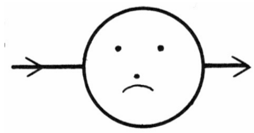
SAFETY NEWSLETTER

No. 136

SOME INCIDENTS WHICH OCCURRED BECAUSE THE LESSONS OF THE PAST WERE FORGOTTEN



136/1 Trips not tested — no gas detectors — poor ventilation → Spillage!

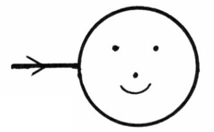
136/2 Protective equipment by-passed → Fatal Accident!

136/3 Methanol mixed with air → Explosion!

136/4 A machine overhauled against valve isolations only → Scald!

136/5 Symptoms treated, cause ignored → Repeat!

AND SOME PREVENTED BECAUSE THE LESSONS OF THE PAST WERE REMEMBERED



136/6 The wrong valve was installed but someone remembered.

136/7 A tool was banned but crept back into use.

ALSO IN THIS ISSUE

136/8 The answer to our pressure problem.

136/9 Is safety like gardening?

An Engineer's Casebook — Thick-walled vessels in hydrogen service

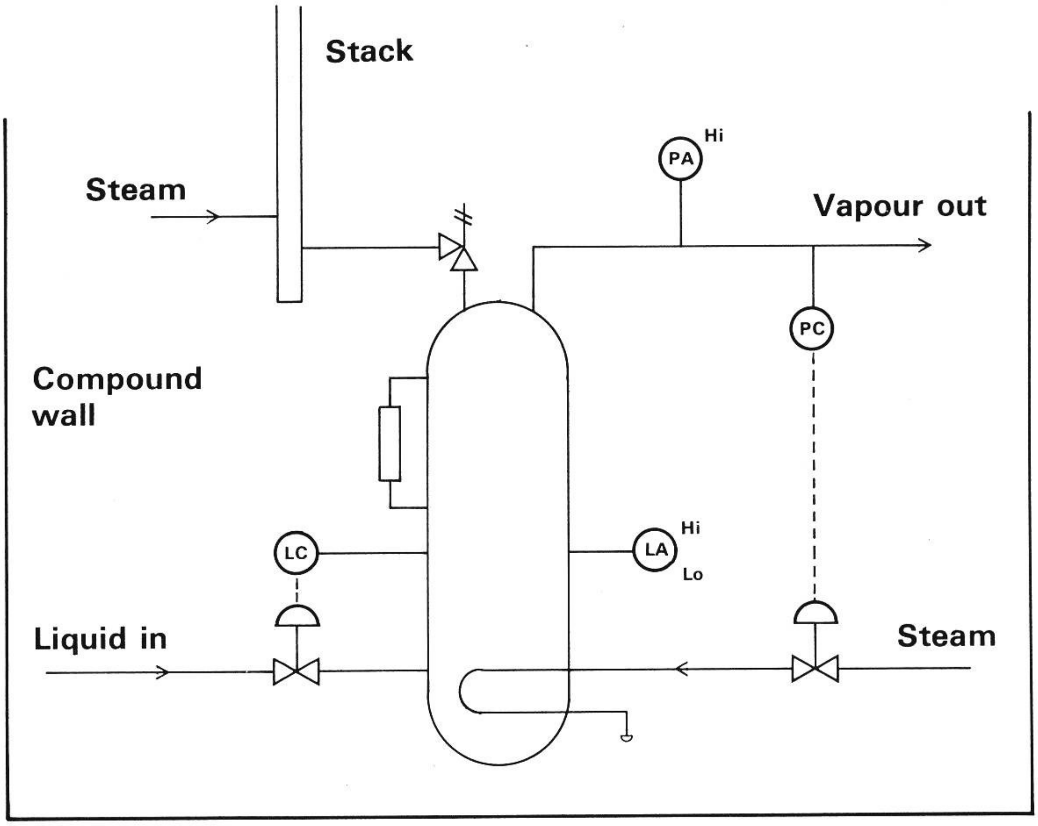
Which is more hazardous — Matches or a bucket?

ICI
IMPERIAL CHEMICAL INDUSTRIES LIMITED
PETROCHEMICALS DIVISION

136/1 A SPILLAGE OF LPG — ALARMS WERE NOT TESTED

A spillage of liquefied petroleum gas occurred recently in the Company. The report on the incident contains a number of recommendations of interest to all who handle LPG and other hazardous liquids.

A small vaporiser and vent stack are located inside a brick compound, about 4 m long by 2.5 m wide by 3 m high. The instrumentation is shown below.



