IMPERIAL CHEMICAL INDUSTRIES LIMITED
PETROCHEMICALS DIVISION

SAFETY NEWSLETTER No 66

66/1 DO NOT RELY ON ONE VALVE WHERE LEAKAGE CAN HAVE SERIOUS CONSEQUENCES—USE DOUBLE BLOCK & BLEED

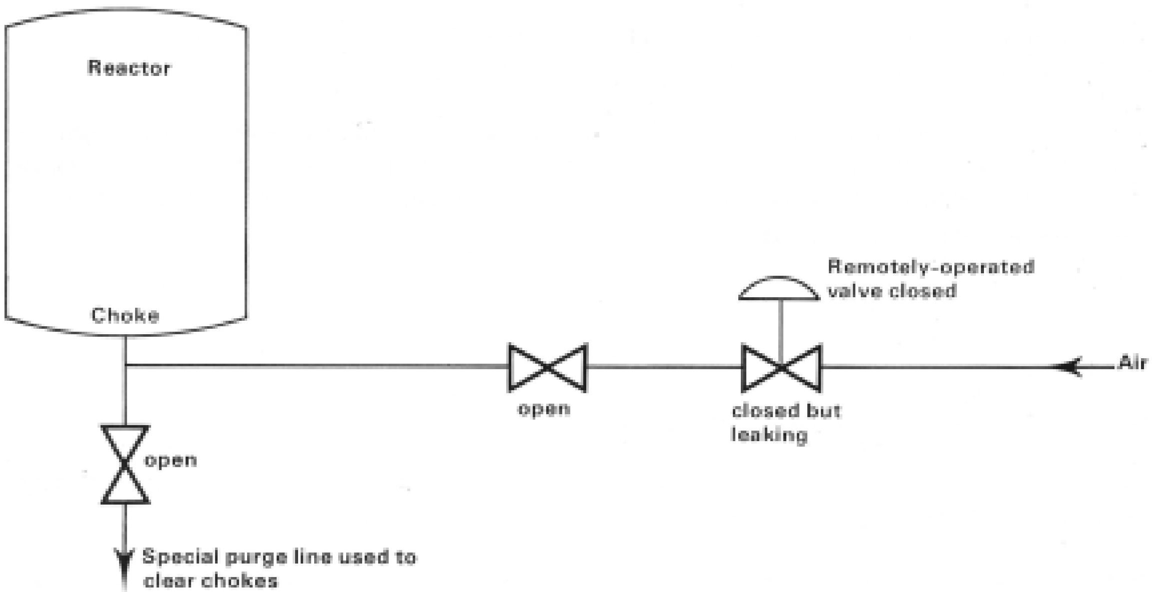
Two serious fires in other companies occurred because the feed to a reactor was isolated by only a single valve which leaked.

The first fire occurred on an ethylene plant. An instrument air failure caused a plant upset and the hydrogen flow to a reactor was isolated by hand. The valve was leaking and hydrogen continued to flow into the reactor, causing a runaway reaction.

This caused a flange to leak, the escaping gas caught fire and soon afterwards a pipe burst. There was no way of preventing 500 tons of hydrocarbon leaking out of the plant and feeding the fire.

In a case like this, where good isolation is very important, double block and bleed valves should be installed.

The second fire occurred on an oxidation plant. The flow of air was isolated in order to clear a choke in the air inlet line by allowing some of the contents of the reactor to flow backwards and out through a purge line which was specially provided for this purpose.



The operator closed the remotely-operated valve in the air line but did not close the hand valve, although the instructions said that he should. The remotely-operated valve was leaking, the air and the reactor contents met in the feed line and reacted. The line ruptured and a major fire followed.

Clearly there should be remotely-operated double block and bleed valves in the air line; there should also be a non-return valve.

66/2 NEVER SPLASH FILL—SPLASH FILLING SETS FIRE TO GAS OIL

On many occasions road tank wagons have caught fire while they were being filled.

Sometimes petrol has been pumped in too quickly or with too much splashing; this has produced a charge of static electricity on the petrol and a spark discharge has ignited the vapour. Such incidents are rare nowadays as most fillers are aware of the risk, and take care not to splash fill or fill too quickly.

Most explosions occur during "switch loading"; that is, while filling a high-boiling hydrocarbon, such as gas oil, into a tanker which has contained petrol and is still full of petrol vapour.

Gas oil is normally filled quickly as usually it does not matter if there is a discharge of static electricity. However, if petrol vapour is present the static spark can ignite it. It is therefore very important, during "switch loading", to fill slowly and to avoid splashing.

