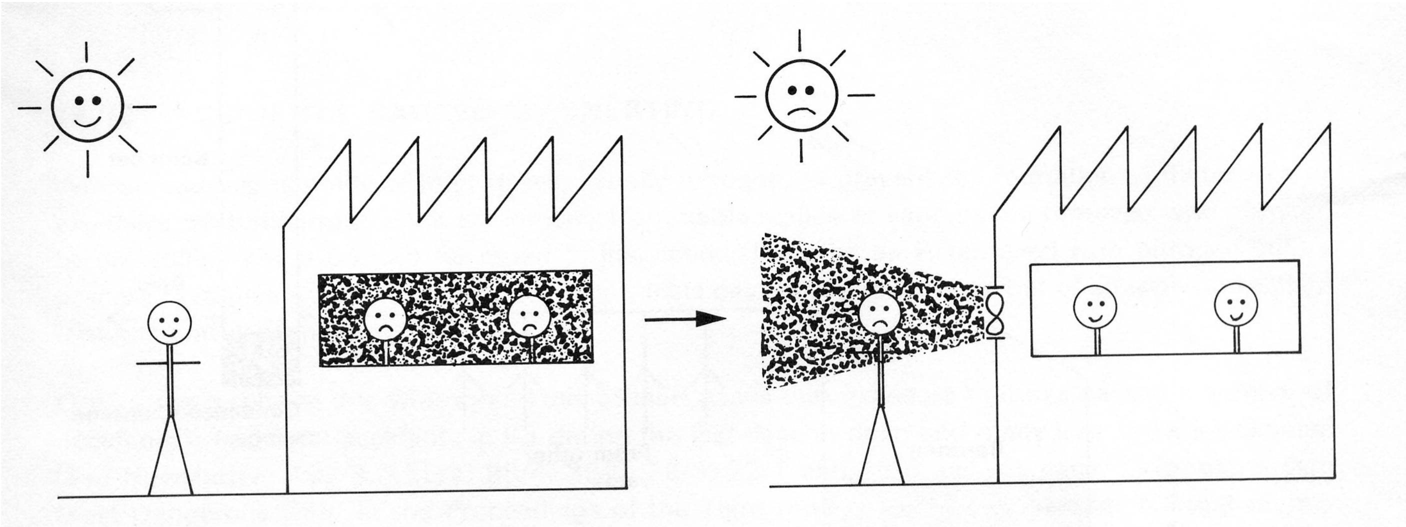
SAFETY NEWSLETTER

No. 147
EXCHANGING ONE PROBLEM FOR ANOTHER



There is an old story about a Factory Inspector who complained about the dust in a factory. The manager installed equipment to collect the dust and blow it outside. The Alkali Inspector then complained about the pollution.

As this story shows, when we solve one problem, we often acquire another. Sometimes the second problem is so serious that we should look for a different solution to the first problem; sometimes we should look for ways of solving the second problem. Often we fail to foresee the second problem and then accidents occur.

This Newsletter contains examples of problems that have been solved only by acquiring other problems.

