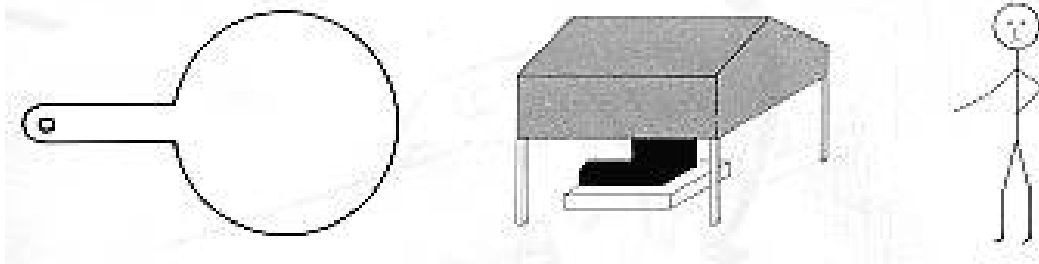


GATEWAY TO NEW SAFETY THEMES

No. 120

THE SYMBOL OF THE YEAR



The Chinese have a symbol for each year, for example, 1978 was the Year of the Horse.

Looking back over the past decade we see that each year one subject or theme has dominated our safety discussions, formal and informal, Newsletters and other publications, or at least played a large part in them. The theme was often the result of a serious incident.

In this Newsletter we summarise these annual themes and by doing so provide a summary of the main lessons of the last 11 years.

Copies of the papers which give more information are available on request.

If you do not see this Newsletter regularly and would like your own copy, please ask Mrs ET (Ext. P.2845) to add your name to the circulation list.

TREVOR A KLETZ

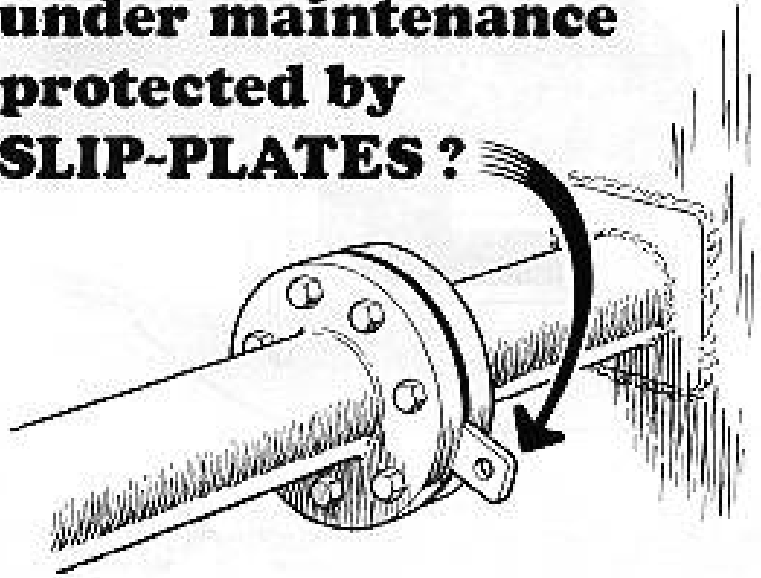
Division Safety Adviser

February 1979



IMPERIAL CHEMICAL INDUSTRIES LIMITED
PETROCHEMICALS DIVISION

Is equipment under maintenance protected by SLIP-PLATES ?



In 1967 a large pump was being dismantled for repair. When a fitter removed a cover, hot oil, above its auto-ignition temperature, came out and caught fire as the suction valve was open. No slip-plates had been fitted as it was not custom and practice to fit them.

Following the fire, instructions were issued that before any equipment is given to maintenance:-

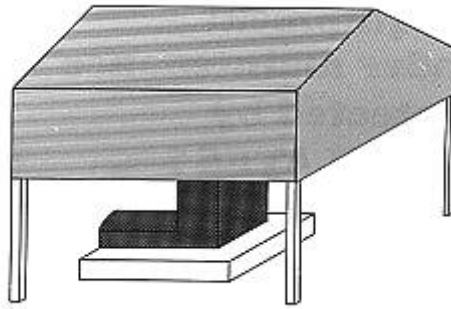
- 1 The equipment must be isolated by slip-plates or physical disconnection unless the job to be done is so quick that fitting slip-plates (or physical disconnection) would take as long and be as hazardous as the main job.
- 2 Valves used to isolate equipment for maintenance, including isolation for slip-plateing or physical disconnection, must be locked shut with a padlock and chain.
- 3 When there is a change of intent, for example, if it is decided to dismantle a pump and not just work on the bearings, the clearance certificate must be handed back and a new one taken out.
- 4 All plant managers and engineers must carry out random inspections of clearance certificates and report their findings to the Works Manager every month.