Earthing the tanker and the filling arm will help to prevent such fires, since it prevents a spark passing between the tanker and the filling arm, however it will not prevent a discharge of static electricity taking place between the charged body of the liquid and the top of the tanker or the tip of the loading arm.

Recently a very unusual fire occurred in the Division while a rail tanker was being filled with gas oil. There was no petrol vapour present but nevertheless a fire occurred with flames 30 feet high. The fire soon went out of its own accord.

The tanker was being splash filled. This formed a lot of mist. The flash point of gas oil is about 60°C but a mist has a flash point very much lower. The splashing produced a charge of static electricity on the gas oil and when this discharged it ignited the gas oil mist. As soon as the mist had burnt the fire went out.

To avoid similar incidents, NEVER SPLASH FILL. The fill pipe should reach to the bottom of the tanker. (A rubber cushion on the bottom of the pipe will prevent it damaging the tanker).

Many thousands of tankers had been splash filled with gas oil before conditions were exactly right for a fire to occur. When dealing with flammable gases or vapours we should never say, "It's okay, we've never had a fire". If flammable gases, vapour or mists are mixed with air, then sooner or later a fire or explosion will occur. (See item 66/6).

66/3 PRESSING THE WRONG BUTTON—1

The following item appeared in Safety Newsletter No. 34/10 (and in an article in "Process Technology International" for March 1973)

The other day I pressed the wrong button on a beverage machine and had to drink my coffee without sugar. It was not the first time this had happened and, looking back, it seems that every 100 times I use the machine I press the wrong button twice.

Operators of plant and other equipment make mistakes from time to time and sometimes these can be dangerous or costly. Is it possible to estimate the frequency with which operators will make mistakes? If we could do so, it would help us to decide whether automatic protective equipment ought to be provided.

In a paper published a few years ago ("An Index of Electronic Equipment Operability", Payne et al., American Institute for Research, Report No. AD 607161-5,1964) a group of American workers described a method of estimating failure rates for operators using electronic equipment. I decided to apply their data to beverage machines and see what answer I got.

The section on pushbuttons considers them under several headings.

The first is *size.* The probability that the correct button will be pressed depends on the size as shown below:—

Miniature	0.9995
½ inch	0.9999
more than ½ inch	O.9999

The pushbuttons on the beverage machines are 1½ inch by $^5/_8$ inch so I have put an arrow against the last item.

Next we consider the *number of pushbuttons in the group*

Single column or row:	
1—5	0-9997
4—10	O.9995
11—25	0.9990

The next item to be considered is the *number of pushbuttons to be pushed*

2	09995
4	0.9991
8	0.9965

On a beverage machine only one button has to be pushed so I assumed that the probability of success is 09998.

The fourth item is the distance between *the edges of the buttons*

$^1/_8$” - ¼”	0.9985
$^3/_8$” - ½”	0.9993
½” up	0.9998

The fifth item is *whether or not the button stays down when pressed*

Yes	0.9998
No	0.9993

The final item is *clarity of the labelling.*

At least 2 indications of control positioning	0.9999
Single, but clear and concise indication of control positioning	0.9996
A potentially ambiguous indication of control positioning	0.9991

The total probability of success is obtained by multiplying these six figures together:—

Reliability=0.9999 x 0.9995 x 0.9998 x 0.9985 x 09993 x 0.9996 =09966

i.e., three or four errors can be expected in every 1000 operations.

This suggests that if I get the wrong drink 2% of the time, I am rather more careless than the average man — most people would be expected to make about three or four mistakes in every 1000 operations. Perhaps I do not have my mind on the job, perhaps I am talking to someone or am under stress — factors which are not taken into account in this rather simple method of calculation.

