Electrostatic Ignition Hazards on the Forecourt

In Focus: Risks in and around the underground piping system – a potential but preventable health and safety issue
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Electrostatic discharges may cause and have caused serious accidents on forecourts

General Background

Static electricity and related electrostatic discharges (ESDs — see glossary: Electrostatic Discharge) have, for quite some time, been known to cause a multitude of more or less severe problems in many industrial processes. Under the “right” circumstances, the energy in an ESD can be sufficient to cause major fires and explosions. In many processes, e.g. aviation refilling, there are tight regulations, guidelines and procedures in place to minimize risks resulting from electrostatic discharges.
The petrol retailing industry presents an environment where explosive atmospheres are rather common. It is also well known that the flow of petroleum liquids through insulating plastic pipes may cause the accumulation of static electricity and the possibility of electrostatic discharges with enough energy to ignite explosive atmospheres (see glossary: Minimum Ignition Energy). Electrostatic discharges may cause and have caused serious accidents on forecourts.

Still, the understanding of these hazards is often rather low in the industry.

Frequent ESD activity inside petrol piping systems may also be a contributor to pipe damage and breakages, thereby shortening piping life-span. However, more research is needed to establish this, and the possible issue is not discussed further in this publication.
Refilling of underground storage tanks – a potential but preventable safety risk.
Purpose

The awareness and understanding of explosive atmospheres and electrostatic health and safety risks in and around forecourt piping systems is often low. This is of relevance to the overall design, operation (e.g. the refilling of underground storage tanks) and maintenance of such piping systems. Serious accidents, including fires and explosions, have been recorded by major oil companies. Attention is increasingly being focused on this issue. The actual number of incidents is unknown.

Regulations that directly address this issue are in place in most countries. However, since little is generally known about the problem and its contributing factors, many petrol retailers still overlook this hazard, as do many regulators, piping suppliers etc.

The purpose of this publication is to shed scientifically correct light on this matter – both theoretically and practically – in a way that can be absorbed by all relevant parties. A second, but no less important purpose, is to highlight solutions to the problem.
Static Electricity – Basics

Static electricity is a phenomenon in which various forms of friction and/or contact transfers electrons from one body to another.

If two objects are rubbed together, especially if the objects have insulating/non-conductive properties, charge separation may occur. The object that loses electrons becomes positively charged (positive electrification) and the object gaining electrons becomes negatively charged (negative electrification). An attractive force develops between the objects.

Non-conductive Properties create the problem
Non-conductive properties of objects may prevent charged particles from “escaping” to e.g. earth (see glossary: Electrical Ground/Earth). This allows for a strong and persistent charge imbalance to emerge – i.e. static electricity.
Electrostatic Discharge and Unpredictability

A strong charge imbalance suggests a strong electric potential, or voltage (see glossary: Electric Potential). This leads to an increased risk for the imbalance to be equalized through an electrostatic discharge (ESD). Numerous parameters, some of which are frequently unpredictable from a practical point of view, influence if, where, when and how an ESD will occur.
Electrostatic Hazards on the Forecourt – Principles I and II

Static charges close to forecourt piping may exceed 15 000 Volts. It is important to understand that a forecourt may operate year after year with no severe problems occurring due to explosive atmospheres and static electricity. However, small and seemingly innocent and perhaps unnoticed

This publication highlights two main electrostatic safety hazards and offers brief explanation models in connection with such hazards in and around the forecourt piping system. They are referred to as Principle I and Principle II.

Principle I – Electrostatic Build-up Between Two Poor Conductors and a Possible Subsequent ESD

When a poor conductor like petrol flows along the inside of an insulating plastic pipe (also a poor conductor) static electricity may accumulate. Minor electrostatic discharges frequently occur within such non-conductive piping systems transporting e.g. petrol.
Electrostatic charge accumulation may result inside a non-conductive pipe e.g. during and after refilling of a petrol storage tank. When a tanker has completed the filling process and the hose is disconnected, air may get sucked into the offset filling pipe. This may create a potentially explosive atmosphere.

An ESD inside the pipe could, according to some experts, ignite the explosive atmosphere, causing a blowout at the offset fill point (blowouts have been recorded by oil companies).

According to Principle 1, an incendive ESD discharges in one of two ways. The negatively charged plastic area discharges to either an earthed metal part in close proximity, or, possibly, to a plastic surface with a different charge.

