

# Static Electricity

The discharge of static electricity can initiate fires and explosions, often leading to large losses. Electrostatic discharge can be controlled. This report summarizes the properties of static electricity and the fire protection concerns related to electrostatic discharge.

Static electricity is generated unintentionally during many industrial operations. Such operations may include the transfer of fluids between containers; the blending and mixing of liquids; or the crushing, grinding, or sieving of powders. While the generation of static charge is a concern, it is the discharge of this energy that causes damage.

Three conditions are required for an electrostatic discharge (ESD) to occur: there must be a process that generates a static charge; the charge must accumulate; and the charge accumulation must be large enough to produce an electrical breakdown of the local atmosphere. The type of discharge and the amount of energy released will depend on the physical and chemical properties of the system.

Electrostatic discharges (ESDs) may initiate fires and explosions. For this to occur, the discharge must be in the presence of a flammable or explosive atmosphere, and the discharge must be energetic enough to ignite the atmosphere. If the mixture is outside of its flammable range or the static discharge does not have sufficient energy, ignition will not occur.

Controlling either of the conditions necessary for an ESD may control static electricity hazards. One common method used to

control static electricity hazards is the use of bonding and grounding, such as when transferring flammable liquids. The bonding and grounding both reduces the amount of charge generation and neutralizes the charge.

This report provides an introduction to static electricity and the control of electrostatic discharge. It describes various fire problems that may be caused by static electricity and summarizes the physics, nature, generation, and methods of control.

## Static Electricity

The nucleus of an atom contains protons, having a positive charge, and neutrons, having no charge. A field of electrons, having a negative charge, orbits this nucleus. This fundamental structure of atoms allows that the surfaces of all materials will possess electrons. When materials with different concentrations of loosely bonded surface electrons are brought into contact with each other, the surface electrons attempt to balance or become electrically neutral. While the two materials are in contact, the surface electrons are freely exchanged. This "bonding" is most prevalent when materials are comprised of materials with a larger amount of free electrons in the atom's outer shell.

When the materials are separated, the transfer of electrons stops, and both materials may be left with electrical charge on their surface. When an object has lost (e.g., positively charged) or gained (e.g., negatively charged) electrons, it has developed a static charge.

Left in the static mode, this charge may increase in size until it can dissipate to another material of opposite charge. A common example of this static charging can be found by rubbing cotton (i.e., socks) across polyester (i.e., carpet). The person in contact (i.e., bonded) with the cotton will develop a charge. When that person touches another object (e.g., door knob) of lesser charge, the charge is transferred (i.e., neutralized).

If the charge is of a high potential, the charge may be able to bridge an air space to dissipate, which is referred to as an electrostatic discharge.

### **Static Charge Generation**

A variety of materials and processes can result in static charge generation, including the movement of liquids through pipes and hoses, atomization of liquids, and the movement of finely divided solids. Static charge generation takes place at the point of contact of materials, which is often referred to as the relative interface. Charge generation typically occurs when the contact involves movement, such as fluid through a hose. This relative movement allows the static charge potential to increase.

Static charging often occurs when materials that are typically insulators, such as paper, contact non-insulating materials, such as steel. The movement of paper across a stainless steel roller allows the free electrons on the roller's surface to be passed to the paper. This causes the paper to develop a negative charge, which may be retained for long periods (e.g., several hours). Evidence of this type of charging can be clearly demonstrated by rubbing a polyethylene sheet (i.e., sandwich wrap) over a piece of

stainless steel. The static charge on the polyethylene will allow it to be attached to lower potential materials, such as walls, resulting in "static cling."

Common industrial conditions where static generation may occur include:

- Fluid flow through pipes and filters
- Pouring of liquid between two separated containers
- Atomization of conductive liquids
- Rubbing the surface of an insulating material
- The passage of conveyors over rollers
- Crushing, grinding, and sieving
- Emptying powder from bags

People may also develop static charges by walking on insulating floors or carpets or removing synthetic clothing.

Regardless of the materials involved, the process of charge generation requires that dissimilar surfaces contact each other and transfer free electrons. The resulting separation causes one of the materials to retain a charge.

