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Case History

SOME FIRES AND EXPLOSIONS IN LIQUIDS OF HIGH FLASH POINT

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Summary

Many fires and explosions have occurred because of a failure to realise that heavy oils, once they are hot, catch fire or explode as easily as petrol.

Some incidents are described, together with the precautions necessary to prevent them happening again.

The incidents described are: an explosion in a distillation column; several explosions while demolishing storage tanks; a fire while demolishing an old pipeline; a plant destroyed when a spillage of solvent caught fire; an explosion in a lorry wheel; an explosion in a cargo of bananas; a fire while filling a road tank wagon.

Introduction

In another article [1] I have discussed "Some Myths of the Chemical Industry" — deeply ingrained beliefs that are not wholly true.

One such myth is that materials of high flash point are "safe" and do not have to be treated with the same respect as low-flash-point materials such as petrol. This is true, as other writers have pointed out [2], provided they are below their flash points. However, once they are heated above their flash points they become as dangerous as petrol and have to be treated with the same respect.

Many fires and explosions have occurred in the oil and chemical industries because these facts were not realised. Some of the incidents are described below.

Explosion in a distillation column

This explosion occurred about 20 years ago when standards generally were not as high as they are today. A batch vacuum distillation column was used to separate a number of high-boiling liquids which had flash points ranging from 80°C upwards.

The column was heated by high pressure steam (15 bar, 200°C) using an internal steam calandria, and this had to be removed for cleaning. The vacuum was broken with air, the residue pumped out, and, a few hours later, the calandria was disconnected and unbolted and the operation of withdrawing it begun. It had been withdrawn about 0.5 m when there was a flash and a bang and the calandria shot out the rest of the way like a torpedo (Fig. 1). Fortunately, there was no-one in the line of fire, but several men were splashed with the tarry residue which had been stuck to the calandria.

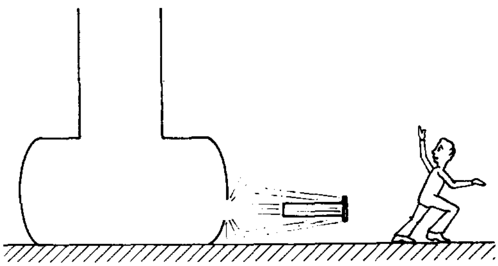

Fig. 1.

Subsequent investigation confirmed that the base of the still had cooled to about 100°C, but was still above the flash point of the contents. Breaking the vacuum with air had formed an explosive mixture. The source of ignition was probably heat developed by dragging the calandria against the edge of the opening in the boiler. This, however, is unimportant; if we have an explosive mixture, it is only a matter of time before a source of ignition turns up.

The recommendations made after the explosion were:

(1) The vacuum should be broken with nitrogen, not air.

(2) Before opening up the distillation column it should be allowed to cool down to well below 80°C, and the contents should be removed by boiling with water (the contents were soluble in water).

(CARE — Do not add water when the temperature of the still is above 100°C or the sudden vaporisation of the water will damage the trays. Do not exchange one problem for another.)

(3) A combustible gas detector cannot be used to detect an explosive mixture in the column as the vapours will condense out in the sample tube or on the sintered metal filter which surrounds the element.

The most interesting feature of this explosion is that petrol was processed in the same factory and none of the men concerned would have dreamt of opening up a still containing petrol until all traces of petrol had been removed by steaming and/or sweeping with inert gas. But high-boiling materials were considered "safe".

A few years later, in the same factory, a leaflet was issued on the hazards of the materials used. It discussed the chemical hazards of the high-boiling materials used and then said "they are not in the slightest degree explosive"! Memories had faded and a belief in the myth had re-established itself.

Explosions while repairing or demolishing tanks which have contained heavy oils

Many explosions have occurred during the repair or demolition of tanks which have contained heavy oils or polymers.

In one incident, which occurred in another country, repairs had to be carried out on the roof of a storage tank which had contained heavy oil. The tank was cleaned out as far as possible and two welders started work. They noticed smoke coming out of the vent and flames coming out of the hole which they had cut. They started to leave, but before they could do so the tank erupted audibly and a flame 80 ft. long leapt out. One of the men was killed and the other was badly burned. The residue in the tank continued to burn for 10—15 minutes.

In another incident, in a different company, the roof was blown off an empty tank while a welder was repairing it.

In both of these incidents, the tanks had been cleaned and freed from gas as far as possible, but traces of heavy oils were trapped between the plates or behind rust, or were stuck to the sides. The welders' torches vapourised these heavy oils and ignited them.

The best known incident of this type occurred at Dudgeon's Wharf in London in 1969 [3]. A tank containing a gummy deposit on the walls and roof had to be demolished. The deposit was unaffected by steaming but gave off flammable vapour when a welder's torch was applied to the outside of the tank. The tank blew up, killing six firemen.

It is almost impossible to completely clean a tank which has contained heavy oils, residues or polymers or any material which is solid at ordinary temperatures, particularly if the tank is corroded, so that oil can get between the plates where there is a defect in the welding (some old tanks are welded along the outside edge of the lap only). Tanks which have contained heavy oils are more dangerous than tanks which have contained lighter fractions such as petrol, as petrol can be completely removed and it is possible to detect any traces that are left with a combustible gas detector.

