on the bag should not exceed 10 meg-ohms.

With these basic requirements in mind we then need to establish what layers of protection we want over the hazard. Let's describe a typical application like tank truck loading. Ungrounded trucks develop enormous voltages such that the energy discharged by a static spark from an ungrounded truck is going to be well in excess of the MIEs of a vast range of gases, vapors and dusts. To ensure the driver grounds the truck he/she should have some primary level of indication to prove that the truck's connection to a designated grounding point is not over 10 ohms. If the connection to ground is compromised during the transfer operation we need the driver or loading rack operator to shut down the product transfer operation as hazardous voltages could accumulate in a few seconds. The time lag between the loading rack operator or driver noticing a red light, indicating a lost ground connection, and manually halting the loading operation could be too long as we need the transfer operation to stop immediately (to stop further charge generation). This means our grounding system needs to be interlocked with the loading process in order to shut down the transfer operation automatically. So depending on what type of process is at risk of static spark discharges, combined with the layers of protection required to control the static ignition hazard, there are a range of process specific static grounding solutions that can be specified at the location where the spark risk is present.

The second part of the entire grounding system is the routing of static charges from the static grounding equipment to verified earth grounding points, i.e. the connection to the general mass of the earth (0 volts). The static charges generated by the process will be routed via bus-bars, jumper wires and ground electrode conductors that run across the plant or site. These installations are primarily designed to provide systems of electrical fault protection and lightning protection. The conductors and bonding jumpers used in these systems, commonly referred to as "ground electrode systems" (GES), need to match the requirements of NFPA 70, the "National Electrical Code" and NFPA 780 "Standard for the Installation of Lightning Protection Systems". The scope of such installations falls outside the recommendations outlined in NFPA 77 "Recommended Practice on Static Electricity". However, NFPA 77 section 7.4.1.3.1 states that grounding systems "acceptable for power circuits or for lightning protection" are adequate for static grounding systems.

This means that networks of bus-bars, jumper wires and verified earth ground electrodes can be used to dissipate static electricity. However, the primary caveat that should be adhered to is that there is not more than 10 ohms resistance between the points at which the static grounding system's grounding points are connected to the GES and the GES's connection to the verified ground electrode(s).

The third part is the ground electrode itself. The ground electrode is the last link in the static charge's path to earth and if the connection to earth is not good, charges will not be dissipated. NFPA 70 and NFPA 780 specify the size and shape of ground rods and other shapes (e.g. plates) that should be used in a grounding system. Whether it is for lightning protection purposes, electrical fault protection or ensuring electronic equipment can function correctly, the resistance of the electrode to the general mass of the earth can vary greatly. However, the National Electrical Code states that a benchmark maximum resistance to earth of 25 ohms is required for a single electrode buried in soil.

Identifying and rectifying non-compliance issues.

Ideally, all of the three parts of the total grounding network will be functioning satisfactorily. In reality, deficiencies in one area will compromise the overall system. Because our attention is focussed on the process that requires static grounding protection we can utilise a dedicated static grounding system that can provide visual indication of a continuously monitored connection to the GES and test the static grounding circuit each and every time it is used. Additional layers of protection, like interlocking systems, can shut down the electrostatic charge generating mechanism.

However, regular testing of the GES and ground electrodes can be less frequent. Ground electrodes should be tested once every two to five years using the fall of potential method but in reality ground electrodes may never be tested. The reasons are varied but the most common reason is the belief that the rod's condition beneath the surface of the ground will not change, therefore testing need not be carried out. Another reason is that fall of potential tests on established sites can be difficult to carry out. This is because the ground electrode being tested needs to be isolated from the GES and be tested using additional electrodes that need to be temporarily inserted into the ground with one of these rods being inserted at intervals, typically 10 ft. from the previous test position. This is an obvious concern where concrete or asphalt needs to be penetrated or where utilities could be present underground. Alternative methods like "clamp on meters" can provide an indication of whether or not a ground electrode is faulty, but it cannot be used to establish the exact resistance of the ground electrode's resistance to the general mass of the earth.