### **Electrostatic Discharge**

Static charges will gradually dissipate over time due to the natural repulsion of like-charged molecules. The rate of charge dissipation will depend upon the characteristics of the material and the availability of a conductive pathway to a material of a different electrical state. If the rate of charge generation is greater than the rate of charge dissipation, or the object is isolated from a conductive pathway so that the charge may not equalize, the static charge will accumulate on the object.

Static discharge is the rapid release or transfer of electrons from one object to another resulting in neutralization of both materials' charge state. This release of energy is referred to as electrostatic discharge. This discharge of energy occurs when the charge accumulation reaches a high enough potential that it can bridge an air space to another material. There are several types of electrostatic discharge, including

sparks, glow coronas, brush discharges, and bulk surface discharges. Essentially the type of discharge is dependent on the materials involved and the shape of the area where the bridge between surfaces occurs. Electrostatic discharge presents a significant ignition source for flammable liquids, gases, and some dusts.

### *Flammable Liquids*

Static charge is generated when liquids move in contact with other materials (e.g., liquid flowing in a pipe). Static charge is also generated during the mixing, pouring, pumping, filtering, or agitating of fluids. This stored energy presents a potential ignition source. When an accumulated charge is dissipated, the resulting energy can ignite a flammable vapor-air mixture. This hazard is greatest when fluids are transferred between containers, allowed to stand in open containers, or applied to surfaces, since both a static charge and an ignitable fuel-air mixture can be generated.

### *Flammable Gases*

As with flammable liquids, static discharge can result in ignition of flammable gases. The process by which this can occur is basically the same as for liquids, except that gases are more readily ignitable. Gases not contaminated with solid or liquid particles generate no significant static electricity. However, a static charge may be generated if flowing gas is contaminated with dust, metallic oxides, or scale particles, or with liquid particles or sprays.

### *Dusts*

Dust displaced from a surface on which it rests may generate a significant charge. The total charge developed depends on the chemical composition of the material, the size of the particles, and the amount of surface contact. Charge generation seldom occurs if both the dust and the surface on which it rests are conductors. However, it is likely to occur if one material is a conductor and the other is a non-conductor.

When combustible dust is suspended in the air and subjected to a static discharge, an explosion

can occur. See Dust Explosions, on Hanover's Risk Solutions website for additional information on this topic.

## Controlling Electrostatic Discharges

Three primary methods can be used to prevent ignition of flammable mixtures by electrostatic discharge. They are controlling the ignitable mixture, controlling static buildup, and neutralizing the charge.

### **Controlling the Ignitable Mixture**

Inerting ignitable mixtures, ventilating the area, or relocating the static-producing equipment can prevent static-induced ignition of flammable mixtures.

#### *Inerting*

The process of inerting of a flammable mixture to prevent ignition is achieved by elimination or reduction of the oxygen content to a point that the mixture cannot be ignited. The most effective method of inerting the mixture is by introducing an inert gas, such as nitrogen, into the gaseous mixture, resulting in an oxygen-deficient environment.

#### *Ventilation*

Mechanical ventilation can be used in a similar method as inerting. Through the use of mechanical ventilation, the mixture can be diluted below its flammable range, resulting in a mixture too lean to burn. This process can also be used to direct combustible dusts away from ignition sources.

#### *Relocation*

Relocation of static-producing equipment is a very effective solution to controlling the ignitable environment. This method is desirable because it removes the source of ignition and does not rely on other control methods that may fail.

## Control of Static Generation

The control of static generation is based on controlling how these materials come together and separate. The type of material, speed of contact, and duration of contact all play key roles in charge generation. Controlling static generation is dependent on the materials contacting each other.

Anti-static coatings, additives, and sprays all reduce a material's ability to generate a static charge by lowering the material's surface resistance, which allows static charge to flow to the ground. Lowering a material's surface resistance allows the electron charging to rapidly dissipate, preventing a release of a large accumulated charge.

Hydrocarbon fuels contain trace amounts of materials that can dissociate into ions. During a flow of fuel, a charge separation occurs at the interface between the fuel and any immiscible material, for example, a pipe wall. This static charging of hydrocarbon fuels during pumping operations has long been recognized as a potential explosion hazard. The hazard can be reduced by imposing fuel flow-rate restrictions during product transfer. This decreased flow rate allows the electron charge to dissipate faster than it can accumulate on the container surface, thus preventing a static buildup.