The circumstances leading up to the incident are not 100% clear but it seems that the level controller failed, so that the vaporiser filled with liquid which passed through the relief valve into the stack which then overflowed. The steam supply to the vaporiser froze but this may have occurred after the spillage due to contact with cold LPG.

The spillage was evaporated with steam and water sprays. Fortunately it did not ignite.

The following points came out of the investigation:

1 The high level and high pressure alarms failed to operate. They were not tested and were not included in the alarm test schedule. When the schedule was drawn up, these alarms were forgotten, because they were on a small unit which is not always in use, on the edge of the plant. This is another example of the point made in Newsletter 132 -

rot starts at the edges.

2 **There was no gas detector in the compound**. One is now being installed.

3 The walls round the vaporiser make it more difficult for leaks to disperse and the walls should be demolished.

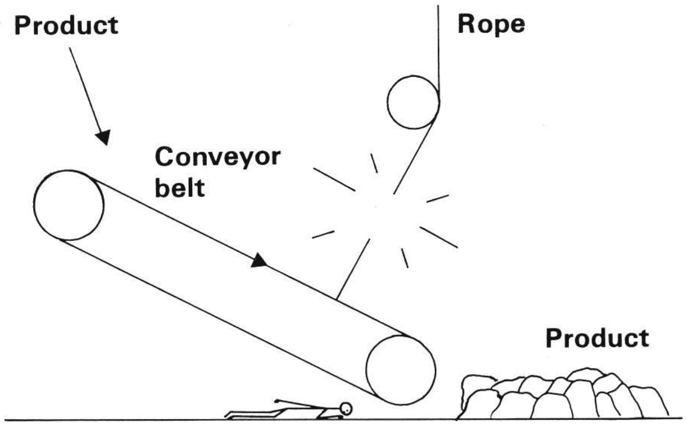
Equipment handling flammable liquids and gases should be located so that it gets as much natural ventilation as possible. See Newsletters 115/8, 112/1, 93/2, 41/1, 37/4 and 35/2.

4 There was a level glass on the vaporiser. **Level glasses should not be used for LPG and other liquids which are handled above their boiling points**. See Safety Note 72/20.

All the lessons which came out of this incident have been mentioned many times in these Newsletters over the last 12 years. **Are there any backwaters on your plant where a similar incident could occur?**

136/2 AN IMPROVISED SHORT-CUT - A FATAL ACCIDENT

In one of our overseas companies a solid product is moved into a store on a conveyor belt. As the store fills, one end of the conveyor belt is gradually raised by a wire rope.



It takes 48 hours for the conveyor belt to rise from its lowest position to the horizontal position.

When the belt has to be maintained it may be necessary to raise it more quickly. It can be raised in 2 hours by getting an electrician to by-pass the controlling timer.

One day an electrician was not available so the timer was by-passed by holding a switch down with a bent welding rod.

Two hours later, after a change of shift, the belt reached the top position. **The limit switch did not operate as it was also by-passed**. The motor continued to turn. The rope broke, the belt fell and killed a man who was working underneath.

The lessons to be learnt from this incident are well-known. They are:

1 **Do not by-pass trips and other protective equipment without written authority and then in an authorised way.** The man who by-passed the timer probably did not realise that he was also by-passing the limit switch.

2 **Do not stand or work underneath equipment which is supported only by a rope.**

3 Do not rely on single ropes. Use a second rope or some other device to catch the belt if the main rope fails.

136/3 A LOOK BACK AT NEWSLETTER 36 (January 1972)

Managerial responsibility and safety

“With the workers of 70 years ago the only way to obtain strict observance of the regulations was by having a rigid disciplinary system. This necessitated the employment of those whose sole function was to ensure that all rules were observed, and severe penalties were meted out to offenders.

Times have changed and such an attitude on the part of management is out of character in the present industrial climate, which recognises that the present day employee is an intelligent, thinking person who does not require to be rigidly disciplined by outsiders with rules for which he may not know the reasons, but can be expected to exercise self-discipline.

While we would not suggest that a return should be made to the regimentation of 70 years ago, we do feel that the level of awareness of the operators to the hazards to which they may be exposing themselves, has not increased at the same rate as has the level of personal responsibility which has been delegated to them."

Extract from the Report of Her Majesty's Inspectors of Explosives for 1970.

The Inspectors remarks are illustrated by the following incident:

Air + Fuel → Bang

On one of our plants waste product is dissolved in methanol. Waste product is put into an empty vessel. The vessel is boxed up and evacuated and the vacuum is broken with nitrogen. Methanol is then added. When the product has been dissolved, the solution is moved to another vessel, the dissolving vessel is evacuated and the vacuum broken with nitrogen. It is then ready for the start of another batch.

