White Paper

How to eliminate electrostatic charging of powder processing equipment

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Powder processing operations can generate vast quantities of electrostatic charge via the movement of powder. The standard method of charging on powder processing operations is due to tribo-electrification, which is basically the contact and separation of the powder with processing equipment, the powder itself or other factors that can cause charging, like surface contaminants.

There are numerous types of equipment that can cause the charging of powders. *Such equipment includes, but is not limited to:*

Powder Processing and Handling Equipment	
Pneumatic Conveying (pipes & hoses)	Sieves & Filters
Micronizers	Blenders
Sieve stacks	FIBC / Big Bags
Fluid Bed Dryers	Tumbling Bins
Hoppers	Granulators
Dust Collectors	Totes & Drums

Table 1. Equipment used in powder processing operations.

A simple calculation will show that a metal drum with a capacitance of 100 pF being filled with 25 kg of charged powder, following a simple pouring operation, could be charged to a voltage of 25,000 V.

$$V = Q / C$$

$$V = 25 \times 10^{-1} \times 10^{-6} / 100 \times 10^{-12}$$

$$V = 25{,}000 \text{ volts } \textit{(25 kilo-volts)}$$

The processes carried out by such equipment can lead to varying degrees of electrostatic charge generation. Typical charge quantities, from published literature, are tabulated below. The values are based on the amount of charge, in coulombs, carried per kilo-gram of powder.

Process Operation	Mass Charge Density (μC/kg)
Sieving	10^{-5} to 10^{-3}
Pouring	10^{-3} to 10^{-1}
Scroll feed transfer	1 to 10^{-2}
Grinding	1 to 10^{-1}
Micronizing	10^{-1} to 10^{2}
Sliding down incline	10^{-1} to 10
Pneumatic Conveying	10^{-1} to 10^{3}

Table 2. Charge generated on powders by different powder processing and handling operations (NFPA 77 / CLCTR: 60079-32-1).

The potential energy that could be discharged from the drum in the form of a spark can be estimated to be:

Potential spark energy, W:

$$W = 0.5(C)(V^2)$$

$$W = 0.5(100 \times 10^{-12})(25{,}000)^2$$

$$W = 62.5 \text{ mJ}$$

By any standard, the voltage generated by an operation that is known to be at the lower end of charge generating capacity can still generate enough potential spark energies to ignite a broad range of combustible atmospheres. Table 2 lists the minimum ignition energy of a sample of powders when they are at a Minimum Explosive Concentration.

Powder in Dust form	MIE (mj)
Magnesium Stearate	3
Polyethylene	10
Aluminium (atomized)	50
Cellulose Acetate	15
Sulphur	15
Polypropylene	30

Table 3. MIE of various powders when suspended in a combustible concentration.

If the powder is being discharged into a blender or mixer that contains a solvent, the MIE of the hybrid atmosphere could be much lower such that the initial ignition of the solvent vapour could propagate a combustible dust deflagration.

The safety factor that needs to be borne in mind with these calculations is the assumption that the equipment being "electrified" by the charged powder is not grounded. If the equipment is grounded, there is no risk of the equipment becoming electrified by static electricity.

Static Grounding protection in powder processing operations.

"Grounding", in its truest form, is the method by which a low resistance electrical connection is made between equipment at risk of electrostatic charging and the general mass of the Earth. This connection is normally described as a "true earth ground". The actual connection to earth is achieved via purpose designed grounding rods, or building structures, that are buried below ground level. These grounding systems are tested by engineers to measure their true earth ground resistances to ensure they are below values required in standards like NFPA 70 "National Electrical Code®" and EN 62305 "Protection Against Lightning". Some static grounding systems on the market today will actually verify if the equipment they are providing static grounding protection for have a true earth ground capable of conducting static electricity.

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. Connections made with items like bonding straps can provide an intentional bond between metal components or assembly mating surfaces may provide an inherent bonded connection.

Fig. 1. A blender getting charged with a powder. Note that the bucket discharging the powder should be bonded to the receiving vessel or grounded independently.