Before welding is allowed on any tanks which have contained heavy oils etc., they must be filled with inert gas or with fire-fighting foam generated with inert gas. Fire-fighting foam generated with air has not been proved to be satisfactory. Filling the tank with water can reduce the volume to be inerted.

Fire during demolition of old pipelines

A similar incident to those just described occurred while some old pipelines were being demolished. They were cleaned as far as possible and then tested with a combustible gas detector. No flammable gas or vapour was detected, and so a burner was given permission to cut them up. While he was doing so, sitting on the pipes 4 m above the ground, a tarry substance seeped from one of the pipes and caught fire. The fire spread to the burner's clothing and he ended up in hospital with burns to his legs and face.

The tarry deposit in the pipe caught fire when it was heated by the burner's torch. The deposit was not flammable when it was cold, so it could not be detected by the combustible gas detector.

It is almost impossible to make pipes which have contained heavy oils or polymers perfectly clean, and therefore fires may occur when the pipes are heated. When demolishing pipelines there should be as many open ends as possible so that a pressure cannot build up. Good access must be provided so that the burner or welder can withdraw from the burning point without difficulty if a fire occurs.

A spillage of solvent catches fire and destroys a plant

An ore-extracting process was carried out in a building with wooden floors, but this was considered satisfactory as the organic solvent used was high-boiling and had a high flash point (42°C). Leaks of solvent drained into a pit inside the building. While some welding was taking place, a burning piece of rag fell into the pit, and, in a matter of seconds, the fire had spread along the solvent film which covered the water in the pit. The rag acted as a wick and set the solvent alight, although a match would not have done so. The fire spread to the wooden floor. Some glass pipes soon burst and these added more fuel to the fire. In a few minutes the building was ablaze and two-thirds of the contents were destroyed [4].

This incident occurred because of a failure by all concerned to realise how readily a liquid of flash point 42°C could be set alight.

Explosion of a lorry wheel

A lorry wheel had to be repaired. It was taken off the lorry and a welder started work with the tyre still inflated to 100 psig. There was a little lubricating oil inside the tyre and this exploded violently. The welder and his mate were killed and the remains of the wheel and tyre went through the roof. Afterwards, tests showed that the metal had reached 660°C, well above the temperature at which lubricating oil will explode [5].

Here, once again, was a failure to realise that heavy oils, such as lubricating oil, can explode.

Explosion in a cargo of bananas

An unusual incident occurred in 1973 when a ship carrying a cargo of bananas caught fire. During the fire-fighting an explosion occurred, injuring nine people, seven of whom were firemen. A small amount of ethylene is used to ripen bananas and it was suggested that the heat from the fire caused some absorbed ethylene to be liberated and it then exploded [6].

It seems incredible that the small amount absorbed could form an explosive mixture. Banana skins are very oily and it seems more likely that the oil from the skins was vaporised by the heat and formed an explosive mixture.

To illustrate the oiliness of banana skins, it is said that if a gearbox runs out of oil, it can be stuffed with banana skins!

Explosion of a gas oil mist

Heavy oils explode very easily when they are in the form of a mist. The source of ignition can be quite small. It does not have to vaporise a significant amount of the oil, as in the other incidents discussed. The phenomenon is more analogous to a dust explosion than a normal vapour explosion [7].

One incident occurred while a road tank wagon was being filled with gas oil, flash point 65°C. The oil was being splash-filled and this filled the tankers with mist and also resulted in the oil in the tanker becoming charged with static electricity. A discharge occurred, probably between the oil and the filling-pipe, and this ignited the mist. A sheet of flame was produced 6 m high, but the oil in the tank wagon did not catch fire.

Note that the tanker was earthed but this will not prevent a charge of static electricity accumulating on a non-conducting liquid and sparking to earth.

Most fires during filling of road tank wagons occur as the result of "switch-filling", that is, adding gas oil to a tank wagon which contains petrol vapour. There was definitely no petrol vapour present in the incident described.

On the installation concerned, thousands of tank wagons had been splash-filled with gas oil before conditions were exactly right for ignition to occur. Nevertheless, one ignition in several thousand is too many and it is important that tank wagons (and other vessels containing air) are never splash-filled; the fill pipe should reach to the bottom of the tanker.

Uses of these incidents

The action necessary to prevent similar incidents happening again has been described. Fundamentally, however, the fires and explosions occurred because of a failure to realise that when heavy oils get hot they behave like petrol. A programme of education is needed.

Some of the incidents described above have been used to teach the principles involved to plant operating and design staff. Each incident is described briefly and illustrated by slides. The group, usually 12—20 people, then question the discussion leader to establish the rest of the facts. They can decide what should be done to prevent similar incidents happening again [8].

Two advantages of this method are:

(1) People learn better by discussion than by listening to a lecture. They are not told what they should do — they work it out for themselves.

(2) Less time is wasted than in a normal syndicate discussion as the discussion leader is present throughout and prevents the discussion going off the track.

Acknowledgements

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