SAFETY NEWSLETTER

No. 126
STATIC ELECTRICITY

Items from old Newsletters showing how static electricity is formed

126/1 & 2	**By pumping liquids**
126/3 - 5	**By splash filling**
126/7	**On plastics**
126/8 & 9	**On people**
126/10 & 11	**By steam jets**
126/12	**On dusts**
126/13	**On ball valves**

An Engineer’s Casebook — Colour Coding of Pipes

ICI

IMPERIAL CHEMICAL INDUSTRIES LIMITED

PETROCHEMICALS DIVISION

126/1 STATIC ELECTRICITY FROM PUMPED LIQUIDS

Not many people have experienced the same accident on successive days. A famous case of this is described in "Electrostatics in the Petroleum Industry" by A Klinkenberg and J L van der Minne. In 1954 a large tank at Shell's refinery at Pernis in Holland blew up 40 minutes after the start of a blending operation in which one grade of naphtha was being added to another. The fire was soon put out and the naphtha was moved to another tank.

The following day they started the blending operation again; 40 minutes later another explosion occurred!

The storage tanks were not nitrogen blanketed and there was an explosive mixture of naphtha vapour and air above the liquid in the tanks. The source of ignition was static electricity — generated because the pumping rate was rather high.

"Electrostatics in the Petroleum Industry" analyses a large number of explosions which have occurred in hydrocarbon storage tanks and have been ignited by static electricity.

Static electricity is generated whenever hydrocarbons are pumped into a storage tank. In Petrochemicals Division we therefore insist that all fixed roof storage tanks, 100 m^3 or more in size, containing hydrocarbons above their flash points, are blanketed with nitrogen. Regular checks must be made to make sure that the nitrogen blanketing is in operation.

Shell's approach is different. They add anti-static additives to the hydrocarbons in the tank. These make the liquid conducting and there is then little or no danger from static electricity. We cannot do this as the additives might interfere with many of our processes.

Liquids like acetone and isopropanol, which contain oxygen, are already conducting and there is little or no danger from static electricity, provided all equipment is earthed so that the static electricity can drain away to earth.

If you would like to know more about static electricity see Safety Note 69/11, "Precautions to be taken against static, lightning and stray currents", an article by H Strawson in "The Chartered Mechanical Engineer", November 1973, page 91 , or Loss Prevention Guide No. 6.

From Newsletter 63/8

126/2 THE HAZARD IS GREATEST AT THE START OF PUMPING

You probably know that to prevent the accumulation of dangerous charges of static electricity, pure hydrocarbons should be pumped at a linear velocity below 7 m/sec, or below 1 m/sec. if any water is present.

An article in "Fire International" (October 1969, p. 76) shows that the charge developed depends also on the length of time the liquid has been flowing.

"... if experiments were repeated, one after the other, or if the fuel flows continuously through the pipe, the charges will diminish ...

This extremely important observation proves that it is the initial quantities of the product pumped that present the greatest danger, since they accumulate charges in a spectacular manner.

The most dangerous moment, therefore, in the operation of any installation is probably when it first goes into service; and putting it back into service after a prolonged interruption is equally dangerous.

It is at these times that operators of the equipment must be most scrupulous in observing the safety regulations".

From Newsletter 19/8

126/3 NEVER SPLASH FILL FLAMMABLE LIQUIDS

If a hydrocarbon liquid is splashed into a tank, a charge of static electricity can be built up on the liquid and this can cause a spark which will ignite the vapour. Flammable liquids should therefore be introduced into storage tanks or road or rail tankers through dip pipes which reach as close as possible to the bottom of the tank or through bottom inlet lines.

Although the tank or tanker should be earthed, this will not prevent a spark occurring INSIDE the tank, between the liquid and the tank. Earthing prevents an EXTERNAL spark between the tank and earth.

Splashing may also cause a mist to form inside the tank and a mist, like a dust, can explode at any temperature; so a liquid like kerosene with a high flash point which cannot form explosive vapour at ordinary temperatures can form an explosive mist. It is also possible that an electric discharge can take place from the mist (rather like lightning); this could occur even with conducting liquids such as non-hydrocarbons, because the droplets are not in contact with each other and cannot lose their charge.

Even if the tank is blanketed with nitrogen, it is good practice not to splash fill in case the blanketing fails.