Regular disassembly for cleaning and maintenance can result in bonding connections being missed or not made correctly when the equipment is reassembled. Vibration and corrosion may also degrade assembly connections so it is imperative to ensure that no parts in the assembly become isolated from a true earth ground reference.

The most effective way of ensuring that equipment used in powder processing operations cannot accumulate static electricity is to provide a dedicated static grounding solution that will monitor the ground connection of components at risk of static charge accumulation and alert personnel to a potential hazard should a component lose its ground connection. This is especially important if the ground connection point to the equipment is not readily visible or easily accessible.

Static grounding solutions: convention versus flexibility.

Most grounding solutions provide grounding protection for discrete pieces of equipment at risk of electrostatic charging like road tanker trucks, railcars, IBCs and drums. For example, if a road tanker truck requires static grounding protection, a single static grounding system, featuring ground status indicators and interlocks for the pumping system, will be installed at the loading rack. If the ground connection is lost at any point during the road tanker truck filling operation, the grounding system will detect this and shut down the pump, or close a valve, feeding the road tanker truck.

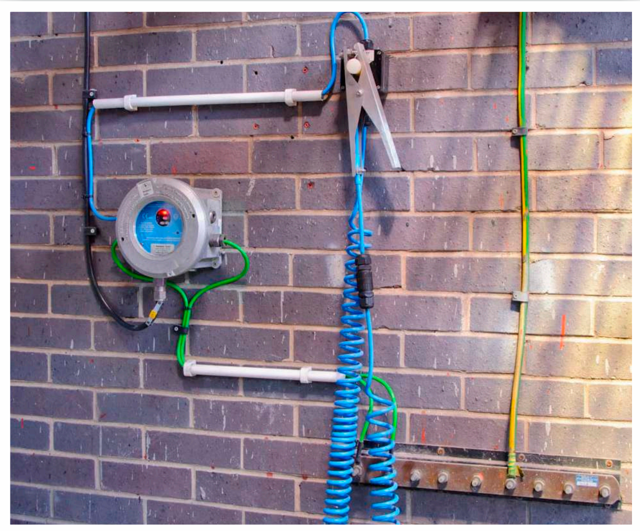

Fig. 2. A dedicated static grounding system for road tanker trucks.

Powder processing equipment presents more of a challenge as there are many metal parts that can make up larger assemblies that are electrically isolated from each other. For example, vibration pads that prevent mechanical destruction may be an inherent design feature, such that electrical isolation, by default, is inherent to the design of the equipment. In other cases, electrical isolation can be an unintended consequence of mechanical designs that have not have taken into consideration, or fully appreciated, electrostatic ignition hazards.

It is therefore important to ensure that multiple components that come into contact with charged powders do have a means of being monitored for static grounding protection purposes. This, however, may be easier said than done, especially if the processing equipment layout, available space and personnel accessibility is restrictive, such that multiple grounding systems may be difficult to install with such limited "real estate" to work with. The only alternative is for plant technicians to take regular measurements with ohm-meters to ensure that none of the plant equipment ever becomes isolated. For many operations this task is very time consuming and results in technicians spending less time on critical maintenance and repair work.

A more specialised static grounding system, like the **Earth-Rite® MULTIPOINT II**, provides the benefits of eight discrete static grounding systems rolled up into a single package. This gives installer's the flexibility of providing monitored static grounding protection for multiple components of powder processing assemblies through a discrete wall mounted monitoring unit with eight ground status indicators for each component being monitored.

In addition, the Earth-Rite MULTIPOINT II will continuously check that all components are connected to a reference earth grounding point, thus ensuring that the ground path resistance between the process equipment and the reference ground never exceeds 10 ohms. A monitored ground path resistance of 10 ohms or less is what is recommended in; NFPA 77, "Recommended Practice on Static Electricity" and Cenelec CLC/TR: 60079-32-1 "Explosive atmospheres - Part 32-1: Electrostatic hazards, guidance."