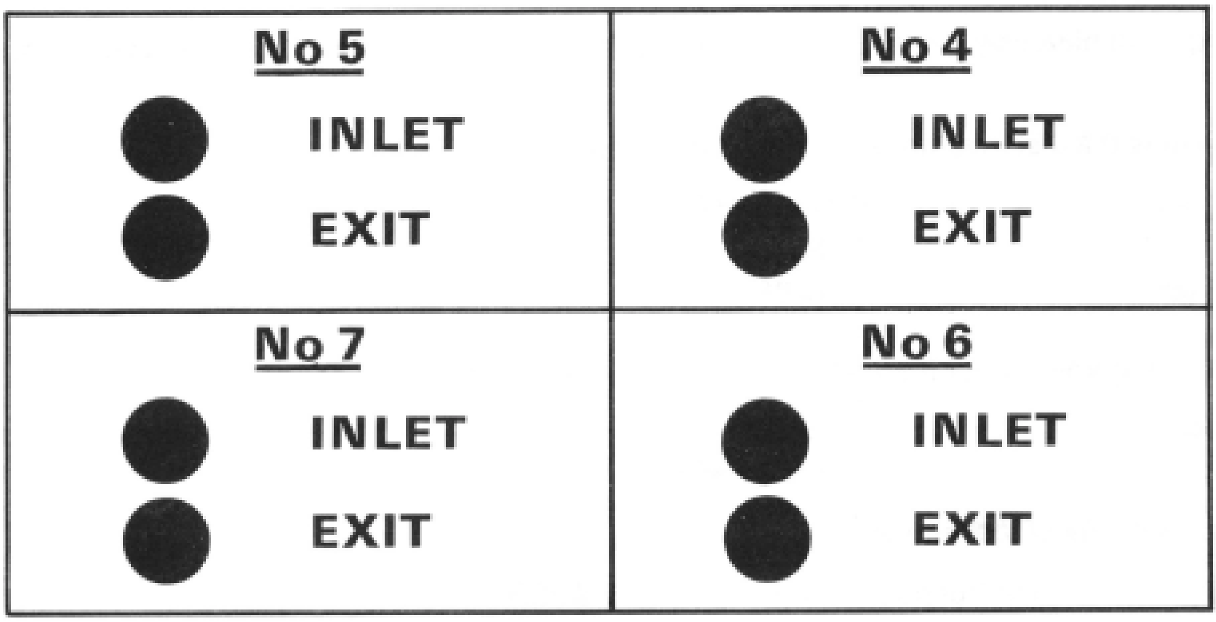
We ought to apply similar reasoning to process operations. If a man has to carry out a number of operations to change over a tank or a pump, or stop a pressure rising to a dangerous level, how often will an average man make a mistake? If we know the answer, and if the consequences of a mistake are dangerous or expensive, then we can decide whether interlocks or warning devices or automatic equipment should be installed. Unfortunately, at the present time we have very little data on human reliability though various organisations are working on the subject.
When someone makes a mistake we have to decide if he is particularly careless, or if an average man might make the same mistake.

If the mistake is the sort that anyone might make, then blaming the man will not prevent it happening again. Either we accept the occasional mistake or we change the work situation.

PRESSING THE WRONG BUTTON -2

A similar mistake to the one with the coffee machine has caused a serious fire in another company, in which several men were killed and many injured.

Nos. 4 and 6 reactors were shut down for maintenance. No. 4 was finished first and was ready for feed. The supervisor told the operator to open the feed inlet valve to No. 4 reactor. The valve was electrically operated and the operator went to the panel and pressed the button.



Unfortunately the operator pressed the wrong button and opened the inlet valve to No. 6 reactor, which was still under maintenance. Flammable gas came out and caught fire.

The company concerned said, ‘What can we do to prevent men making mistakes like this?”

The answer is that we cannot prevent men making mistakes like this. We can make mistakes less likely by putting the buttons further apart and by using bigger labels but an occasional mistake will still happen, particularly if the operator is busy or under stress.

We should never get into a situation where this sort of mistake has such serious consequences. The inlet valve to No. 6 reactor should have been defused and locked shut and in addition, the inlet line should have been slip-plated or blanked.

The operator was NOT to blame for the accident. He made the sort of mistake that everybody makes occasionally. The accident was the result of a poor method of working.

66/4 WILL A COMBUSTIBLE GAS DETECTOR SUCH AS A SIEGER OR MSA ALWAYS DETECT FLAMMABLE GAS OR VAPOUR?

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

The answer is “No”. Although combustible gas detectors are very useful instruments there are occasions when they will not detect flammable gases or vapours.

They will not detect them if there is no air (or oxygen) present. Pure ethylene, for example, or a mixture of ethylene and nitrogen, will not give a reading. The sample must first be mixed with air. It is possible to get a device in which the sample and the air are mixed automatically.

Combustible gas detectors will not detect flammable vapours if they are flammable when hot but not flammable at atmospheric temperature. If the gas detector is the type that uses a sample tube, such as the MSA, then the vapour is cooled in the sample tube and by the time it reaches the gas detector it is no longer flammable. In the Sieger gas detector the detector head is put in the area to be tested, but the detector head is surrounded by a screen of porous metal and this cools the sample.