Equally important is the regular testing of the GES which is made up bus-bars, bonding straps, flooring, wire conductors and jumper wires that transfer electrostatic charges from the static grounding systems to the plant's network of buried ground electrodes. Any breaks in electrical continuity on route to the ground electrode will result in the accumulation of static electricity on equipment. The normal recommendation is to test these circuits once every twelve months. Regular audits of these circuits can highlight breaks in continuity in the GES and identify faulty connections in the network passing charges to the site's ground electrodes.

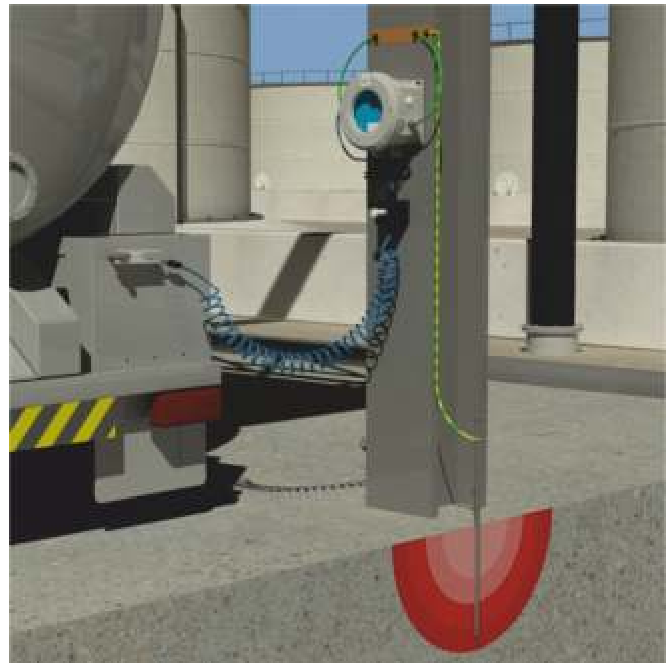

Figure 2: Verified ground electrodes are critical to ensuring static electricity is removed from the HAZLOC area. Concentric shells of resistance present around the ground electrode can impede the flow of electrical currents, regardless of whether they from electrostatic, lightning or electrical fault sources.

Figure 3: regular audits of a site can highlight safety risks similar to the broken bonding strap highlighted above.

Earth-Safe™: static audit and reporting service.

To help identify and combat these risks Newson Gale provides a service called Earth-Safe™. The objective of Earth-Safe™ is to identity and remedy safety critical breaks in electrical continuity from installed static grounding equipment all the way through to the ground electrode's connection to the general mass of the earth.

Earth-Safe™ is delivered by a qualified Newson Gale engineer who carries out an audit of the facility identifying and testing safety critical bonds, connections, conductor circuits and static dissipative flooring throughout the site. After the audit, the Earth-Safe™ engineer compiles a report for the client, outlining which parts of the facility that comply, or do not comply, with the recommendations of NFPA 77 "Recommended Practice on Static Electricity".

Included in the report is the location of each test, the test results and most importantly, recommendations to remedy any safety critical problems that may exist in the grounding circuit for the plant or site.

Conclusion.

There are three vital stages in the passing of static charges from equipment at risk of charge accumulation.

1. Removing static charge from equipment with a dedicated static grounding system.
2. Routing the static charge across the plant to ground electrodes via bus-bars, jumper wires, piping, flooring etc.
3. Passing the static charge to the general mass of the earth via buried ground electrodes.

Any weak links in this chain of protection will elevate the risk of an ignition caused by a static spark. A static audit and reporting service like Earth-Safe™ can ensure this chain of protection is functioning in accordance with the recommendations of NFPA 77 "Recommended Practice on Static Electricity", protecting your workers and property from fires and explosions caused by static electricity.

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