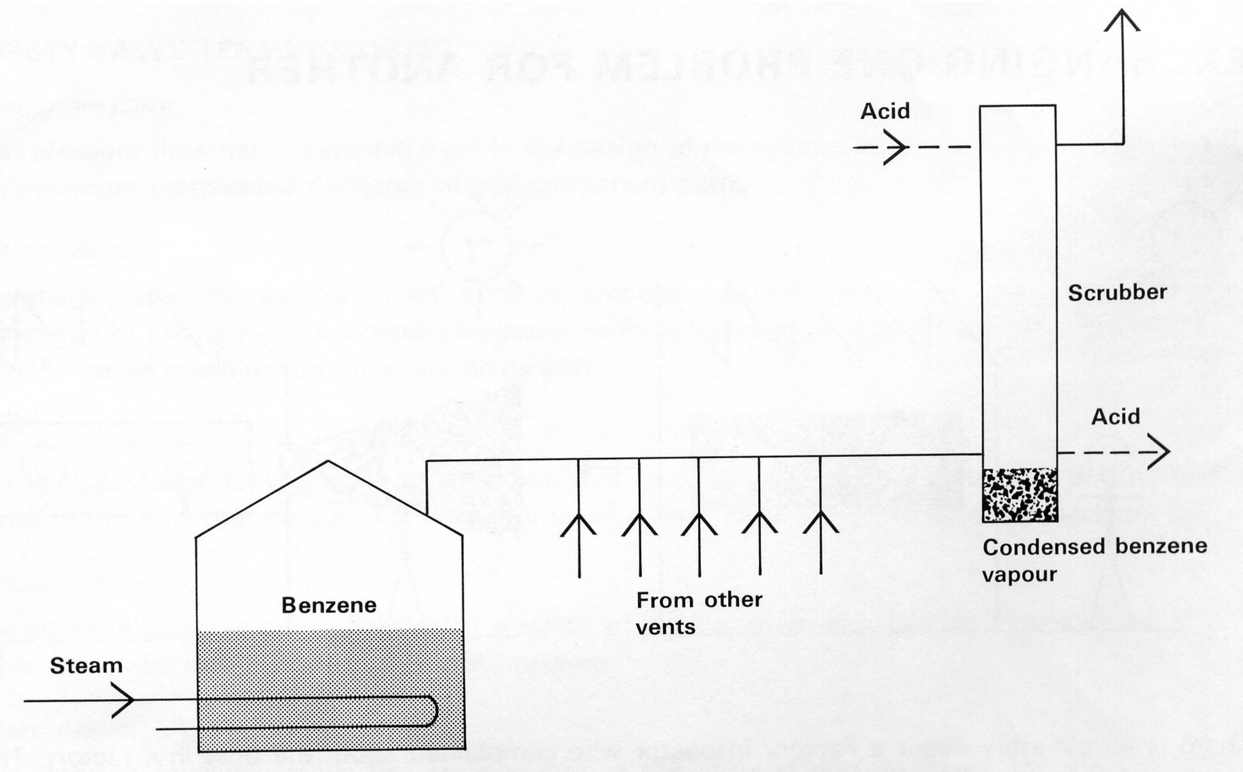
An Engineer's Casebook — Electrically operated cranes.

IMPERIAL CHEMICAL INDUSTRIES LIMITED
PETROCHEMICALS DIVISION

147/1 TRYING TO STOP POLLUTION CAUSED AN EXPLOSION

A European Company has described an incident which shows how, in trying to stop pollution by collecting vapour, we can easily produce a more serious hazard.

A plant was fitted, at the insistence of the environmental authorities, with a scrubber to prevent traces of benzene being discharged to the atmosphere. The vent gas was scrubbed with acid which removes the benzene.



As the benzene freezes at 5 ºC the benzene storage tank was heated by steam. There was no automatic temperature control and the tank got too hot. While the plant was shut down and the scrubber was out of action benzene vapour condensed in various parts of the scrubbing system. When acid circulation was started, the acid reacted vigorously with the pools of benzene and the scrubber was completely destroyed. The largest parts left were about 1 foot square!

The answer is not, of course, to ignore pollution but to examine pollution control equipment thoroughly for possible hazards. We must not design and install it too hurriedly and we must be prepared to add on a number of safety features such as trips and alarms.

A number of explosions have occurred in off-gas scrubbing systems because the mixture of vapour and air entered the explosive range.

147/2 OTHER ACCIDENTS CAUSED BY TRYING TO PREVENT POLLUTION

In one part of the US the Environmental Protection Agency insisted that the fumes emitted when the petrol tank of a car is filled should be collected. The mixture of petrol vapour and air, often in the explosive range, is collected by a fan and blown into a recovery system. Twenty fires occurred in four months (W H Doyle, *Loss Prevention*, Vol 10, p 79). Sources of ignition were usually unknown.