If this system is followed an explosion is impossible as air and methanol are never mixed.

However the operators got into the habit of adding methanol as soon as the waste product was in the vessel, without bothering to evacuate or add nitrogen. One day a fire occurred. One man was injured, fortunately not seriously. The source of ignition was never found.

It is easy to say that the fire was caused by the operators not following the rules. But why didn't they follow the rules? Have we as managers and supervisors failed to give them the right *"level of awareness ... of the hazards to which they may be exposing themselves".* Have we failed to make them aware that mixtures of fuel and air will catch fire, even though we keep out all known sources of ignition?

The manager should also from time to time, have checked that the correct procedure was being followed.

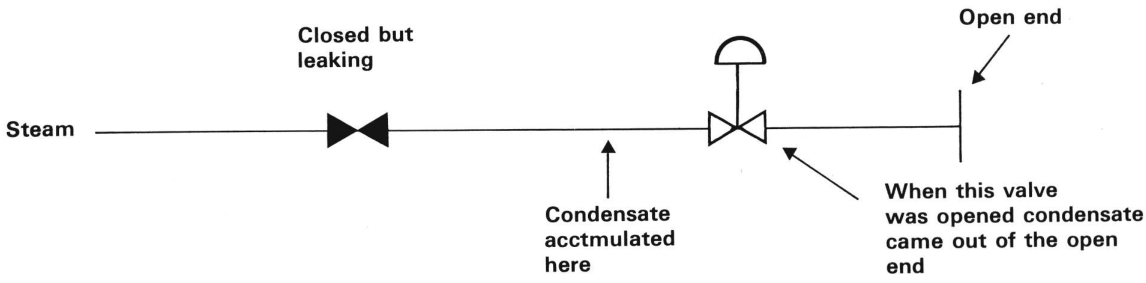
136/4 ISOLATION OF EQUIPMENT FOR MAINTENANCE

There may be times when some of us wonder if the Petrochemicals Division rules on the isolation of equipment for maintenance are really necessary.

A good antidote for this feeling is to read reports of incidents which occur in other Companies which do not have such stringent rules and rely on valves rather than slip-plates.

Here is one such incident:

A man opened a trip valve on a steam turbine which was dismantled for repair. The isolation valve was leaking, hot condensate had accumulated behind the trip valve and when it was opened the man was scalded on the forehead.



A similar incident on an ammonia pump twelve years ago killed a man and was one of the incidents which led to a change of policy in Petrochemicals Division (See Newsletter 68/6).

136/5 DON'T JUST TREAT THE SYMPTOMS - DIAGNOSE THE ILLNESS

Under this heading Newsletter 37/8 described an incident in another company. A compressor cylinder lining was changed 27 times in 9 years. No-one asked why it had to be changed so often; they just went on changing it. Finally, a bit of the lining got caught between the piston and the cylinder head and split the cylinder.

A similar incident is described in "Power", February 1972, page 154. A motor developed a hot bearing. It was changed. It over-heated again very quickly, was changed a second time and again ran hot. The motor was thoroughly overhauled and put back; it lasted 30 minutes. An identical motor was purchased and installed; it also lasted 30 minutes. The motor and the impellor of the fan it was driving were checked for balance. Temperatures, pressures and currents were measured; none of these helped. Finally, the trouble was traced to the coupling between the motor and the fan which was out of balance.

Reminder: Couplings were discussed in An Engineer's Casebook No. 34 in Newsletter 134.

136/6 A SECOND MISTAKE IS AVOIDED

Newsletter 78/4, July 1975, reported that a valve had to be changed on a plant which handles a mixture of acids. The shift fitter could not find a suitable valve in the workshop, but after looking round he found one on another plant. He tested it with a magnet and, finding it to be non-magnetic he assumed it was one of the 321 or 316 valves normally used on the plant. He therefore installed it.

Four days later the valve was badly corroded and there was a spillage of acids.

The valve was made of Hastalloy, an alloy that is suitable for use on the plant where it was found, but was not suitable for use with the mixture of acids used on the plant in which it was installed.

Three years later the same mistake was made again and another wrong valve was installed. However, this time a supervisor spotted the mistake in time. He not only remembered the original incident and had a copy of the report in his locker but also remembered the markings on the wrong valves.

On many plants they keep a "black book" in the control room or in the supervisor's office (See Newsletters 108/7 and 72/5). Accident reports of technical interest are put in it. The book is compulsory reading for everyone who joins the plant, other people dip into it from time to time to refresh their memories, and it is discussed at group meetings.