Thirdly, a gas detector will not detect flammable gas or vapour if it is out of order. **Gas detectors should be tested before use, every time they are used.**

For more details see Safety Note 73/13, “The Limitations of Combustible Gas Detectors” and Safety Note 73/16 “Testing Portable Flammable Gas Detectors”.

66/5 FAILURE TO FOLLOW CORRECT ENTRY PROCEDURE CAUSES A FATAL ACCIDENT

A fatal accident in another company shows the need to follow the correct procedure when entering vessels.

A reactor had been opened up for cleaning and a process foreman had a last look through the manhole before the reactor was boxed up. He saw an old manhole gasket lying on the bottom. He decided to go in and remove the gasket and, as it would only take him a minute or two and as all the other men were having a meal break, he decided to go in alone without a second man keeping watch outside. He entered the reactor, picked up the gasket, tied it round his waist so that his hands were free and started to climb back up the ladder. He slipped and fell and was knocked unconscious. He was found 1 5 minutes later laying on his back with his head tipped back. His tongue had blocked his throat and he had suffocated.

66/6 WHAT THE LAW SAYS No.17

I have often said in these Newsletters that if a flammable gas or vapour and air are allowed to mix then sooner or later a source of ignition will turn up and there will be a fire or explosion.

AIR & FUEL ⟶ BANG.

This view has now been supported by the law.

A contractor’s labourer was carrying a drum of lacquer across a shipyard when he tripped over some electric cables and dropped the drum. The drum broke and cut through the cable, and a short circuit ignited the lacquer. The fire caused serious damage.

The judge ruled that the contractor was responsible for the damage. Trailing cables are a normal hazard in a shipyard and the labourer should have taken more care. **The labourer, if he had applied his mind to the matter, could reasonably have foreseen that dropping the drum would create a fire hazard, even if he could not reasonably have foreseen the particular source of ignition which arose.**
From “Industrial Safety”, May 1974, p.261.

66/7 UNUSUAL ACCIDENTS — No.36

At a garage in Turkey, a road tanker arrived late at night to deliver petrol. The driver awoke the night attendant who lit a kerosine lamp. The driver connected the hose to the underground tank and then went to sleep. After a while the night attendant climbed onto the tanker with the lantern in his hand to check the product level in the compartment. To illuminate the liquid level better he lowered the lantern through the manhole into the compartment. The tanker exploded and caught fire, the flames enveloping the forecourt and the office building. The attendant was fatally injured and died on his way to hospital. The road tanker was completely burned out and extensive damage was done to the garage.

To many this accident will seem almost unbelievable; in fact a similar incident occurred in the UK not so long ago, when a young garage attendant used his cigarette lighter to check the level in a road tanker.

66/8 SOME QUESTIONS I AM OFTEN ASKED

1 — DO WE SPEND MORE ON SAFETY THAN OTHER COMPANIES?

I am often asked if Petrochemicals Division spends more on safety than other petrochemical companies.

The answer, I think, is yes. We do spend a lot more money on safety features such as steam curtains, gas detectors, remote isolation valves, cable protection and fire-proofing. Most other petrochemical companies do not install all these features, or do not install them to the same extent.

This safety equipment costs us a lot of money, money which some of our competitors do not spend. We think it is money well spent, primarily because it reduces the chance that people will be hurt by a fire or explosion or other dangerous incident. In addition, fires and explosions cost money and in the long run, by reducing the chance that fires or explosions will occur, we get back the money we have spent on safety features.

Remote isolation valves and so on have to be paid for today. The saving is in the future. A short-sighted company, which looks only at this year's profits, might not install them.

66/9 RECENT PUBLICATIONS

(a) A new ICI specification for Direct Acting Spring Loaded Safety and Relief Valves, reference No. A40, can be obtained from Standards Section (Tel B.3373) or from the corresponding sections in other Divisions.