So remember — **never splash fill any flammable liquid, even one with a high flash point.**

The fill-pipe should enter a fixed roof tank through the side, not through the roof, so that it is not broken if the roof is blown off by an explosion.

From Newsletter 20/6

Report No. 0.200,652/A, a translation of a German report, describes how acetone caught fire while being splashed into a can from a tap. The can and the man holding it were not earthed, a charge accumulated on them and a spark jumped from the man's hand to the tap. The can should have been earthed.

Safety Note 73/18 describes two explosions which occurred when liquids were being splashed into unearthed metal drums. The drums should have been earthed.

126/4 SPLASH FILLING SETS FIRE TO GAS OIL

On many occasions road tankers have caught fire while they were being filled.

Sometimes petrol has been pumped in too quickly or with too much splashing; this has produced a charge of static electricity on the petrol and a spark discharge has ignited the vapour. Such incidents are rare nowadays as most fillers are aware of the risk, and take care not to splash fill or fill too quickly.

Most tanker explosions occur during "switch loading", that is, while filling a high flash point hydrocarbon, such as gas oil, into a tanker which has contained petrol and is still full of petrol vapour.

Gas oil is normally filled quickly as usually it does not matter if there is a discharge of static electricity. However, if petrol vapour is present the static spark can ignite it. It is therefore very important, during "switch loading", to fill slowly and to avoid splashing.

Earthing the tanker and the filling arm will help to prevent such fires, since it prevents a spark passing between the tanker and the filling arm; it will not prevent a discharge of static electricity taking place between the charged body of the liquid and the top of the tanker or the tip of the loading arm.

A very unusual fire occurred in the Division while a rail tanker was being filled with gas oil. There was no petrol vapour present but nevertheless a fire occurred with flames 30 feet high.

The fire soon went out of its own accord.

The tanker was being splash filled. This formed a lot of mist. The flash point of gas oil is about 60°C but a mist — like a dust — has no flash point — it can explode at any temperature. The splashing produced a charge of static electricity on the gas oil and when this discharged it ignited the gas oil mist. As soon as the mist had burnt, the fire went out.

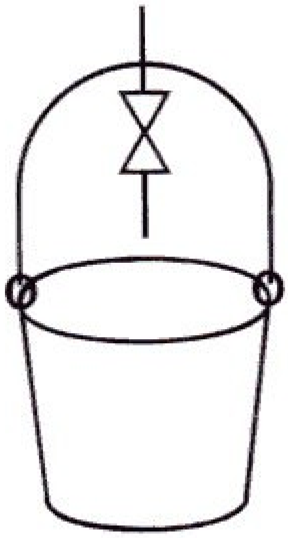
To avoid similar incidents, NEVER SPLASH FILL. The fill pipe should reach to the bottom of the tanker. (A rubber cushion on the bottom of the pipe will prevent it damaging the tanker).

Many thousands of tankers had been splash filled with gas oil before conditions were exactly right for a fire to occur. When dealing with flammable gases or vapours we should never say, "It's okay, we've never had a fire". If flammable gases, vapour or mists are mixed with air, then sooner or later a fire or explosion will occur.

From Newsletter 66/2

126/5 A FIRE WHILE DRAINING LIQUID INTO A BUCKET

Acetone had to be drained into a bucket (in another company). One day the operator **hung the bucket on the drain valve** instead of placing it on the ground.



The handle of the bucket was covered with plastic.

When the acetone was drained, a charge of static electricity accumulated on it and on the bucket. The plastic prevented the charge flowing to earth via the drain pipe. Finally, a spark passed between the bucket and the drain pipe and the acetone caught fire.

Although acetone is conducting, a static charge can still build up if it is in contact with equipment which is not earthed.

***Reminder**:*

Flammable and corrosive liquids should be drained into cans, not buckets. See Newsletter 90, page 8.

From Newsletter 111/3

126/6 A MISLEADING NOTICE

We all know that road tank wagons should be earthed while they are being filled with flammable liquids.

One tanker was not earthed. When this was pointed out to the driver he said "On this design of tanker an earth is not necessary". He pointed out a notice in the cab which said

This vehicle is fully insulated **Attach no earth**

This notice actually referred to the vehicle's electric system. On most cars and lorries, the body is used as an earth to complete the electric circuit. On petroleum spirit tankers, all the connections are made by means of wires as accidental sparks due to bad connections are then less likely. The notice meant that the electric wiring should not be earthed. It had nothing to do with the method to be used for filling the barrel.