## Charge Neutralization

Charge neutralization is the process by which accumulated static charges of one potential are rendered neutral. By eliminating (e.g., neutralizing) the charge, the potential for an uncontrolled dissipation of charge, and the resulting ignition, is eliminated. Methods of charge neutralization include humidification, grounding and bonding, ionization, and static combs.

### *Humidification*

Humidification is the process by which the relative humidity in a work area is increased to prevent accumulation of static charges on non-conducting materials. Humidification is most effective for controlling static buildup where

insulating materials, such as paper, wood, and textile, are used in processes. Because these materials are typically insulators, they can develop static charges through processing and routine handling. By increasing the relative humidity, the surfaces of the materials become moist. This moisture increases the surface conductivity, allowing the static charge to dissipate freely. To be effective, the humidity level must be raised to at least 60 percent or higher. Humidification is not effective at controlling static on materials with high hydrocarbon content, due to the inability of hydrocarbons to absorb water.

### *Grounding (Earthing) and Bonding*

Grounding and bonding are among the most common methods of dissipating charge. "Bonding" is the technique of connecting two or more conducting objects together by means of conducting wires or cables. "Grounding" or "Earthing" is a method of connecting two or more conducting objects to the ground and is a special form of bonding. Some objects are inherently bonded to the ground (e.g., underground piping or under- or above-ground storage tanks). Bonding minimizes potential differences between conducting objects. Grounding eliminates or minimizes potential differences between conducting objects and the ground.

Liquids with a flashpoint<sup>1</sup> below 100°F (37.8°C) should not be transferred between containers unless both containers are bonded or grounded. Proper bonding or grounding is required to prevent the buildup of static electricity produced by the transfer of liquids. Provisions for bonding or grounding include:

- Connecting (i.e., bonding) the containers to each other electrically before transferring the liquid.
- Connecting both containers electrically to earth ground before transferring the liquid.

<sup>1</sup>Flashpoint is the minimum temperature at which sufficient vapor is given off from a liquid to form an ignitable mixture with air.

Additional guidance for controlling static electricity may be found in NFPA 77, *Recommended Practice on Static Electricity*, published by the National Fire Protection Association (NFPA). Annex A of NFPA 77 provides detailed drawings of the various bonding and grounding techniques. These drawings can be used as a guide to the types of grounding and bonding techniques that may be applied to various dispensing processes.

Bonding connections can be made with pressure-type clamps, brazing, or welding. Battery-type clamps or magnetic clamps may be used to make metal-to-metal contact, depending on the type of metals used.

Grounding can also be accomplished by use of a "static comb." A static comb is simply a metal bar provided with a series of sharp needle-points. If a grounded static comb is brought close to an insulated charged body (or charged insulating surface), ionization of the air at the points will offer enough conductivity to enable the charge to quickly dissipate. Static combs are typically used to dissipate energy in process that involves insulating materials, such as paper and textiles. The comb is made of a conducting material, such as steel or copper, which is electrically connected to ground (neutral). By maintaining constant contact with the product, the surface charges picked up by the insulator are dissipated, through the comb, to ground, thus eliminating static build up. This technique is highly effective and is utilized both in manufacturing and in common appliances, such as a computer printer.

### *Ionization*

A static charge on a conducting object is free to flow on the surface of the object. On a conducting spherical object, the charge will distribute itself uniformly on the surface. On a non-spherical conducting object, the self-repulsion of the charge will cause it to accumulate on the surface with the least radius of curvature.

If a conducting body is surrounded by air (or other gas) and there are sharp needle points on the conducting object, the charge will concentrate on the points and produce ionization of the air, making it conductive. The sharp needlepoint enables the conductor to reach only a small voltage before the leakage rate, or charge dissipation rate, equals the rate of charge generation. Therefore, a static charge will not accumulate on such an object.

### Summary

As long as dissimilar materials come in contact with each other, static charges will be developed. These charges can present themselves as minor nuisances or a significant source of ignition energy in certain environments. Controlling the generation, buildup, and discharge of static electricity requires a focused review of the processes involved and implementation of control measures.

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