IMPERIAL CHEMICAL INDUSTRIES LIMITED
PETROCHEMICALS DIVISION

SAFETY NEWSLETTER No. 53

53/1 DRAINING WATER FROM LPG TANKS

One of the worst incidents in the history of the oil and petrochemical industries was the fire at Feyzin in 1966 which started when water was being drained from a tank of liquefied petroleum gas. Following this incident it was agreed that all tanks from which water is drained regularly for process reasons will be fitted with two isolation valves (for details see ICI Engineering Codes and Regulation, Group D, Volume 1 .6) and that drains which are used only for occasional maintenance purposes will be kept blanked off. A recent survey of one of the Works in the Division disclosed over 100 drain valves on which the blanks had been removed and either not replaced or left dangling loosely on one bolt.

53/2 TRAINING OPERATORS TO ISSUE CLEARANCE CERTIFICATES —THE USE OF SPECIMEN CERTIFICATES

When a large part of a plant was shut down last year, it was no longer necessary for an assistant foreman to be in charge and the senior operators were trained to issue clearance certificates.

The manager gave each of these operators a set of completed specimen clearance certificates. This simple act produced a big increase in competence and confidence. The men are much clearer about what they should do and, therefore, less worried.

In addition, the foreman countersigned each clearance until he was satisfied that the operators were fully proficient.

53/3 HOW DO YOU DETECT LEAKS?

On most of our plants several percent of the raw material that is fed in just disappears. Some of it may disappear through leaks in flanged joints. How do you find out if they are leaking?

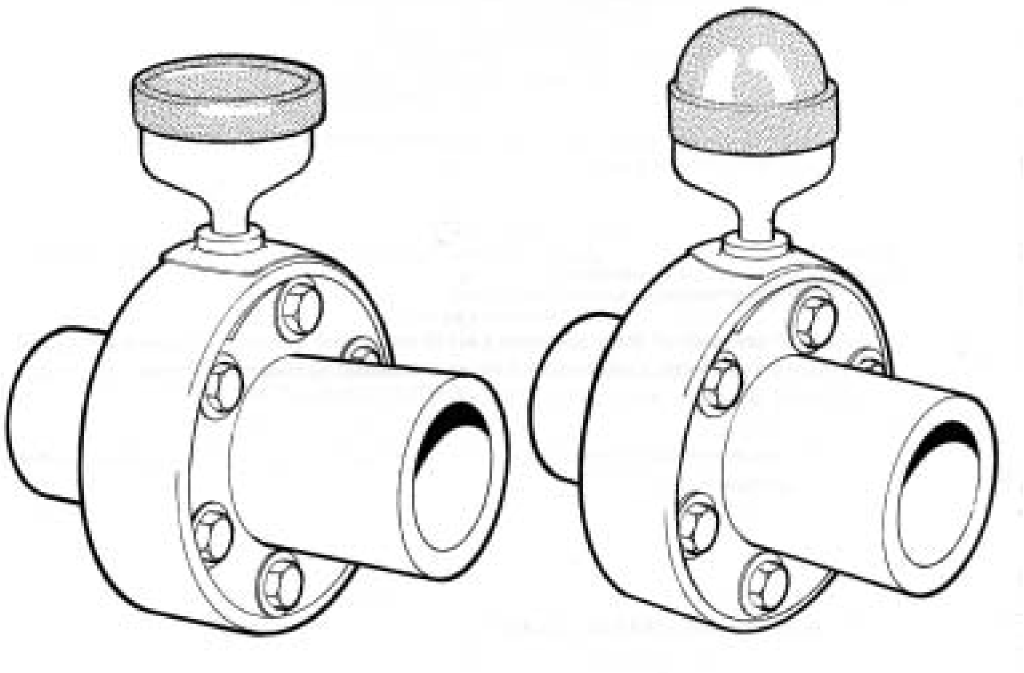
One method is to test the joints with soapy water (or shaving soap from an aerosol container). This is fine on a new plant or after a long shut down but it is difficult to test every joint regularly in this way and impossible to do so if they are hot.

Another method is to wrap sticky tape round the joint, punch a hole in it and test the atmosphere by the hole with a combustible gas detector. Again it is time-consuming to go round every joint; access is needed and if the plant is hot the sticky tape will not stick.