The actual number of incidents is presently unknown.

changes to the fill system design, environment, operation, fuel composition etc. may trigger an incident when least expected.
Principle II – Electrostatic Charging of an Isolated Conductor, and a Possible Subsequent ESD

The majority of fires and explosions caused by electrostatic discharges in and around the underground piping system is probably attributable to Principle II related matters.

An electrical conductor, e.g. a metal part, can under certain circumstances become charged if it is electrically isolated. The charging may be caused by a triboelectric effect (see glossary: Triboelectrification) or contact charging (see glossary). This can be illustrated by an electrically isolated metal part in direct contact with a charged plastic pipe.

What complicates the matter further is the phenomenon of induction in an electric field (see glossary: Electric Field and Induction). Around e.g. an insulating plastic pipe that has been charged by the flow of petrol, an electric field will emerge. Any isolated conductor within the electric field may become charged (induction). This means virtually any unearthed metal part (metal caps, jubilee...
clips, welding socket wiring etc.) as well as personnel.

If isolated and unburied conductors become charged for any of the above reasons, an electrostatic discharge between the charged isolated conductor and a differently charged object (e.g. a grounded steel fill box) in close proximity may, under certain circumstances, occur. High voltages may emerge in the electric field, and energy-rich and potentially incendive (concerning a petrol based explosive atmosphere) discharges may result.

Some devices like flame arrestors (see glossary: Flame Arrestor) may actually cause electrostatic field strength to increase even further, increasing the risk for a potentially incendive electrostatic discharge. With petrol spillage vapours and oxygen present, an explosive atmosphere may be present as well. This means that an explosion and/or fire may take place, the ESD being the ignition source. Such incidents have been recorded by major oil companies.
Electrostatic build-up may only occur in piping systems not properly grounded to earth. A non-conductive pipe can never be properly grounded to earth.
Parameters Influencing Electrostatic Build-up Inside a Non-conductive Pipe

- Electrical conductivity of the pipe wall
- Electrical conductivity of the liquid
- Liquid impurity content
- Petrol additives like sulphur may have some effect on the extent of electrostatic build-up
- Flow velocity – more than 1 m/s is potentially hazardous
- Relative humidity of the air – lower humidity meaning greater danger
- Other factors such as use of flame arrestors etc.
First of all it is important to identify all zones where, even rarely, explosive atmospheres could be present. Then a process to control even rare potential ignition hazards should be initiated.

Specialists may have to be consulted. These and other necessary measures are specified in the CENELEC Code of practice (CLC/TR 50404:2003, Electrostatics – Code of practice for the avoidance of hazards due to static electricity, CENELEC – European Committee for Electrotechnical Standardization).

Solutions Overview:

1. **Reducing** ESD Hazards in Existing Non-conductive Piping Systems – General Guidelines (page 18)

2. **Eliminating** ESD Hazards When Installing New or Replacing Old Piping Systems (page 21)
Electrostatic Ignition Hazards on the Forecourt
Reducing Hazards in Existing Systems

Reducing ESD Hazards in Existing Non-conductive Piping Systems – General Guidelines

1. Ground all conductors including metal parts and people:
   – All conductive components close to a possible explosive atmosphere should be earthed or, if this is not practical, completely sealed off with a non-conductive material.
   – Personnel working close to a possible explosive atmosphere and a possible electrostatic ignition source should take special precautions and avoid becoming electrostatically charged.

2. Avoid unburied piping as far as possible.

ESD related hazards may be present during piping installation, operation, maintenance and repair work if not necessary precautions are taken (see CENELEC Code of Practice; CLC/TR 50404:2003 - Clause 5.5.4.2 “Buried non-conductive pipe”).
3. Introduce systems and routines that reduce the likelihood of explosive atmospheres and electrostatic build-up.
4. Ensure dielectric properties – i.e. sufficient pipewall thickness.
5. Avoid potentially hazardous liquid impurities and compositions.
6. Regularly check piping systems for damage caused by electrostatic discharges (e.g. pinholing – see glossary: Pinholing).
7. Minimize the number of hazardous designs, routines and human errors through strict guidelines, education and training of all relevant parties.