Concern about the possible long-term affects of fluorinated hydrocarbons on the ozone layer of the atmosphere has caused some aerosol can packers to switch to hydrocarbon propellants. This has caused at least one serious explosion because the packing companies were not familiar with the precautions required with hydrocarbons (E Naidus, *Loss Prevention*, Vol 10, p 79).

Reducing the amount of air used in a furnace to reduce formation of oxides of nitrogen can result in fuel-rich mixtures and a consequent risk of explosion when the unburnt gas is mixed with air (F Bodurtha, *Loss Prevention*, Vol 10, p 88).

Bag filters and precipitators, installed to avoid discharge of dust to atmosphere, have produced dust explosions (F Bodurtha, *Loss Prevention*, Vol 10, p 88).

An air blower was installed to suck foul gases from a pit containing sulphurous residues. The blower also provided some of the combustion air for a furnace, thus disposing of the foul gases and saving a little fuel. An upset on another plant resulted in the release of LPG from a lute. The vapours were sucked into the blower, which blew up. (A report from another Company).

147/3 ACCIDENTS CAUSED BY INERTING

Widespread use is made of inert gases, usually nitrogen, to prevent the formation of flammable or explosive mixtures inside plant equipment. Flammable liquids or vapours are removed with nitrogen before equipment is opened for repair or inspection; later the air is removed with nitrogen before process materials are put back into the plant; inert gas is used to keep air out of storage tanks, flare systems and centrifuges.

One of the results of this widespread use of inert gas is that exposure to it has caused a number of accidents — four fatal accidents in ICI during the last decade or so and many less serious incidents. (See Newsletters 137/3, 125/1, 88/4, 28/5, 25/3, 22/1 and 18/6 and my paper “Nitrogen — Our Most Dangerous Gas” in the Proceedings of the Third International Loss Prevention Symposium). These were due, in part, to a failure to realise the hazards — the phrase “inert gas” suggests a harmless material.

No doubt many more people would have been killed — in different ways — if inert gas had not been used. Nevertheless, in attacking the problem of fires and explosions did we give enough thought to the problems introduced by the remedy — the side-effects of the cure?

In crude oil tanks or tankers which are not blanketed with inert gas iron sulphide is slowly oxidised by air without much heat being liberated. If blanketing is used, then, when air is admitted because of inert gas failure or because the tank is emptied for maintenance, the iron sulphide is oxidised quickly, gets hot and may ignite any residual hydrocarbon or even make the metal too hot. (From *Loss Prevention Bulletin* No 012, published by the Institution of Chemical Engineers).

147/4 ACCIDENTS CAUSED BY MODIFYING PLANT TO SAVE ENERGY

A number of hazards which have been, or might be, introduced in this way are:

(i) Air preheaters for furnaces involve complex control systems which may not work rapidly enough to avoid the formation of rich mixtures, especially when the equipment is no longer new.

(ii) The burning of waste streams to save fuel (and avoid pollution) has produced serious corrosion and tube failure.

(iii) Shortening of pipe-runs to avoid heat losses has resulted in congested plants; if a fire occurs the damage is increased. Stacking of equipment above pipe-runs or other equipment is particularly short-sighted.

(iv) The demand for cheap and efficient insulation has resulted in widespread use of flammable polyurethane. This should be covered with a layer of fire-resistant material such as vermiculite-concrete or steel.

While we want to save fuel bit-by-bit and day-by-day, this is of no value if we waste the saving in one big display of fireworks. (H S Robinson, *Energy Conservation, Equipment Designs and Systems — Are there any Dangers?*, API 1976 Mid-year Meeting, Reprint No 22-27).

147/5 ACCIDENTS CAUSED BY PLANT MODIFICATIONS

We often exchange one problem for another when making modifications to existing plants. See Newsletters 145/2 & 5, 144/6, 142/5, 139/2, 135/5, 131/1, 127/3 & 5, 126/12, 118/2, 111, 100/2, 99/1, 97/6, 83, 71/7, 67/7d and 63/7.