Have you got a plant "black book" on your plant?

136/7 A BANNED TOOL CREEPS BACK INTO STORE

While a man was dressing an abrasive wheel, the tool he was using came apart and bits of the tool flew in all directions. Fortunately no-one was hurt.

The design was poor and stocks of the tool were withdrawn from stores.

Six years later the same man was supplied with the old type of tool. A well-meaning person had put it back into stock!

Do not assume that a tool is safe just because it is supplied by a well-known firm.

Do not assume that a situation is under control because you put it under control. Systems lapse. People forget. Vigilance is always necessary.

136/8 A PROBLEM ABOUT PRESSURES

Here is the answer to the problem in our last issue.

The drums were filled at 0°C by pouring in liquid until they were 90% full. The drums were open to the atmosphere during the filling so that, when the drums were closed, the pressure inside was 1 atmosphere which was made up of 3 psia of the vapour of the liquid and 11.7 psia of air. On warming the drums to 30° C, the liquid expanded to 92.7% of the volume of the drum and the vapour pressure of the liquid increased to 12 psia. The vapour space occupied by the air decreased from 10% to 7.3% of the drum volume. Therefore, the air pressure rose from 11 .7 psia to 16 psia (11.7 x $^{10}/_{7.3}$) (neglecting the further small increase in pressure due to the rise in temperature, i.e.$^{307}/_{273}$). The solubility of the air in the liquid was very small and the increase in pressure did not cause any transfer of air from the vapour space into the liquid. Therefore, the pressure in the drums rose to 16 + 12 = 28 psia and the drums burst.

136/9 OTHER MEN'S VIEWS No 20

It is unfortunate that the whole business is often called safety engineering. Although there are obviously engineering aspects the approach is more like gardening than engineering. The engineer makes things happen by direct effort and intellect, the gardener doesn't make things grow in this sense, he devotes his effort and intellect to creating the conditions in which growth can best be encouraged. Since safety is basically about ensuring that things (accidents) do not happen rather than making things happen, creating the environment for safety rather than attempting to create safety directly would seem the more fundamental approach. In a nutshell, we don't say, "here's a problem, we will fix it," rather we say, "here is a problem, we will encourage it to fix itself."

W T Singleton, *Human Aspects of Safety*, Keith Shipton Developments, 1976, p 21.

136/10 UNUSUAL ACCIDENTS No 97

A deplorable accident has taken place at the Grenoble Lycée. The professor of chemistry was lecturing on salts of mercury, and had by his side a glass full of a mercurial solution. In a moment of distraction he emptied it, believing he was drinking a glass of eau sucrée. The unfortunate lecturer died almost immediately.

From *Nature*, 18 March 1880, quoted in *Nature*, 20 March 1980, p 216.

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

June 1980

An Engineer's Casebook No 36
THICK WALLED PRESSURE VESSELS IN HYDROGEN SERVICE

It has been reported that a thick walled hydrogenation desulphurisation reactor exploded whilst leak testing with nitrogen close to the operating pressure of 55-60 bars (780-850 psi) and at ambient temperature. It broke into 35 separate pieces.

The reactor was 89 mm (3½ inches) thick made from C½ Mo steel and clad on the inside with 3 mm ($^{1}/_{8}$ inch) of 12/13% Cr steel. Its operating temperature was 350-400°C with a hydrogen partial pressure of 33 bars (480 psi) and it had been in service for 17 years.

The operating conditions are close to the upper boundary limit for safe operation on the revised Nelson Curves in API 941. At the time of manufacture of the vessel the Nelson Curves showed a more optimistic situation for the area of safe operation of C½Mo in hydrogen service than of now. Even today, after revision, there is still doubt as to the long term resistance of C½Mo steel to hot hydrogen, in particular in very thick sections.

In addition to its poor resistance to high temperature hydrogen attack C½Mo is also prone to cracking during fabrication by a completely different hydrogen mechanism which is often referred to as 'hydrogen induced delayed cold cracking' (or hydrogen cracking for short). These two weaknesses together with its low ductility behaviour under creep conditions have led to the use of CrMo alloys today where C½Mo would have been used in the past.

As a result of these deficiencies cracks can be present in old C½Mo vessels which were not detected during fabrication because of the less powerful NDT techniques in use at that time.