The above measures will ensure a high level of safety. However, in practice, it is difficult to avoid human errors (e.g. when earthing numerous metal parts at numerous forecourts), problematic designs and routines.
Reducing Hazards in Existing Systems (Cont’d)

A range of measures can reduce electrostatic risks when non-conductive piping is used. However, in practice it is difficult to avoid human errors, e.g. when earthing numerous metal parts at numerous forecourts. Even pipe parts in a sump or a containment area are unburied and may contribute to risk.
Eliminating Hazards

Eliminating ESD Hazards When Installing New or Replacing Old Piping Systems

Installing conductive petrol piping with the right conductivity properties, and then earthing the whole system, will eliminate ESD related hazards described in Principle I and Principle II (as well as the possible issue of piping damage/breakage and subsequent shortening of piping life-span due to static electricity).

Conductive petroleum piping solutions are mainly available in plastics and steel.
Summary

1. The flow of e.g. petrol through non-conductive/insulating plastic pipes generates static electricity.

2. Metal objects such as welding socket wiring or metal clips may become highly charged by the static electricity inside the pipe.

3. Objects close to the pipe may become highly charged even if they are not, directly or indirectly, in physical contact with the pipe. Resulting charges may exceed 15,000 Volts.

4. The petrol station presents an environment where explosive atmospheres are rather common – fires and explosions may occur.

5. Non-conductive and unburied piping as well as fittings, including those inside a sump, can give rise to hazardous charges and electrostatic spark discharges in explosive atmospheres.

6. Electrostatic sparks, in accordance with the above, represent an ignition hazard and may be present while e.g. refilling storage tanks or performing piping repair work.
7. Such accidents involving fires and explosions have been recorded by major oil companies, thus making them a health and safety risk.

8. In existing non-conductive piping systems electrostatic hazards can be reduced through a range of measures.

9. These measures can provide a high level of safety, but the described hazards cannot be entirely eliminated, especially when taking human error into account.

10. Electrostatic build-up may only occur in piping systems not properly grounded to earth. A non-conductive pipe can never be properly grounded to earth.

11. Conductive piping systems, with the right conductivity properties, easily eliminate the described hazards as long as all parts of the piping system are properly grounded to earth.

12. A forecourt with non-conductive piping may operate year after year with no problems occurring due to explosive atmospheres and static electricity. Small and perhaps unnoticed changes to the fill system design, environment, fuel composition, operation etc. can cause and have caused unexpected incidents.
Glossary

- **Contact Charging**
  The contact and separation of materials can generate static electricity. Highly insulating liquids or solids, intensive contact and quick separation of the materials encourage electrostatic charge build-up.

- **Electric Field and Induction**
  An electric field can be described as a region of space characterized by the existence of a force generated by electric charge. Any isolated conductor (e.g. virtually any unearthed metal part) within the electric field may become charged (induction).

- **Electric Potential**
  Electric potential is an energy level associated with an electric field, also called the electrostatic potential, typically measured in volts.

- **Electrical Ground/Earth**
  An intentional or accidental conducting path between an electrical system or circuit and the earth or some conducting body acting in place of the earth.

- **Electrostatic Discharge (ESD)**
  A transfer of an electrostatic charge between a material with an excess of electrons and a material with a deficiency of electrons. The transfer can manifest itself through spark discharges, brush discharges as well as through other types of discharges, depending on the specific circumstances.
• **Explosive Atmosphere**  
An explosive atmosphere is a mixture of substances (fuel) with air/oxygen, under atmospheric conditions, in the form of gases, vapours, mist or dust in which, after ignition has occurred, combustion spreads to the entire unburned mixture. Atmospheric conditions are commonly referred to as ambient temperatures and pressures. That is to say temperatures of –20°C to 40°C and pressures of 0.8 to 1.1 bar.

• **Flame Arrestor**  
Flame arrestors stop flame propagation into or through a pipe. A problem is that the arrestor itself may increase the strength of a potentially dangerous electric field around the pipe.

• **Minimum Ignition Energy (MIE)**  
The minimum electric spark energy that can ignite a mixture of a specified flammable material with air or oxygen, measured by a standard procedure.

• **Pinholing**  
Pinholing is the creation of a hole between the inside and outside walls of the pipe. It can be caused by a material defect and/or an electrostatic discharge. The latter will normally occur under high-charging levels.

• **Triboelectrification**  
A process of charge separation that involves the rubbing together of dissimilar material surfaces.
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This publication has been developed by Kungsörs Plast AB in close co-operation with leading experts in the field of electrostatics. Kungsörs Plast AB designs, develops and manufactures advanced piping solutions.