For example, as described in Newsletter 83, many years ago a liquid ethylene tank was fitted with a relief valve which discharged to a low stack. At a late stage in design it was realised that on a still day cold vapour from the stack would fall to ground level where it might be ignited. To solve this problem steam was injected into the stack. Unfortunately the condensate from the steam ran down the stack, met the cold gas and froze. The 8 inches diameter stack became blocked, the tank was overpressured and split. Fortunately the split was only small and the escaping ethylene did not ignite.

146/6 HOW CAN WE AVOID CREATING A NEW PROBLEM WHEN WE SOLVE AN OLD ONE?

There is no magic or easy remedy. All we can do is to search diligently for possible problems. Often this is not easy. When we have a problem and think of a solution, we are so relieved that one has been found that a “mental block” makes it hard to see the snags. Operability studies may help when the change is a big one. For smaller changes the methods developed for the control of modifications such as the Guide Sheet shown in Newsletter 83 may help. In many cases it would help if someone else has a look at the subject — perhaps an expert, perhaps just someone to whom the problem is new.

What do we do when we have found the snags in our solution?. Sometimes they are so serious that we should think of another solution. On other occasions we should accept our solution, but control the side-effects in some way.

147/7 A LOOK BACK AT NEWSLETTER 47 (December 1972)

Works Instructions

I have received from one of the Works in the Division a revised safety instruction on the precautions to be taken and the procedure to be followed before men are allowed to enter a confined space, or before welding is allowed in areas where flammable gas or vapour may be present.

The instruction runs to 23 pages plus 33 pages of appendices, 56 pages in all. It is easy to say this is too long but there are many special circumstances which have to be covered and most Works have similar instructions, though not perhaps quite so long.

How do we make sure that supervisors and other people concerned really read and understand these instructions? People are human and many people on receiving a 56 page report will put it aside to read when they have time. On the Works concerned the new instructions were discussed in draft with groups of supervisors and the changes pointed out. This is time-consuming both for the supervisors and the managers but it is the only way in which we can make sure that the supervisors really understand the changes which are being made and the managers can find out whether or not it is possible for the new instructions to be operated as intended.

Before you issue a new instruction or make important alterations to an old one do you discuss it in the same way with the people who have to carry it out? It is easy to send out lots of paper but most people absorb new information better through discussion.

Before we issue an instruction we could ask ourselves, "Have we written this instruction and put it out to help the people concerned or have we done it to protect ourselves?"

Thickness measurements on distillation columns

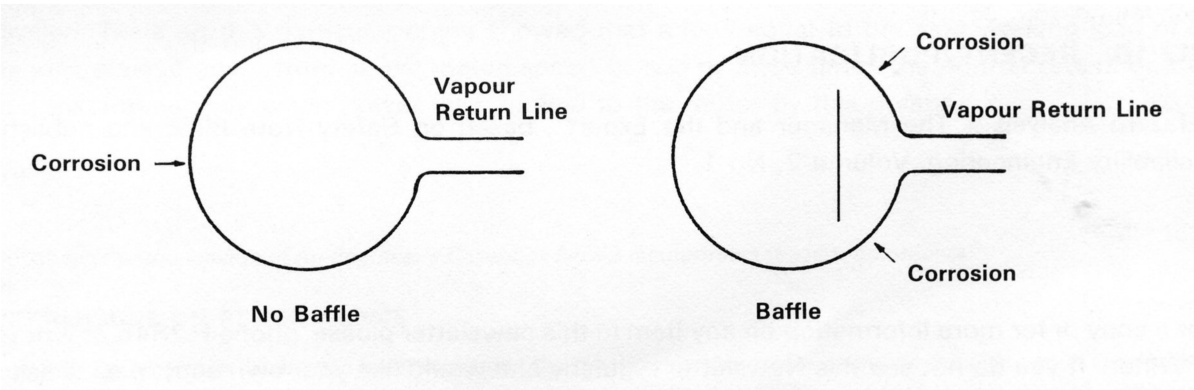
Corrosion was suspected on a distillation column. Ultrasonic thickness measurements were therefore made on the outside of the shell. These showed that although some corrosion had occurred, the thickness was still well above the design minimum.