A third method is to wrap sticky tape round the joint and if there is a leak the pressure of the escaping gas will burst the tape. The burst tape may be hard to see unless the access is good and again if the plant is hot the sticky tape will not stick.

Nylon Works, Ardeer have devised a leak detector which overcomes all these disadvantages. A silicone rubber band is strapped round the edge of the joint. A small plastic funnel is fixed into a hole in the band and the top of the funnel is covered with a thin diaphragm. Even a very slight increase in pressure will cause the diaphragm to blow out and the leak can be seen at a glance.

These detectors have been used successfully on a plant operating at 160 ^{o}C. Soap tests showed that it was pressure tight when cold but the leak detectors showed that leaks were occurring when it got hot.

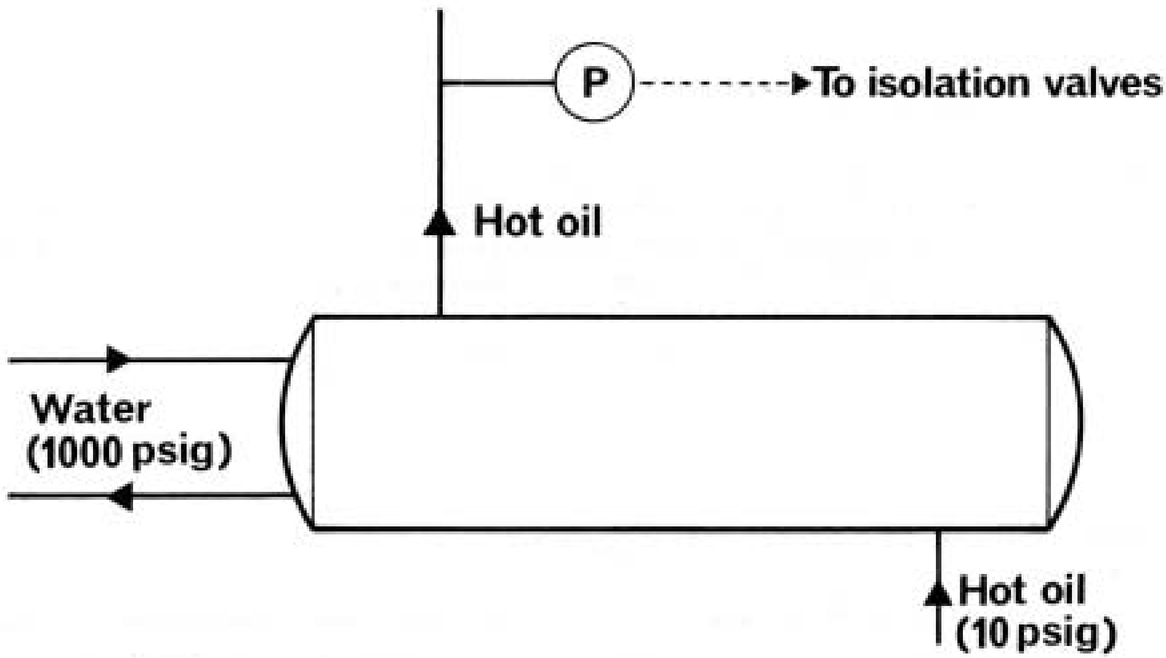


The leak detector, which has been patented, is being marketed by Martindale Protection Limited, Neasden Lane, London NW1O 1RN who can supply a trial pack for £7.60.

In the plant mentioned above, £30,000 worth of raw material disappears every year. This will pay for a few leak detectors.

53/4 NEGLECT OF A TRIP LEADS TO A SERIOUS FIRE

On one of our plants a stream of high pressure water is heated to 300^{o}C by hot oil.



If a tube leaks water will leak into the oil and will very quickly turned into steam, causing a rapid rise of pressure

A pressure switch is, therefore, installed on the oil line and the signal from this switch closes valves in the oil and water lines.

When a tube leaked, this system operated, but the valves closed so slowly that hot oil was blown out of the expansion tank. The oil caught fire, causing serious damage and loss of production.

After the fire it was discovered that:

The setting on the pressure switch had been raised from 75 psig to 140 psig.