For more information see:- Safety Newsletter No 93.

“What are the Causes of Change and Innovation in Safety”, Proceedings of the Second International Symposium on Loss Prevention and Safety Promotion in the Process Industries, Dechema, 1977, p 1.

Accidents Illustrated No 1 (grey cover).

1969 THE YEAR OF THE BUILDING WITHOUT WALLS



In January 1969 a leak of ethylene gas occurred from a high pressure pipe joint in the ground floor area underneath a compressor house. The ventilation in the area was poor. The leak ignited after a few minutes. The cause of ignition was never established with certainty, but might have been faulty electrical equipment. The resulting explosion killed four men and caused serious damage; half the building had to be completely re-built.

The following recommendations were made for future plants:-

- 1 Locate compressors in an open-sided building so that small leaks can be dispersed by natural ventilation.
- 2 Install gas detectors so that leaks are detected without delay.
- 3 Install remotely operated valves so that leaking compressors can be isolated and blown down from a safe distance.
- 4 Surround the compressors and associated equipment by a water or steam curtain so that the vapour from leaks cannot reach a source of ignition.

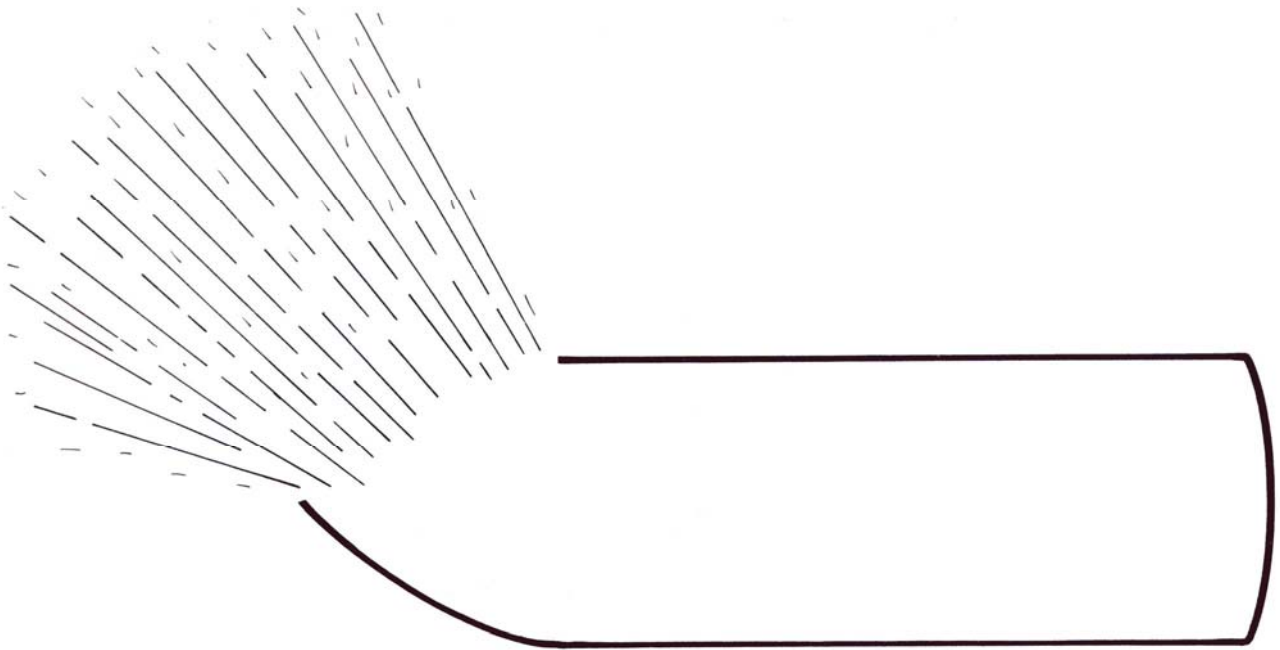
Particular attention was paid to the improvement of ventilation on existing plants and the walls of many older compressor houses were knocked down.