Do you know of any other notices which meant different things to different people?

From Newsletter 73/6

126/7 ELECTRICALLY CONDUCTING POLYETHYLENE BINS

In a plant in another Division some crystals are drained in a vacuum filter and then transferred to polyethylene bins. The bins become charged with static electricity, and over a period of five years this caused three small fires. The hazard was overcome by using a new conducting grade of polyethylene containing 0.5% carbon.

For further details see the ICI Materials Handling Review for January/February 1975. More information about the conducting plastic can be obtained from Polyethylene Technical Service, Plastics Division,Welwyn Garden City.

From Newsletter 75/3

126/8 CAN DISCHARGES OF STATIC ELECTRICITY FROM PEOPLE IGNITE FLAMMABLE MIXTURES OF GAS OR VAPOUR AND AIR?

The answer is yes but the circumstances must be exactly right. Two recent incidents show what is necessary. The first is taken from the Mond Division Safety Report for September 1973.

An ICI employee on holiday in Scotland pulled into a garage to fill up his car with petrol. While the car was being filled he took off a woollen sweater and threw it into the car. He was wearing a 'Crimplene' shirt underneath the sweater. When the tank had been filled, he was about to replace the filler cap which he had been holding in his hand. A spark jumped from the filler cap to the end of the fill-pipe and a flame appeared at the end of the fill-pipe. Fortunately the flame was only about four inches long and he was able to blow it out and replace the cap.

When the man took off his sweater there was a charge of static electricity on it and this left an equal and opposite charge on the man. He was wearing rubber-soled shoes so the charge could not drain away to earth. When he went close to the car the charge caused a spark to jump from his hand to the end of the fill-pipe and this spark was sufficient to ignite the petrol/air mixture. Fortunately, the tank itself contained so much petrol vapour that it could not explode — there was not enough air present.

Note that synthetic fibre clothing cannot cause people to become charged unless some clothing is removed. As long as the man was wearing his sweater there may have been a charge on the sweater and an opposite charge on the man but the man and the sweater as a whole had zero charge. Normally we are not likely to remove our clothing while dealing with a leak in the plant so synthetic fibre clothing presents no hazard. However, if a person is continually sitting down and then getting up again he can leave a charge behind on the chair and an equal and opposite charge on himself — but only if his footwear is non-conducting or the floor is non-conducting. Most footwear is conducting.

The second incident is described in “Design Engineering” for October 1973, page 199. A woman went to a toilet of the old-fashioned bucket type. Some methane gas had accumulated in the bucket. When she took off her pants there was a separation of charge between her pants and herself and a charge passed from her to the toilet. The methane exploded with a loud bang.

From Newsletter 59/7

‘A lady removing her scanties
Heard them crackle electrical chanties.
Said her husband, ‘My dear',
I very much fear
You suffer from amps in your panties”.

Actually microamps, static electricity produces high voltages but very small currents.

I recently saw an advertisement in a newspaper for “Anti-static cami-knickers”.

126/9 A SLIPPING ACCIDENT ON A STAIRCASE

A man slipped on a staircase, twisted his ankle and was absent for 17 shifts. The staircase seemed to be in good condition and so did the man’s boots.

When we read this our first reaction is that it is just another of those incidents that we can do nothing about — another of those occasions when “Man told to take more care” should appear in the accident report.

However, on the plant concerned they were not satisfied with this easy way out. They looked into it more thoroughly. They asked the injured man why he had not used the handrails.

It then came to light that the handrails were covered with plastic, and that when anyone wearing insulated footwear used them he got an electric shock when his hand touched bare metal. As he ran his hand along the plastic coating he became charged, and as soon as he touched a piece of bare metal an electric spark jumped from him to the metal. The spark, of course, was not serious enough to cause any injury, but it was unpleasant, and people tended, therefore, not to use the handrails.

From Newsletter 81/7

The minimum energy that can be felt is about 1 mJ.

The minimum energy required to ignite a mixture of flammable vapour and air is much less, about 0.2 mJ.

126/10 PRODUCTION OF STATIC CHARGES IN GAS JETS

It is well-known that gas jets containing liquid droplets or solid particles can produce static electricity. If there are any unearthed conducting objects in or near the jet, then they collect the charge which may then cause a spark as it jumps to earth.