The pilot valves had not been lubricated

The trip had not been tested for 6 months

The set point of the pressure switch has now been put back to 75 psig, the pilot valves are lubricated regularly and the trip is tested every week. In addition the expansion tank has been moved to a new position, away from the structure, so that if there is another fire it will not cause so much damage.

In a protective system such as the one described it is necessary to consider the speed with which a pressure rise can be detected following a leak of high pressure water into the oil and the time taken for the valves in the oil and water lines to close. If this time is significant it may be necessary to protect the oil system by a bursting disc discharging to a safe place.

53/5 UNUSUAL ACCIDENTS NO.23

A steam main runs alongside the Billingham factory fence. Some years ago a steam trap on the main discharged on to the ground and the condensate ran through the fence and formed a pool next to a public footpath. The plant engineer was, therefore, asked to divert the condensate to a safe place; he diverted it into the nearest manhole.

A man working nearby complained that when he went to the toilet he got scalded!

53/6 MANCHESTER SHIP CANAL ACCIDENT

"This accident resulted from inadequate supervision of the transfer of petroleum spirit from a shore-based tank to a tanker vessel on the canal. We must draw attention to the tragic circumstances of an accident which might have been avoided. The tanker was over-filled and some 35 tons of petroleum spirit poured over the side into the water. No alarm was given at the time and the spirit spread over a considerable area of the Ship Canal. The fumes from the surface overwhelmed the passengers in a ferry boat and ignition occurred while another boat was attempting to rescue the first. The resultant fire covered a large area of water, including that in which the boats were floating and it resulted in the deaths of 6 people and injury to 3 more. The saddest aspect of this serious accident was that, even after the spillage had occurred, there was an interval of some 2½hours during which warnings could have been given. Such warning may have prevented the fire and should certainly have reduced the number of casualties".

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

For more information on any item in this Newsletter please write to Miss M.N., Organic House, Billingham or ring B.3927. If you do not see this Newsletter regularly and would like your own copy please ask Miss M.N to add your name to the circulation list.

June 1973

SUPPLEMENT TO SAFETY NEWSLETTER No. 53

THE PREVENTION OF FIRES AND EXPLOSIONS ON PLANTS HANDLING FLAMMABLE LIQUIDS AND GASES — A SUMMARY OF THE METHODS RECOMMENDED

This note is concerned only with hardware. Software is equally important but is considered in Report No. 0.21,200/B, “Prevention of Loss Through Fire, Explosion, and other Accidents: The part to be played by Better Training, Auditing, Operating Methods etc. 23.10.70.

This note is not concerned with fire-fighting nor with materials which are toxic or cause chemical burns. It is concerned only with the prevention of fire and explosion, including the bursting of vessels.

Fire and explosion hazards arise from the nature of the materials handled and from the reactions employed. The former are considered first, as they arise on all plants handling flammable liquids and gases. The latter arise only on those plants, a minority, which employ reactions which can run away explosively.

Many fires and explosions have occurred because the recommendations below were not followed.

1 HAZARDS ARISING FROM THE NATURE AND QUANTITIES OF THE MATERIALS HANDLED

The quantities of flammable materials handled in some of the Division’s plants are large and exceed those kept in storage areas a few years ago. For example, a single still can contain 200 tons of volatile hydrocarbons and a refrigeration system can contain 50 tons of propylene.

For a fire or explosion we need air, fuel and a source of ignition. Experience shows that if air and fuel are allowed to mix in flammable concentrations, a source of ignition sooner or later turns up, even though everything possible is done to eliminate known sources of ignition. Air and fuel must not, therefore, be allowed to mix except under closely defined conditions where the risk of fire is accepted, for example, in the vapour spaces of fixed roof tanks containing flammable non-hydrocarbons.

To prevent fires and explosions we must therefore:—

KEEP THE AIR OUTSIDE THE PLANT

and KEEP THE FUEL INSIDE THE PLANT

To keep the air outside the plant the vapour spaces of fixed roof tanks, stacks, centrifuges and any other equipment with free space in which air might enter must be blanketed with inert gas. The inert gas flow should be measured and must be sufficient to ensure a slight positive pressure. The atmosphere should be analysed regularly so that any failure of the blanketing is soon spotted. Many explosions have occurred because these precautions were not taken.

