The hazards of static electricity

Static electricity has been known for many years to be able to ignite petroleum vapours. Nevertheless, accidents continue to happen. Why is this?

Static electricity incidents have occurred in recent years which have highlighted concerns about explosion or fire while transferring vehicle fuels. These may indicate that changes taking place threaten the existing precautions for controlling these hazards.

It is a well-known phenomenon that if two materials are rubbed together, static electricity is generated and electric sparks can be produced. Common examples are walking across a nylon carpet and then touching a metal surface such as a hand-rail when an alarming (but harmless) shock can be felt. Also, removing nylon clothing in the dark can generate an impressive display of sparks. What is perhaps less well known (outside industry) is that the same phenomenon can occur with liquids, including gasoline, kerosine and diesel, which are poor conductors of electricity. Static discharges (e.g. lightning) can also be generated by water drops passing through the air. Although much smaller voltages than lightning are developed, water washing (and indeed fire-fighting sprays) can generate enough charge to ignite flammable liquids.

A build-up of static charge arises when low conductivity liquids are poured or pumped from one container to another. If precautions are not taken, then sufficient electrical charge can build up to cause a spark that can have enough energy to ignite a flammable vapour. This phenomenon was first observed in the oil industry many years ago and if no precautions were taken, fires would be extremely common, rather than the rare events that they are.

To prevent such fires, a number of precautions have been developed over the years. These include mechanical, procedural or chemical measures. For example, a key mechanical measure is to electrically bond all metal containers, pipework etc. to each other and to earth. Charged conductors cause a high spark risk. Procedural measures include instructing the operator to earth his road vehicle before filling, and to control fuel pumping rates to limit charge generation. Good design can help enforce procedural controls through automatic earthing or electrical interlocks. A further possibility is to modify the fuel itself by adding chemicals to increase its conductivity.

Engineering and procedures have been formalized in Codes of Practice issued by individual companies and by various groups such as professional and national bodies. It is essential that such Codes are kept under review as the original assumptions made when they were written may no longer apply due to changes in equipment or fuel properties.

A recent series of incidents occurred when road tankers were being loaded with diesel fuel. It has been recognized for a long time that this activity is more hazardous if the vehicle has previously contained gasoline. When filling starts, the gasoline vapour is too rich to be ignited, but as the vehicle fills with diesel, the hydrocarbon vapour moves through the explosive range. If a spark occurs at this point, an explosion is possible. This procedure is called switch loading and is considered a normal event provided that all the proper precautions have been taken. It had been thought that this was the case with these incidents so what went wrong?

At least two factors may be involved. The first relates to the design of road tankers which has changed in recent years to allow recovery of the hydrocarbon vapours so that they are not emitted to the environment. A result of this is that the vapour spaces of the various tanks in the vehicle are connected. It is thus more difficult to predict when a hazardous atmosphere may be present. Secondly, a number of these incidents involved a product known as 'City Diesel'. This product is very highly refined to remove virtually all of the sulphur and other trace compounds containing oxygen or nitrogen which contribute to the conductivity of hydrocarbon fuels. Consequently, the electrical conductivity is generally lower than the grades of diesel fuel previously marketed. This lower conductivity increases static charge accumulation and, hence, the risk of sparking. Research into the causes of these incidents found that other grades of diesel also can have lower conductivities than used to be the case, due to more intensive refining and better control of the distribution system.

Another series of fires was of more concern to the immediate consumer as they involved fires in car fuel tanks during refuelling in a number of countries. Fortunately, most of these were not serious and in most cases only led to minor damage.

When cars fill up at a service station, the pump is earthed and the filling hose is made of conductive material and electrically bonded to the metal nozzle. Electrical continuity is normally established by metal-to-metal contact between the car and the filling nozzle but this depends on there being a conducting path between the filler pipe and the rest of the car. Finally, the car itself is earthed through the tyres which contain enough carbon to have an adequate conductivity. This last factor is important as the car can be charged to a high voltage during its journey.

Failure of any of these connections could lead to a static discharge, but fires are normally very rare. Upon investigation, many of the incidents involved two particular models of cars where there was inadequate electrical bonding between the filler pipe and the rest of the car. Repair of accident damage using non-conducting filler gave the same result in some cases. In one series of incidents, the main cause seemed to be very dry weather which meant that the conductivity of the ground was too low to allow the charge to leak away from the car. This may have been made worse by the impermeable lining often installed in service stations to prevent oil pollution of the ground.

A variety of other factors were found to be involved in other incidents. Some tyres used silica rather than carbon, hence reducing their conductivity. Although not shown to be a factor in these incidents, sampling of current grades of gasoline found that, like diesel, the conductivity of gasoline can be much lower than used to be the norm.

During the research into these incidents, it was shown that electrical discharges can actually occur inside the car filler system. These did not start any fires, firstly because the energy was too low, but more importantly because the vapour inside the tank is too rich to support combustion. There are demands to lower the vapour pressure of gasoline to reduce VOC emissions. If this is taken too far, then under some conditions, the vapour in a car fuel tank could be explosive with possibly catastrophic results.

A common feature in many of these incidents was that changes to fuel specifications, vehicle design and service station construction standards, many of which were implemented for environmental reasons, could have been contributory factors. The message for the oil industry is that change, for whatever reason, has to be managed positively. The message for regulators is that when mandating such changes, all the possible impacts have to be thought through, and this can only be done through consultation with all interested parties.