For more information see:-

Safety Newsletter No 93

Accidents Illustrated No 2 (pale blue cover)

1970 THE YEAR OF THE BURST TANK



In 1968 the end of a tank was blown off, killing two men who were working nearby. The tank was used for storing, as liquid, a product which melts at 100°C. It was therefore heated with a 100 psig steam coil.

The line into the tank was being blown with compressed air to prove that it was clear — the usual procedure before filling the tank. The vent on the tank — an open hole 3 inches in diameter — was choked and the air pressure (80 psig) was sufficient to burst the tank (design pressure 5 psig).

The vent hole was not heated. It was known that the vent was liable to choke, but this was looked upon as an inconvenience rather than a danger. Many of those concerned did not realise that the air pressure was sufficient to burst the tank.

The tank had originally been fitted with a 6 inch vent but at some time this had been replaced by a 3 inch hole. The change had been made without realising that an open vent is a relief valve and must be treated like a relief valve: checked regularly and not altered without authorisation by an engineer.

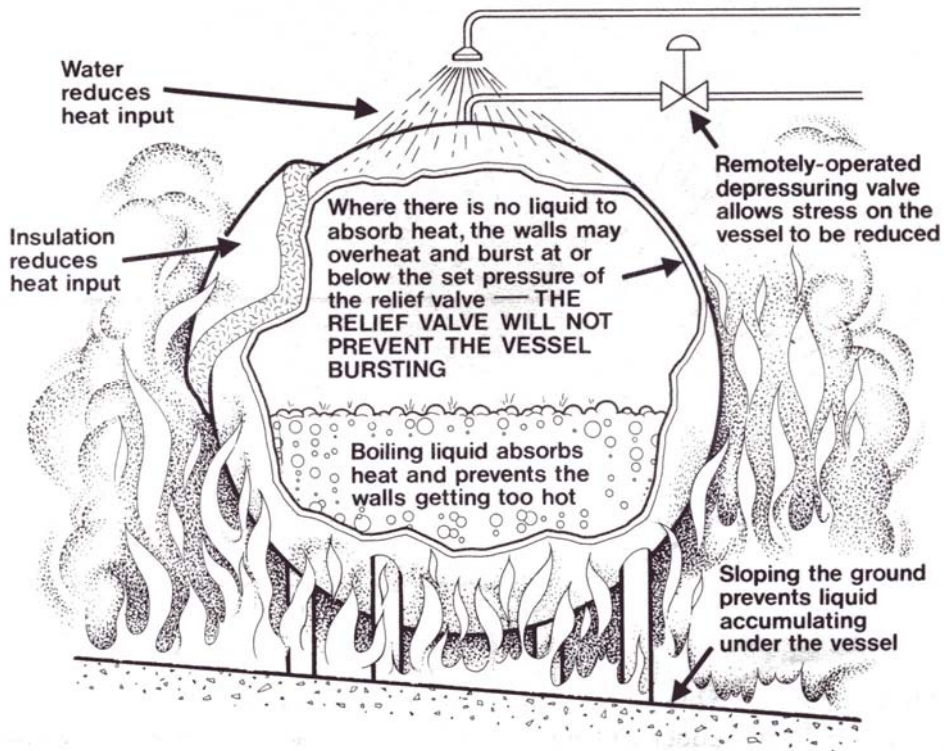
For more information see:-

Safety Newsletter No 93

Accidents Illustrated No 3 (red cover).

Hazard Workshop Notes and Slides No 1, available from the Institution of Chemical Engineers, 165/171 Railway Terrace, Rugby CV2 1 3HQ.

How to protect pressure vessels from fire



In 1966 at Feyzin, France, a leak occurred from a 2000 m³ storage vessel containing propane at 8 bar. The leak ignited and a fierce fire burned underneath the sphere. The fire brigade were advised to use the available water for cooling neighbouring vessels. They were told that the relief valve would protect the vessel which was on fire and, as if to support this view, the relief valve soon lifted.

1½ hours after the start of the fire the vessel burst and burning propane wiped out the firefighters. The fire then spread unchecked. Incidents like this are called BLEVES (Boiling Liquid Expanding Vapour Explosions).