In small tanks (say less than 100 m^3) and in tanks containing non-hydrocarbons, some relaxation of these rules is permitted.

Sometimes air and fuel have to be mixed. See ‘**2**’ below.

To keep the fuel inside the plant we need good engineering design and maintenance. The problems differ for each item of equipment. On many items of equipment, particularly those operating at high pressure, at high or low temperature or subject to strain in some other way, eg by vibration or thermal shock, leaks are liable to occur despite the fact that the designs used are the best available.

When experience shows that leaks are likely during the lifetime of the plant, and especially with materials such as liquefied flammable gases which spread a long way without dispersing, automatic leak detectors should be provided unless the area is continuously manned. Sieger gas detectors are of proved reliability.

When a serious leak is detected, an alarm should be sounded and all those who can do so should leave the area.

Means of isolating the leak from a distance should be provided so that men do not have to enter the vapour cloud. This can be done by remotely operated valves or by hand operated valves located outside the area of the leak. In some cases it may also be necessary to provide a means of blowing down the inventory in the equipment to a safe area. The push buttons controlling remotely operated valves must be located well away from the source of leak.

If a leak cannot be isolated from a distance, and men have to enter or approach close to a cloud of vapour, they should do so under the protection of water sprays.

Deliberate releases of flammable gas or vapour to atmosphere should be flared or should take place under such conditions that the vapour is rapidly dispersed to a safe concentration.

Plants should be designed so that leaks disperse easily. To make the full use of natural ventilation, equipment handling flammable materials should not be installed in closed buildings but in the open air, or in "Dutch barns" with no walls at equipment level and with good ridge ventilation. Portable weather protection can be used during maintenance.

In some cases steam curtains should be installed to confine and disperse leaks. They are needed when the chance of a leak is not remote and calculation shows that it is unlikely to disperse naturally before reaching a source of ignition.

If a closed-in building is essential, for example, because the equipment would deteriorate in an open structure or because the process operations would be affected by weather or dust, then forced ventilation should be used but it must be realised that even on a still day an open-sided building will be far better ventilated.

Despite our precautions, a proportion of leaks will ignite and we should, therefore:—

(a) Divide plants into units separated by at least 50 feet so that the capital at risk is limited and so that there is access for fire-fighting appliances. This distance should be increased to 75 feet if the plant structure is tall (say over 50 feet).

(b) Fire-proof vessels and load-bearing structures to a height of 30 feet.

(c) Slope the ground so that spillages of liquid do not accumulate and burn under the plant but run off to one side.

(d) When there is a danger of explosion the use of bricks and other materials which readily become missiles should be avoided.

(e) Make some walls of very light construction so that they will collapse if the internal pressure rises. This will prevent serious damage to the occupants and contents by blast though they may still be damaged by fire.

Not all these measures can be applied to existing plants — the layout cannot be changed nor the slope of the ground altered. But gas detectors can be installed, extra isolation valves fitted, wails knocked down, fire-proofing added and steam curtains installed.

2 HAZARDS ARISING FROM THE NATURE OF THE REACTIONS EMPLOYED

The reactions used in some of the Division's processes are liable to run away explosively if the concentration of the reactants, the temperature or some other variable goes outside certain limits. Oxidation processes are of this type. In addition, certain substances explode spontaneously if they get too hot or become contaminated.

Normal supervision and automatic control are not always sufficient to reduce the chance of this happening to an acceptable level. The hazard rate — the rate at which dangerous conditions arise — must be calculated and protective equipment — alarms and trips — designed to reduce the hazard rate to an acceptable level.

Blast walls should not be used in place of protective equipment except for Research Plants.

Air and fuel have to be deliberately mixed in the combustion chambers of furnaces. The precautions should be taken to avoid explosions are described in Ref. (e).

3 THE PROTECTION OF PLANT AGAINST OVER- AND UNDER-PRESSURE

All vessels which might be subjected to a pressure above (or below) that which they can safely withstand must be fitted with relief devices. The details of the devices must be registered and they must be inspected regularly. Their size must not be altered unless calculation shows that the new size is adequate. If any changes are made to the plant or to operating conditions, the size of the relief device may have to be increased.