It has been suggested that electric discharges can take place directly from the droplets in the gas jet - rather like lightning which is a discharge from the water droplets in a cloud.

A discharge of this sort was seen one night in a steam leak and is described in full in Safety Note 70/3 and Addendum. The discharge was not a spark but a partial electrical breakdown or corona discharge and looked like a small flame.

It is not known whether or not discharges of this sort have enough energy in them to ignite mixtures of flammable gas and air. The possibility cannot be excluded. Inside a steam leak the steam would prevent ignition but a similar phenomenon might occur in a leak of flammable vapour containing liquid droplets.

There is no way of preventing corona discharges. Spark discharges can be prevented by making sure that all metal equipment is earthed and by not leaving bits of unearthed metal lying around.

Corona discharges are sometimes seen on ships' masts during storms; they look like balls of fire, and are known as St. Elmo's fire. St. Elmo is the popular name of St. Peter Gonzalez (c.1190-1246), the patron saint of seamen. The fire used to be interpreted as a sign of his protection though sometimes as a sign of impending doom.

From Newsletter 18/3

126/11 OTHER MEN'S VIEWS No 14
SPARKS FROM WATER DROPLETS — AN EXAMPLE OF FORGOTTEN KNOWLEDGE

In the January, 1978 edition of *Electronics and Power*, there was an article by A F Anderson telling the story of the Armstrong "hydroelectric" (static electricity) generator, and its development from the discovery in 1840 of the phenomenon of static charge generation by escaping steam.

The first recorded case of electric shocks from steam occurred when the engine driver of the Cramlington Colliery Railway near Newcastle, on a fine and dry evening in September 1840, walked through a cloud of steam escaping from the relief valve flange on the stationary haulage engine boiler and received "a curious pricking sensation in the ends of his fingers" when he attempted to adjust the relief valve. Over the next few days the weather remained fine and dry, and he and some of his workmates were able to repeat the experience. It was soon noticed that sparks were being drawn, and the news of the phenomenon reached the ears of the colliery engineer and subsequently the scientific community, including Armstrong and Faraday. Armstrong's investigations showed that the steam became electrified as it entered the atmosphere, and not in the boiler.

Armstrong recognised that the phenomenon could be utilised to produce high electrostatic voltages simply and more reliably than by existing apparatus, (The Wimshurst machine had not then been invented). He finally produced a device which he described as "a colossal hydroelectric machine". It comprised a fired boiler with internal flues and mounted on glass legs, with the steam being fed through an external iron vessel (to allow partial condensation) and from there through a battery of friction nozzles to atmosphere. The charge on the condensate cloud was collected by impinging the jets on an electrically isolated metal comb. Sparks 22 inches long could be drawn from the collector. Notice that Armstrong recognised that both two-phase flow and turbulence increased charge generation. Thus the generation of static by sprays of droplets was a well documented and understood phenomenon over 130 years ago.

And now for the moral of the story. In December, 1969, three large oil tankers suffered severe damage from explosions in their cargo tanks. All three were in the process of washing out their tanks with high pressure water jets, and the frictional charge generated was sufficient to ignite the vapour/air mixture present. Quoting from Anderson in his paper in *Electronics and Power* “This illustrates how easy it is for a body of fundamental knowledge, once well disseminated, to become forgotten with the passage of time... We have now come full circle. The moral is that we should be keen students of the past if we want to avoid costly mistakes in the present”. This last sentence admirably summarises the philosophy of the Loss Prevention Bulletin. We hope that it assists subscribers to become “keen students of the past” so that costly mistakes will not be repeated.

From Loss Prevention Bulletin No 021, Published by the Institution of Chemical Engineers.

Can you think of any other examples of fundamental knowledge that has been forgotten?

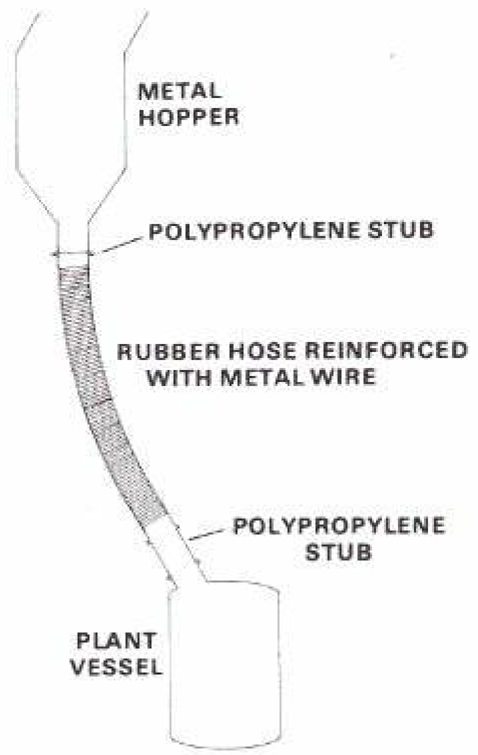
(Newsletter 109 showed how knowledge of accidents is forgotten after a few years).

