St Aiden's Homeschool

Static Electricity Totally Explained

Advanced Edition

Everything about *Static Electricity* totally explained

:For the science of static charges see Electrostatics **Static electricity** refers to the accumulation of excess electric charge in a region with poor electrical conductivity (an insulator), such that the charge accumulation persists. The effects of static electricity are familiar to most people because we can see, feel and even hear the spark as the excess charge is neutralized when brought close to a large electrical conductor (for example a path to ground), or a region with an excess charge of the opposite polarity (positive or negative).

History

The natural phenomenon of static electricity was known at least as early as the 6th century BC, as attested by Thales of Miletus. Scientific research into the subject began when machines were built to create it artificially, such as the friction generator developed by Otto von Guericke in the 17th century. The connection between static electricity and storm clouds was famously demonstrated by Benjamin Franklin in 1750

. In 1832, Michael Faraday published the results of his experiment on the identity of electricities, which proved that the electricity induced using a magnet, voltaic electricity produced by a battery, and static electricity were all the same. Since Faraday's result, the history of static electricity merged with the study of electricity in general.

Causes of static electricity

The materials we observe and interact with from day-to-day are formed from atoms and molecules that are electrically neutral, having an equal number of positive charges (protons, in the nucleus) and negative charges (electrons, in shells surrounding the nucleus). The phenomenon of static electricity requires a sustained separation of positive and negative charges.

Contact induced charge separation

Electrons can be exchanged between materials on contact; materials with weakly bound electrons tend to lose them, while materials with sparsely filled outer shells tend to gain them. This is known as the triboelectric effect and results in one material becoming positively charged and the other negatively charged. The polarity and strength of the charge on a material once they're separated depends on their relative positions in the triboelectric series. The tribo electric effect is the main cause of static electricity as observed in everyday life, and in common high-school science demonstrations involving rubbing different materials together (for example fur and an acrylic rod).

Pressure induced charge separation

Certain types of crystals and ceramics generate a separation of charge in response to applied mechanical stress.

Heat induced charge separation

Certain materials generate a separation of charge in response to heating. All pyroelectric materials are also piezoelectric, the two properties being closely related.

Charge induced charge separation

A charged object brought into the vicinity of an electrically neutral object will cause a separation of charge within the conductor as charges of the same polarity are repelled and charges of the opposite polarity are attracted. As the force due to the interaction of electric charges falls off rapidly with increasing distance, the effect of the closer (opposite polarity) charges is greater and the two objects feel a force of attraction. The effect is most pronounced when the neutral object is an electrical conductor as the charges are more free to move around.

Careful grounding of part of an object with a charge induced charge separation can permanently add or remove electrons, leaving the object with a global, permanent charge. This process is integral to the workings of the Van de Graaf Generator, a device commonly used to demonstrate the effects of static electricity.

Static discharge

volts-per-centimetre depending on humidity. The discharge superheats the surrounding air causing the bright flash, and produces a shockwave causing the clicking sound.

The feeling of a static electric shock is caused by the stimulation of nerves as the neutralizing current flows through the human body. Due to the ubiquitous presence of water in places inhabited by people, the accumulated charge is generally not enough to cause a dangerously high current.

Lightning

incandescence. The clap of thunder is the result of the shockwave created as the superheated air rapidly expands.

Simple experiments

» *Note: a humid atmosphere provides a conducting path for the rapid neutralization of static charge; hence the following examples work best in dry, winter conditions.*

Static electricity is notable as a physical phenomenon that can be demonstrated using simple experiments that can convey genuine understanding of the physics involved.

Charged adhesive tape

A simple and illuminating example of the effects of static electricity can be observed using adhesive tape (such as Scotch tape, on the negative side of the triboelectric series, hence tends to gain electrons and acquire negative charge) charged by peeling.

If a length of tape adhered to a smooth surface is rapidly peeled off, the tape will acquire an excess negative charge (generally polypropylene with an acrylic adhesive). Do this with two lengths of tape and that'll repel each other, demonstrating the fact that **like charges repel**. Each individual length of tape will experience a small attraction to almost any object as the presence of the excess negative charge induces a charge separation in nearby objects. Negative charges are pushed further away, while positive charges are attracted, and the strength of the attractive and repulsive forces falls off quite rapidly with distance. This effect is most pronounced in materials such as metals, that conduct electricity, as the negative charges are free to move within the material.

Finally, try attaching two lengths of tape together, exhaling on them along the entire length to neutralize the charge, then rapidly pulling them apart. There will be some imbalance in the distribution of negative charge between the two pieces such that one is *more positive* and the other *more negative*; you should now find that the two lengths of tape attract each other, demonstrating the fact that **opposite charges attract**. Attaching the adhesive side of one length of tape to the non-adhesive side of the other reduces the chance of tearing and increase the charge imbalance, and hence the strength of the attractive force.

Applications

Static electricity is commonly used in xerography, air filters (particularly electrostatic precipitators), and some automotive paints.

In the 1963 British science-fiction television serial "Doctor Who", an alien creature encased in metal called a Dalek was powered by static electricity.

Risks

Despite the apparently innocuous nature of static electricity as we generally experience it, there can be significant risks associated with it in circumstances where large charges may accumulate in the presence of sensitive materials or devices.

Electronic components

Many semiconductor devices used in electronics are extremely sensitive to the presence of static electricity and can be damaged by a static discharge.

The chemical industry

Discharge of static electricity can create severe hazards in those industries dealing with flammable substances, where a small electrical spark may ignite explosive mixtures with devastating consequences. Factories dealing with large quantities of finely powdered substances in the presence of combustible or explosive materials. Major incidents occurred at a grain silo in southwest France, a paint plant in Thailand, and a factory making fibreglass mouldings in Canada.

Space exploration

Due to the extremely low humidity in extraterrestrial environments, very large static charges can accumulate, causing a major hazard for the complex electronics used in space exploration vehicles. Static electricity is thought to be a particular hazard for astronauts on planned missions to the Moon and Mars. Walking over the extremely dry terrain could cause them to accumulate a significant amount of charge; reaching out to open the airlock on their return could cause a large static discharge, potentially damaging sensitive electronics.

Fuelling Operations

Static electricity can build up and discharge into fuel. If the voltage of the discharge is high enough, it can actually ignite the fuel or vapour. This is a present danger at gas stations. It is one of the reasons why one shouldn't leave their car running while fuelling. This type of accident has occurred in the past at gas stations. Fires have also been started at airports while refuelling aircraft. New technologies now help prevent static electricity from forming and/or discharging.

Mobile Phones and Gasoline Pumps

Although there have been numerous media reports, emails, laws, and posted warnings at gasoline pumps about the risk of fire caused by mobile phones, there hasn't been a confirmed case of an electrical discharge from a mobile phone ever causing a fire or explosion among gasoline fumes. To date, it's simply an urban legend.

Ozone cracking

Many elastomers are sensitive to ozone cracking, which causes deep penetrative cracks to grow into critical components like gaskets and O-rings. Fuel lines are also susceptible to the problem unless preventative action is taken. This includes adding anti-ozonants to the rubber mix, or using an ozone-resistant elastomer. Fires from cracked fuel lines have been a problem on vehicles, especially in the engine compartments where ozone can be produced by electrical equipment. Static discharge will also create ozone, which can then attack rubber parts.

Source: http://static_electricity.totallyexplained.com/