Some months later, when it was possible to take the column out of use, the lagging was removed and it was discovered that part of the column was so thin that it could be flexed by hand.

The thin spot was immediately opposite the vapour return line from the reboiler. The thickness measurements had been made on the other side of the column where the staging and ladders made access more convenient.

The lessons to be learned are:

1 Thickness measurements in distillation columns should be made at the points at which corrosion is most likely to occur. In the case described above, this was opposite the vapour return line. Often there is a baffle near the return line and corrosion is then most likely near the edges of the baffle.



The geometry of the column must be studied.

2 During design, access ladders should be positioned to facilitate thickness measurements at the points where corrosion is likely to be heaviest.

For further details see Engineering Technical Services Progress Report, October 1972, Ref. No. A17,880/72/10

147/8 EXCHANGING ONE PROBLEM FOR ANOTHER — AT HOME

"My younger brother used to be a fair tennis player. Some even said he had considerable promise. His play isn't so hot now following a rash instantaneous action several years ago.

One summer evening he was walking his bassethound a short distance from his home when he noticed volumes of smoke issuing from the back of a house. He rushed up to the front door and after ringing and knocking several times decided that either no one was home or that the occupants had been overcome by the fire. He decided he must enter the house to find occupants and/or fire. In traditional TV fashion he moved a step back from the plate (?) glass front door and kicked it in.

When he regained consciousness, he was being lifted out of a pool of blood at the front door, onto a stretcher and into an ambulance, while firemen rushed round with fire hoses and extinguishers. It turned out that in attempting to kick in the glass front door, my brother had not only seriously gashed his ankle but had also severed his Achilles tendon. He spent about one month in hospital and another month at home before returning to work. He is lucky in that he can still walk, but he plays only an average game of tennis now.

This well-meant, but foolish, action that summer evening had not been thought out. Although he only wished to help, he became a liability because he did not consider the consequences of his action. The fire brigade arrived without his help and he risked serious incapacitating injury because he failed to consider how the burning house could be safely entered."

From an ICI Australia report.

147/9 UNUSUAL ACCIDENTS No 107

I cannot vouch for the truth of this story but it does provide a good example of a remedy more dangerous than the original hazard.

While a man was painting his house, his wife suggested that the ladder should be tied to something. He tied it to the rear bumper of his car.

While he was up the ladder his wife got into the car and drove away.

147/10 RECENT PUBLICATION

"Hazard Analysis — The Manager and the Expert", based on Safety Note 80/2 and published in Reliability Engineering, Volume 2, No 1.

For a copy or for more information on any item in this newsletter please 'phone P.2845 or write to us at Wilton. If you do not see this Newsletter regularly and would like your own copy, please ask us to add your name to the circulation list.

May 1981

An Engineer's Casebook No 47
ELECTRICALLY OPERATED CRANES

A recent dangerous occurrence involving an overhead crane has highlighted two points worthy of note.

The incident occurred at a stage in the operation when a load had been lifted and had been moved to a position above the required new location. When the load had been lowered to about 18 inches from the floor the operator tried to stop it by removing his finger from the "lower" button. The load continued to fall and indeed seemed to accelerate. Subsequent attempts to stop the crane using the pendant control failed and the load continued to fall until it hit the floor.

The crane is fitted with a drum brake on the motor drive shaft. The brake shoes are pulled away from the drum by the action of a solenoid: when the electrical supply is removed the shoes are pulled onto the drum by the action of a spring. The supply for the solenoid is taken from the motor terminals. Thus, as in all electrically operated cranes, the brake is automatically applied when power is removed from the motor.

The first point is the obvious one that an effective braking system is essential for the safe operation of the crane. The brake provides the only means of stopping and holding a load both under normal conditions and if the "emergency stop" button is pressed. It is clearly necessary for the brake to be set up correctly.