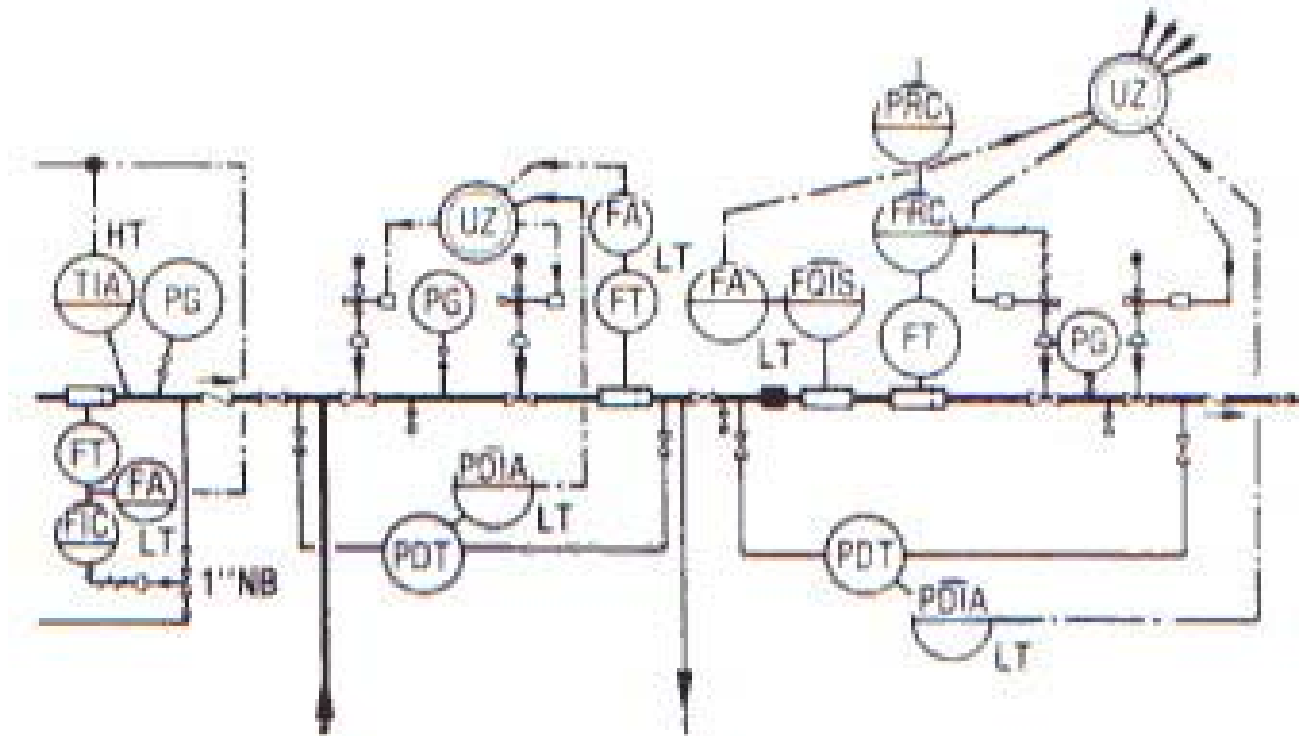
The vessel burst because the unwetted upper portion was heated to a temperature at which the steel lost most of its strength and could not withstand the design pressure. There was nothing wrong with the relief valve.

For more information see:-

Hydrocarbon Processing, Vol 56, No 8, August 1977, p 98.

Accidents Illustrated No 4 (dark blue cover).

1972 THE YEAR OF THE TRIP



Over the years plants have become increasingly dependent on trips and alarms for their safety. In 1972 our safety training emphasised the need for regular testing and drew attention to incidents which have occurred because trips were disarmed without authority, or not tested or were inadequate for the job.