126/12 A DUST EXPLOSION IGNITED BY STATIC ELECTRICITY

Some dusts can be ignited almost as easily as vapour-air mixtures and it is difficult to be certain that all sources of ignition have been eliminated. With these dusts the best policy is not to allow explosive mixtures to occur but this is not always possible. Alternatively, explosion vents can be provided or automatic systems can be installed for detecting the start of an explosion and injecting a quenching agent.

A discharge of static electricity can ignite a dust and cause an explosion. This is illustrated by a report from another Division of an explosion which resulted in a fatality.

A powder was emptied down a metal chute into a plant vessel. The chute was replaced by a plastic one, as shown below.



The flow of powder down the chute developed an electrostatic charge on the hose. The hose was conducting but the polypropylene end pieces prevented the charge leaking to earth. Finally, a spark occurred and ignited the dust cloud.

The original metal chute was safe as it was earthed.

A plastic chute would have held a charge but if the plastic was non-conducting, the charge could not all discharge at once; any spark that occurred would have been small and might not have been big enough to ignite the dust.

An unearthed conducting hose introduced maximum risk — it allowed a charge to build up and then allowed it all to discharge at once.

The incident described is a good example of how a modification to a plant can introduce a new and unforeseen hazard.

The full report (No. D76,223/C) can be borrowed from Division Reports Centres.

Similar effects occur with liquids. Newsletter 31/4, described how a metal bobbin piece was introduced into a plastic pipe and reacted with the acid in the pipe, building up a pressure. The metal bobbin piece was also dangerous in another way — it could have accumulated a static charge.

From Newsletter 33/5

Another Division report that a small fire occurred while an open container was being filled with powder. The container should have been earthed.

The earth lead had been clipped onto the container but the other end of the lead had broken off the structure.

How often do you check your earth leads?

126/13 SOME OTHER PAPERS ON STATIC ELECTRICITY

The following are available on request, together with the Safety Notes mentioned earlier.

On one occasion sparks were seen jumping between the handle and body of a ball valve. Safety Note 74/26 considers the hazard and makes recommendations.

Safety Note 70/8, “Notes on the 1st International Congress on Static Electricity”.

Safety Note 70/5, “Notes on a Meeting to discuss Hazards from Static Electrification, held in the Institution of Electrical Engineers on 8 April, 1970”.

For copies of these publications or for more information on any item in this Newsletter please ‘phone ET or CJ (Ext. P.2845) or write to them at Wilton. If you do not see this Newsletter regularly and would like your own copy, please ask them to add your name to the circulation list.

August 1978

An Engineer's Casebook No 26
Colour Coding of Pipes and Piping Components

BS 5383 "Colour Coding of Pipes and Piping Components" was published in 1976 as an aid towards identification of materials used in piping systems.

The development of this standard was initiated by ICI and CEGB following several incidents involving incorrect material placement in complex piping systems and was supported by the rest of industry represented on OCMA and BSI committees.

Since the publication of BS 5383 it has been necessary to negotiate implementation with the manufacturers. This has turned out to be a slow and difficult task. Although this work is not yet fully completed, progress has been significant and material purchased from approved manufacturers should now be starting to arrive on site correctly colour marked. The exception to this is carbon steel pipe to API 5L or equivalent which will not be colour marked until the pipe mills have installed automatic marking equipment.

As the British Standard does not cover piping and components to American specifications but does allow the marking of equivalent materials by arrangement with the purchaser, Company Standards 18/0307 and 18/0308 have been produced as an addendum to BS 5383. These list materials to both British and American Specifications.

With users in mind, the Company has produced a handy reference booklet entitled "ICI Addendum to BS 5383". Copies can be obtained from Division Piping Engineers.

J Downing