If the Earth-Rite MULTIPOINT II monitoring unit detects that an assembly component is not grounded, it will send a signal to the controller which, if interlocked with the circuit powering the operation, can halt the process, thereby eliminating the electrostatic charging mechanism and potential charging of un-grounded equipment.

If such an event does occur, the plant's technicians can rapidly identify which connection needs to be investigated. They can do this by referencing the monitoring unit's ground status indicator panel which will indicate which channel needs to be checked.

Once the connection to the equipment is re-established the Earth-Rite MULTIPOINT II controller will provide a permissive condition for the process to start again.

Figure 3. Earth-Rite MULTIPOINT II monitoring unit.

Earth-Rite MULTIPOINT II: a flexible solution designed for the powder processing industries.

Installation flexibility is one of the key, and unique, benefits inherent to the Earth-Rite MULTIPOINT II. The Monitoring Unit, which consists of 8 green and 8 red panel mounted LED indicators, fitted inside a stainless steel enclosure, can be positioned in a location that is easy to wire to and from, but is also easily accessible for technicians to observe if the LEDs linked to their corresponding monitoring points are green or red. Should any of the red LEDs be indicating a break in continuity with plant equipment the technician can check the corresponding location to investigate if the connection to the equipment is not correctly made or if there is a fault with the monitoring cable.

Connections to plant equipment can either be permanent or temporary. Permanent connections are suitable where the plant equipment remains in place for relatively long periods of time. The most common connection is via two conductor cable with eyelet terminations made by both conductors to the equipment that must be grounded. This ensures the equipment is on a 10 ohm ground path loop back to the Monitoring Unit.

If connections are temporary, i.e. where mobile totes and drums are in use, then two pole grounding clamps can be used to ground the totes or drums when they are being charged or discharged with powder.

The most common set up, from an interlock option perspective, is to halt the entire process via a single relay output from the Earth-Rite MULTIPOINT' II controller so that the isolated equipment can be identified and repaired. Halting the movement of the powder ensures that electrostatic charges are not being generated while a piece of plant equipment does not have grounding protection in place.

However, if the grounding of plant is not required 100% of the time then, depending on the characteristics unique to the process, the number of relays being utilised by the operation may be increased. Referencing the illustration in Figure 4, channels 1 through to 7 could be connected to one relay, while channel 8 could be connected to a separate relay. Only when the grounding of the tote is required would channel 8 need to be permissive such that its corresponding relay may open a valve that will charge powder into the mobile tote. The relay taking inputs from channels 1 through to 7 could be interlocked with the starter circuit or PLC controlling the conveying system or powder drying system.