The principle recommendations were:-

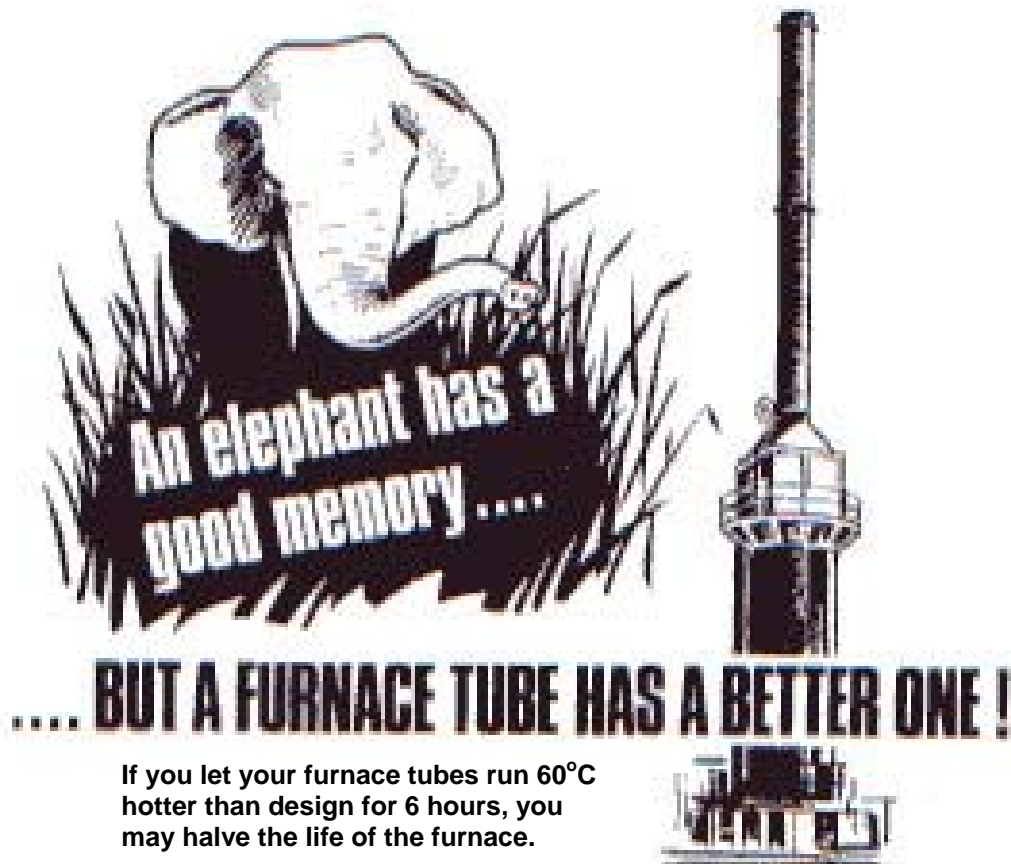
- 1 Trips should be tested regularly.
- 2 Alterations to trip settings should be authorised in writing. Trip settings should be clearly displayed.
- 3 Disarming of trips should be authorised in writing and clearly signalled, for example by a flashing light.
- 4 We should not allow trips to be disarmed when an operator's failure to act can have disastrous effects.

For more information see:-

Accidents Illustrated No 6.

"What are the Causes of Change and Innovation in Safety?", Proceedings of the Second International Symposium on Loss Prevention and Safety Promotion in the Process Industries, Dechema, 1977, p 1.

1973 THE YEAR OF THE FURNACE



In 1972 a tube burst occurred in a furnace, causing considerable damage. The investigation showed that many people did not fully understand the principles of furnace operation and, in particular, that overheating furnace tubes will shorten their lives. The main recommendations were:-

- 1 Operators, supervisors and managers need to know more about furnace design and operation.
- 2 Furnaces are key items of equipment operating close to failure conditions. Several times the design pressure is needed to burst a pressure vessel but a few percent increase in absolute temperature will burst a furnace tube. The design and operation of furnaces therefore needs as much professionalism as other key items such as compressors.

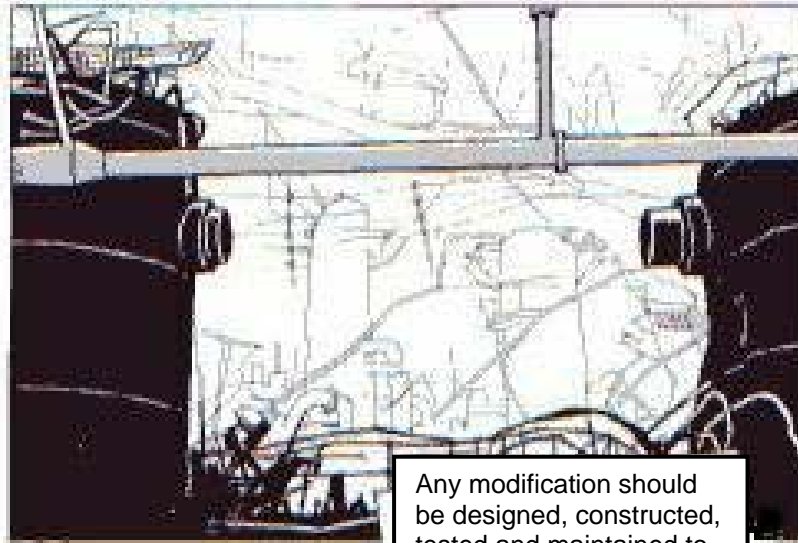
For more information see:-

Accidents Illustrated No 7.