When sub-surface cracks are present hydrogen can accentuate their propagation in service as a result of hydrogen diffusion through the steel and the formation of methane due to direct reaction of the hydrogen with the carbides present. This leads to the generation of high gas pressures within the crack and causes it to propagate. In other cases fine fissures can be formed within the body of the steel as a result of the hydrogen/carbide reaction. These are found at grain boundaries and sub-microscopic discontinuities and result in a general embrittlement of the material. This embrittlement affects the ambient temperature properties of the steel to a greater degree than the properties at the working temperature.

The combination therefore of embrittlement with or without the growth of fabrication defects means that a critical sized defect can eventually form in service notwithstanding the original successful hydrotest which proved that no critical defects were present at the time the vessel was tested.

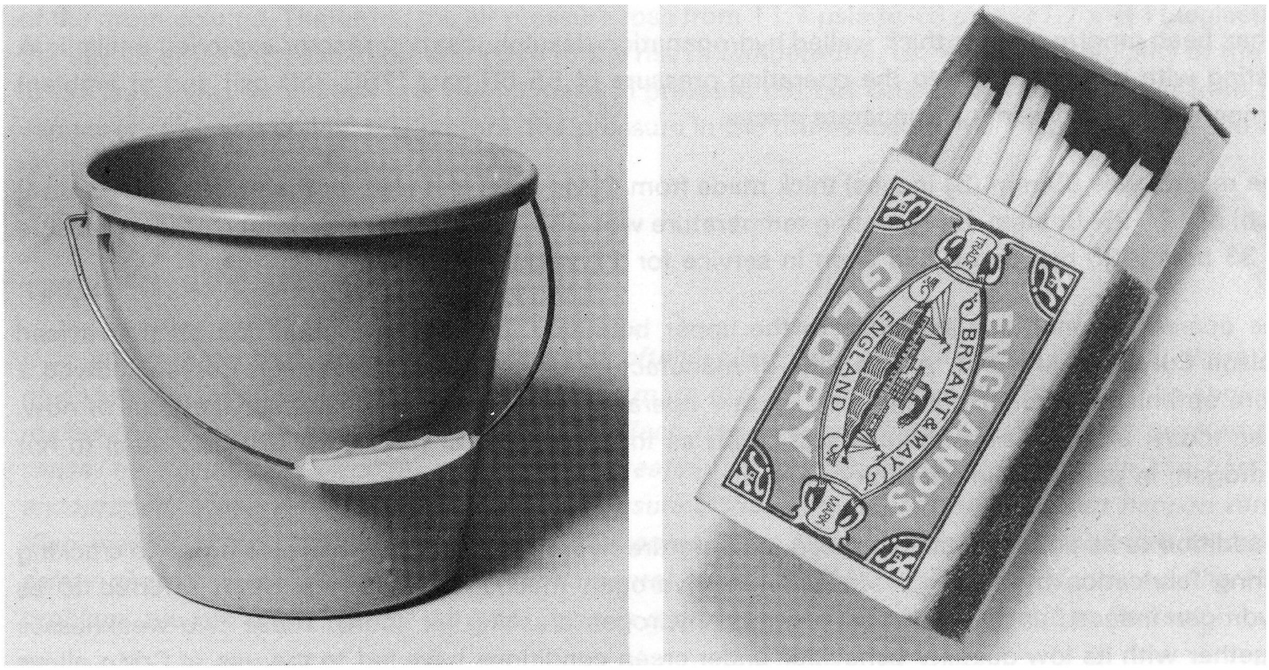
Some vessels are more difficult to inspect than others hence it is just possible that a critical defect may escape detection. The full working pressure applied when the vessel is cold could therefore introduce a risk of brittle fracture in a thick walled C½Mo vessel.

A wise precaution with these vessels, and indeed with all thick walled alloy steel vessels, is to avoid cooling off below about 70/100°C before any substantial degree of pressure (say 50% working pressure), and hence stress, is re-applied. It is unlikely that piping will suffer damage in this way.

Where the application of these precautions may cause any problems metallurgical advice should be sought. Thanks are due to Dr 0 J Dunmore of Teesside Materials Group for help with the preparation of this article.

E H Frank

WHICH OF THESE IS MORE HAZARDOUS — on plants which handle flammable liquids?



The bucket is more hazardous because if flammable liquid is placed in a bucket there is always an explosive mixture above the surface and sooner or later a source of ignition will set it alight.

Matches will ignite a flammable mixture only if they are struck when a flammable mixture is present — and in a well-run organisation flammable mixtures occur very rarely.

I am ***not*** suggesting that we allow matches in the Works. Obviously we must do what we can to get rid of all known sources of ignition. But I do suggest that we take as much care to get rid of buckets and other open containers — used for flammable liquids — as we do to get rid of matches.