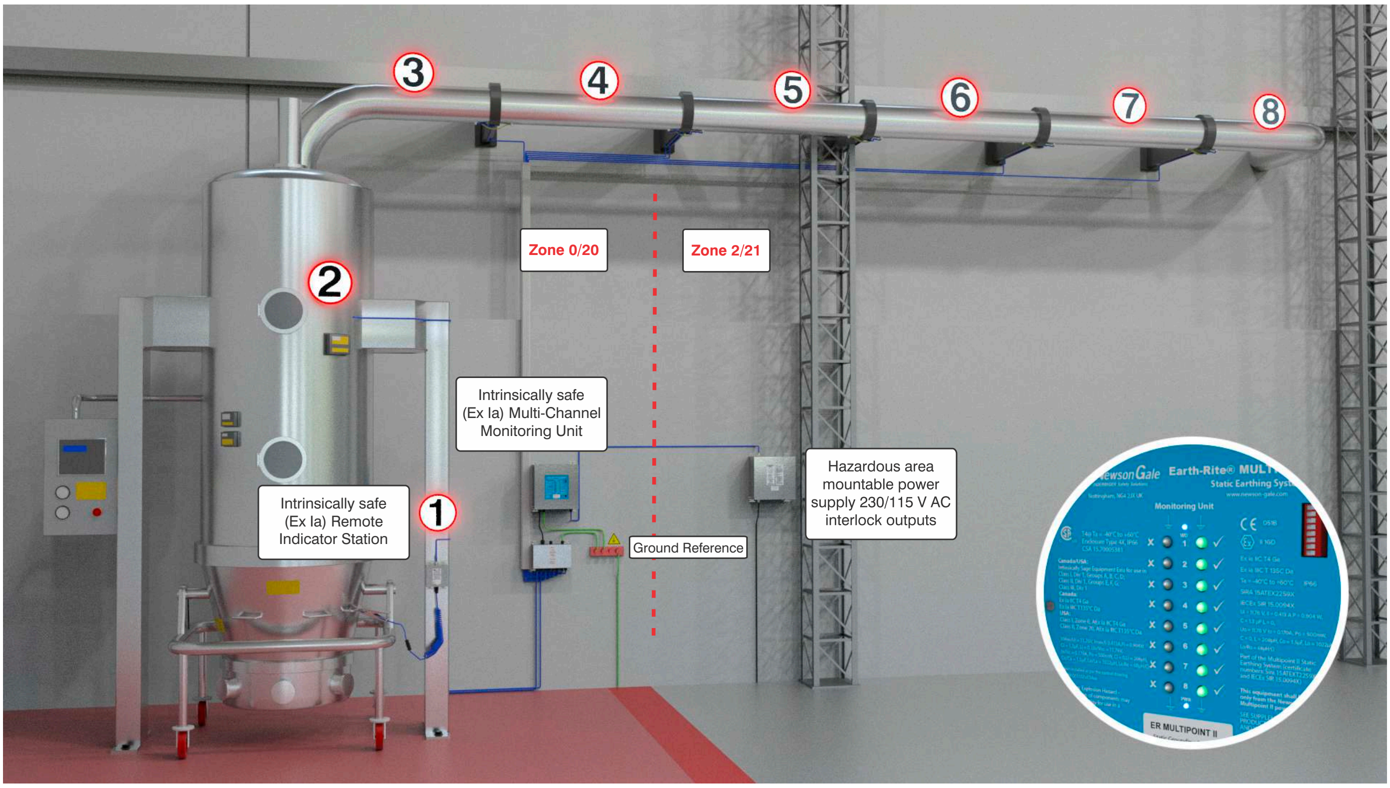

Fig.4. An example of an Earth-Rite MULTIPOINT II installation.

Although 8 monitoring channels are provided, not all may be required. For example, if only 5 process items require monitoring, only 5 channels need to be utilised. However, the available 3 channels may be used at some point in the future should any modifications to the process require the addition of more plant equipment.

Additionally, the Earth-Rite MULTIPOINT II may be installed to utilise individual channels to monitor multiple items of interconnected equipment, provided the equipment has a dedicated connection back to an earth ground reference and no fortuitous connections to earth are inherent in the design of the structure being monitored. A useful connection option for this method is a single pole plug and socket connector that enables plant technicians to rapidly make and break monitoring cable connections to the plant equipment being monitored. Specialist advice is available to determine the most appropriate method of installation.

Summary

In the powder processing industries, the generation and accumulation of static electricity presents an insidious ignition risk in potentially combustible atmospheres. The electrostatic charging mechanisms and corresponding quantities of charge generated are generally higher than those produced by petrochemical operations handling and processing flammable liquids. As such, it is imperative that all conductive components, be they members of machine assemblies or portable containers, have static grounding protection in place to prevent the accumulation and eventual discharge of static electricity as a high energy spark.

The installation of conventional static grounding systems, designed to monitor discrete equipment, like IBCs and road tanker trucks, are unlikely to be a viable solution for typical powder processing equipment like fluid bed dryers or sieve stacks. The quantity of systems required, the lack of available space and installation difficulty would either be too complicated, too expensive, or a combination of both.

A unique static grounding protection system like the Earth-Rite MULTIPOINT II minimises the site's use of valuable installation "real-estate" while simultaneously bridging the gap between time-consuming checks with multi-meters and the highest levels of grounding protection provided by dedicated static ground monitoring systems.

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