Safety Note 72/28, "An Anthology of Furnace Tube Failures and Some Notes on Ways of Preventing Them or Minimising Their Consequences", 1972.

Report No 0.200,655/A, "A Review of Explosions on Chemical Plant Furnaces and Some Notes on Their Design and Operation", 1970.

1974 THE YEAR OF FLIXBOROUGH



Any modification should be designed, constructed, tested and maintained to the same standards as the original plant.

From the official report on the explosion at Flixborough on June 1st 1974

Although the explosion did not occur until half-way through 1974, it so dominated the rest of the year that it became the Year of Flixborough. The after-effects of the explosion are still being felt but the immediate lessons drawn, apart from the need to check modifications, were:-

- 1 All managers, including the most senior, need to spend some time walking round the plant on the lookout for anything unusual or abnormal.
- 2 Companies should ask themselves if they have enough staff of the right professional qualifications and with relevant experience.
- 3 Plants should be laid out to avoid domino effects.
- 4 On new plants, occupied buildings close to hazardous plants should be strengthened.

For more information see:-

“The Flixborough Cyclohexane Disaster”, Loss Prevention, Vol 9, 1975, p 106.

ICI means

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Changed

It

Before you modify the plant check that:

The right materials are used.

**The size of relief valve required
is not changed.**

The area classification is not affected.

**The correct engineering standards are
followed.**

There are no other effects on safety



As the dust of Flixborough settled it became clear that modifications of all sorts had to be controlled much more closely than in the past. Other incidents brought home the same message. In addition to the points listed above it became clear that we need a 3-pronged approach:-

- 1 We need a system for ensuring that modifications are critically examined before authorisation at managerial level, are recorded on the line diagram of the plant and inspected on completion.
- 2 We need a guide sheet or check list to help us examine modifications.
- 3 We need a training programme to persuade people that control of modifications is necessary, or after a while the system will lapse. We need to convince people that the modification control system should be treated with the same respect as the clearance system.

For more information see-

Safety Newsletter No. 83 (reprinted, with slight modifications in Chemical Engineering Progress, Vol 2, No 11, Nov 1976, p48).

Hazard Workshop Notes and Slides No 2, available from the Institution of Chemical Engineers, 165/171 Railway Terrace, Rugby CV21 3HQ.

1976 THE YEAR OF THE SUM

If you...



...the risk to life is the same.

Since 1968 we had pioneered the application of numerical methods to safety problems and had published many papers and reports saying *why* we thought this was necessary: We cannot do everything possible to prevent every conceivable accident and therefore we need a rational method for deciding which risks should be dealt with first, which can be left, at least for the time being. By 1976 people were saying, "Don't tell us why, tell us *how*" and we devoted much of our safety training to this subject.

For more information see-

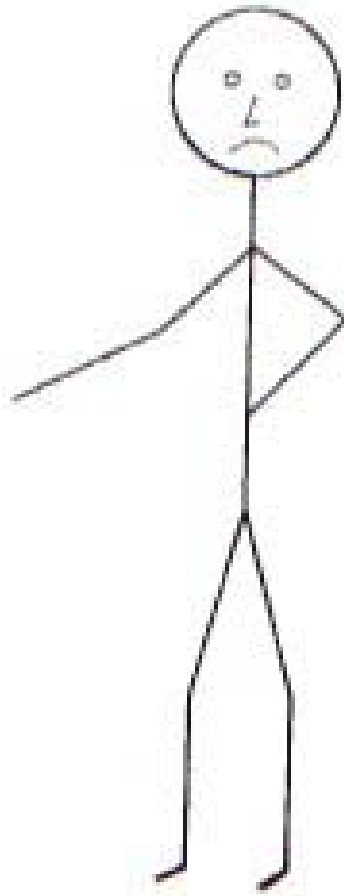
"What Risks Should We Run", *New Scientist*, Vol 74, No 1051, May 1977, p 320.

"Evaluate Risks in Plant Design", *Hydrocarbon Processing*, Vol 56, No 5, May 1977, p 297.

"Practical Applications of Hazard Analysis", *Chemical Engineering Progress*, Vol 74, No 10, October 1979, p47.

Safety Note 77/12, "An Introduction to Hazard Analysis", 1977.