These rules apply to the simplest form of relief device.- a hole or open vent pipe. If the vessel is liable to contain a flammable mixture then any vent must be fitted with a flame trap, preferably one that can be removed for cleaning without the use of tools.

Any equipment which effects the size of relief device required, for example, certain restriction plates, certain non-return valves and certain control valve trims, must be included in the relief valve register and inspection routine.

It should be impossible to isolate a relief device from the equipment it protects. If it is necessary to change a relief valve or bursting disc with the equipment on line, then twin relief devices with interlocks should be used. The isolation of line relief valves is, however, permitted if the line contains non-hazardous materials.

Relief valve calculations should be checked on all contractor designed plants.

Precautions should be taken to prevent the addition of hot oil (over 100°C) to vessels containing water (or water to vessels containing hot oil). Many vessels have been burst in this way.

Vessels may be burst by high temperature as well as by high pressures. Vessels which can get too hot, for example, electric heaters, should be protected by trips.

If a vessel is exposed to fire it should be kept cool by water sprays and the internal pressure should be reduced. If the metal gets too hot the vessel may burst even though the pressure is below the setting of the relief valve.

4 SOURCES OF IGNITION

As already stated, the design of plants handling flammable liquids and gases should be based on the assumption that mixtures of air and fuel will ignite even though everything possible is done to exclude sources of ignition. Nevertheless, action should be taken to eliminate sources of ignition so far as is possible, and to control their use rigidly when complete elimination is impossible. The obvious sources of ignition such as smoking and welding, need not be discussed here. The following notes refer to some of the less obvious causes.

(a) Electrical Equipment

If electrical equipment is of the right type and properly maintained, it presents no hazard. However,

considerable effort is needed to maintain electrical equipment in sound condition.

(b) Diesel Engines

Diesel engines, unlike petrol engines, are widely regarded as safe and in many plants are admitted quite freely; where permits are needed their issue has often become a mere formality.

Several incidents have shown that diesel engines can readily ignite flammable mixtures. Though the risk can be reduced, it cannot be eliminated and much more stringent precautions to control the entry of vehicles to plant areas are needed. A Code of Practice is available.

(c) Static Electricity

It is well established that static electricity generated by the flow of liquids or the emission of gas jets containing solid or liquid droplets can ignite flammable mixtures.

Though the risk of ignition by the discharge of static electricity generated by the flow of hydrocarbon liquids can be reduced by control of pumping rates, prohibition of splash filling and other measures, storage tanks containing flammable hydrocarbons should still be blanketed with inert gas.

The risk of ignition of escaping gas jets can be reduced by earthing all metal equipment but this will not eliminate the risk completely. Gas jets have ignited when there was no unearthed equipment nearby.

5 REFERENCES

For more information see:—

(a) Loss Prevention Guides, especially the following:—

Guide No.	Title	Guide No.	Title
1	Pressure Relief	12	Electrical Area Classification
3	Furnace Fires & Explosions	13	Flame Traps
5	Storage Tanks	17	Flexes and Hoses
6	Static Electricity	18	Gas Detectors
8	Liquefied Flammable Gases — Safety in Plant Design and operation	19	Leaks
10	Ignition Sources & Explosive Mixtures	22	Explosion Venting
		25	Plant Layout
11	Aluminium and Light Metals — Incendive Sparks		

(b) "Safety in Plants Handling Liquefied Hydrocarbons", Report No. 0.21,186/B, H G Simpson, 22.12.70.

(c) "Liquefied Flammable Gases, Storage and Handling", ICI Engineering Codes and Regulations, Group D, Volume 1.6.

(d) "Safety Aspects of Plant Layout - Review of Work Carried Out 1966-7 1 ", Report No. 0.21,388/B, H G Simpson, 18.5.72.

(e) "A Review of Explosions on Chemical Plant Furnaces and some Notes on their Design and Operation", Report No. 0.200,655/A, TA Kletz, 21.4.70.

(f) "An Anthology of Furnace Tube Failures and some Notes on Ways of Preventing them or Minimising their Consequences", Safety Note 72/28, T A Kletz, 29.12.72.