The second point concerns the action to be taken should a brake failure occur. Tests subsequent to the incident described above showed that with the brake badly adjusted a large load accelerated very rapidly when power was removed from the motor by releasing either the "raise" or "lower" buttons. Under these circumstances the operator's first reaction might be to press the "stop" button. This, however, would compound the problem by ensuring that power could not be restored until the system had been reset. If, instead, the "lower" button were pressed the rate of descent could be controlled. Tests on this particular crane showed that a load equal to the safe working load of the crane was slowed down from an estimated speed of two or three times the normal rate of descent almost instantaneously when power was applied to the motor by this means.

D Walker

The following revised version of *An Engineer's Casebook No 43* incorporates readers' comments.

BACKPRESSURE ON RELIEF VALVES

When a relief valve which discharges to atmosphere lifts, the initial backpressure acting on the disc and in the discharge pipe is nil. As flow builds up the exhaust pressure rises to expel the discharge from the tail pipe to unrestricted atmospheric pressure. This has the effect of reducing the pressure differential across the valve and results in a rise in the pressure in the vessel to sustain the dynamic flow conditions determined by the nozzle area of the valve and the fluid properties. When equilibrium is reached the amount by which the set pressure is exceeded, referred to as the over-pressure, is limited by pressure vessel Codes to 110% of the design pressure at the design temperature.

Most valve discharge capacities are sized on the basis of 10% overpressure. The designer must ensure that the relief valve tail pipe is large enough and short enough so as not to restrict the discharge capacity of the valve.

Some relief valves discharge into an enclosed gathering system, such as a flare header, or into a closed vessel at some lower pressure which may itself be fitted with a relief valve. In these cases, if for example the flare system is already receiving discharge(s) from other valves or the closed vessel pressure is greater than atmospheric, an additional pressure will act on the relief valve seat. This additional pressure will be variable dependent upon the conditions pertaining in the flare header or closed vessel at the time the safety valve is called upon to discharge. Unless steps are taken to correct this situation the relief valve will lift ‘heavy’, ie at a pressure greater than the set pressure, the extra pressure being equal to the backpressure in the system.

To prevent this happening ‘balanced’ valves must be used. Balancing is achieved either by using a flexible bellows between the top of the valve disc and the valve body or through the use of a differential area piston. In either case it is important to ensure that the inside of the bellows or the area above the piston is vented to atmosphere. When using balanced bellows or balanced piston valves, the limit of backpressure is approximately 30% - 50% of the set pressure dependent upon the make of valve used.

Within these limits the valve will lift at the correct set pressure.

Balanced valves may, of course, be used for valves which discharge directly to atmosphere. Conventional unbalanced valves must not be used in closed systems in which there may be a backpressure. The integrity of any bellows, or impulse piping in the case of valves with differential area pistons, must be checked when balanced valves are overhauled.

SAFETY VALVE TERMINOLOGIES

Design pressure

That pressure (internal or external) used in the design of the system for the purpose of determining the minimum permissible thickness of the component parts.

Set pressure

The gauge pressure at the inlet at which the valve opens under service conditions of temperature and backpressure. Under these conditions the pressure forces tending to open the valve are in equilibrium with the forces retaining the valve disc on its seat.

Cold set pressure

The inlet pressure at which the valve is adjusted to open at ambient temperature and no back-pressure. It is the set pressure corrected for service conditions of temperature and backpressure.

Accumulation

The pressure increase above the *design pressure* of the system during discharge through the safety valve expressed as a percentage of that pressure.

Overpressure

The pressure increase above the *set pressure* of the valve during discharge through the valve expressed as a percentage of that pressure.

NB: The overpressure and the accumulation are equal when the set pressure is equal to the design pressure.

Re-seating pressure

The value of inlet static pressure at which the valve will close tightly after operation.

Blowdown

The difference between the set pressure and the re-seating pressure usually expressed as a percentage of the set pressure.

Backpressure

The static gauge pressure on the discharge side of the valve. It is the sum of:

a Superimposed backpressure:

The static pressure at the outlet of the valve which is present when the valve starts to open.

b Built-up backpressure:

The pressure which develops at the outlet of the valve as a result of flow after the valve opens.

E M Flatman