1977 THE YEAR OF THE MAN IN THE MIDDLE



During 1977 we discussed a number of accidents which occurred because someone forgot to close a valve or pressed the wrong button. We came to realise that well-trained, well-motivated men, physically and mentally capable, make occasional mistakes and that this will not be prevented by telling them to be more careful. We should therefore:-

Estimate the likely error rate

and then either

Accept the occasional mistake

or

Modify the work situation, that is, change the design of the plant or the method of working.

For more information see:-

Safety Note 74/7A, "Human Error— Some Estimates of its Frequency", 1975, Safety Newsletters 86 and 109.



Is this at the frontiers of technology or is it a dinosaur?

Many of our plants contain large inventories of hazardous materials. We try to keep these under control by *adding on* a lot of protective equipment: trips and alarms, relief valves and flare systems, gas detectors, emergency isolation valves and so on. It would be better, if we could, to devise processes that use safer raw materials and intermediates, or not so much of the hazardous ones, or use the hazardous ones at lower temperatures and pressures.

During 1978 we tried to draw attention to some ways in which this has been done or might be done, for example, the use of tubular or vapour phase reactors instead of pot reactors, the use of water instead of boiling oil as a heat transfer medium.

For more information see:-

Safety Newsletter No 95/1.

“What You Don’t Have, Can’t Leak”, Chemistry and Industry, 6 May 1978, p 187.

1979 THE YEAR OF THE



What is the symbol for 1979? We do not know. The themes for each year were not planned in advance but grew out of our needs. Hazzarding a guess, during 1979 we may perhaps be reminding ourselves that:-

- 1 We should look for simpler solutions to our problems, altering designs instead of adding something on. See Safety Newsletter 117/1 and Safety Note 78/8 (reprinted in "The Chemical Engineer", March 1979).
- 2 It is ten years since the last major fire, causing loss of life, occurred in the Division. After this period of time memories often fade and mistakes are repeated. Will we forget the lessons of the past? See Safety Newsletter No 93.
- 3 Our plants often cost more than those of our competitors? We could build plants as cheap as theirs, but we must not forget that we would then have their loss record.

An Engineer's Casebook No 20

SHAKEDOWN

From time to time new words may come into regular use to describe things which, whilst known about, may not have been specifically labelled. Shakedown is such a case.

A fabricated structure, for example a pressure vessel, will after fabrication have locked into it various stresses. These arise from plate forming, pressing, local dogging to get plates into alignment prior to welding, burning or otherwise cutting holes in the shell, weld contraction effects etc. Some of these may be partially removed by a stress relief heat treatment which can be applied to particularly critical parts or to the whole vessel. Even with fully stress relieved vessels some residual stress will remain and this may be significant if the vessel has undergone a proof hydraulic test after heat treatment.

When the vessel enters service and is loaded by the operating conditions of pressure, temperature, weight of contents, piping reactions etc., the level of stress at any point will be determined by the combination of the applied loads and moments. The level of stress will not be uniform throughout the structure even though the designer may have tried his best to ensure this. The stress will be concentrated or intensified in local areas, typically in the back of flanges, in the vicinity of openings, at changes of section, in way of supports, attachments and over saddles etc., and by residual effects mentioned above.

On the first application of the maximum loading at any place in the stressed structure, which might be during the initial hydrotest or, in the case of vessels operating at temperature is often at plant start-up, the level of stress can be so high that the material in a limited local area yields and behaves plastically. Plastic deformation causes a change in shape with consequent re-distribution and diminution of the level of stress. If when the loadings are removed and subsequently reapplied to a level not higher than the original loading the behaviour of the material is totally elastic, then the vessel is said to have shaken down.

Repeated application of an ever increasing load or excessive cycling close to the boundary between elastic and plastic behaviour can result in premature failure. When using any of the higher design stress Codes such as BS 5500 or ASME VIII Div. 2, the formula therein allows the calculation of the stress level at all significant points. It is recognised that 'shakedown' has a part to play in the redistribution of stress in local areas of high stress. BS 5500, Appendix 6, Clause 2.6 gives a method for radial nozzles in spherical shells whereby the shakedown factor for internal pressure loading, for radial thrust and external moment, may be calculated.

A proof hydrostatic test will result in a certain amount of shakedown and can be positively beneficial. Repeated application, in doubtful cases, which results in yielding and plastic deformation can result in incremental collapse or fracture under test.

E H Frank