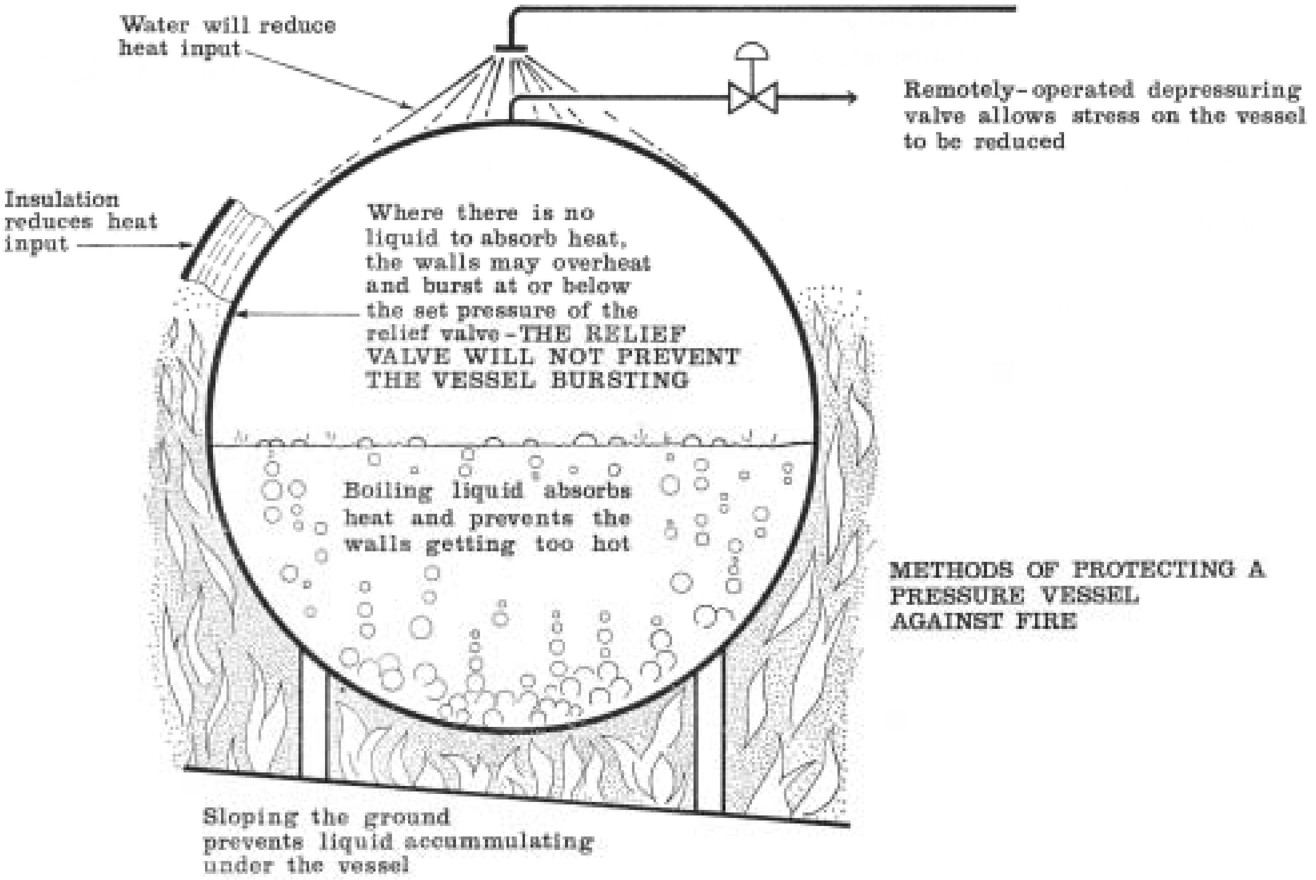
(b) Safety Newsletter 64/4 stated that Allied Chemicals can supply a cleaner for flame traps which is better than caustic soda solution. The cleaner is actually made by Applied Chemicals, P.O. Box 43, Uxbridge, Middlesex. It is known as "Applied 8-66" and is described in their leaflet, "Carbonised Oil Removers".

For more information on other items in this Newsletter please ring B.3927. 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.

July 1974

The protection of pressure vessels against fire

by Trevor A. Kletz BSc, ARIC
ICI Petrochemicals Division Safety Adviser



METHODS OF PROTECTING A PRESSURE VESSEL AGAINST FIRE

On a number of occasions pressure vessels have burst when exposed to fire even though they had been protected by pressure relief valves. There was nothing wrong with the relief valves, but heat weakened the vessels to such an extent that they burst at a pressure below the set point of the relief valve. This article explains how pressure vessels can be protected against the effects of fire by:
Sloping the ground so that spillages of flammable materials do not accumulate under the vessel; (page 19)
Thermal insulation; (Page 19) Cooling with water; (page 20)
Lowering the pressure in the vessel. (page 20)
Particular attention is paid to the rate at which the pressure should be reduced and the methods of reducing it. (page 20)
A remotely- operated depressuring valve allows stress on the vessel to be reduced

From “Fire Prevention” No. 103, May 1974 page 17. Copies available on request

SUPPLEMENT TO SAFETY NEWSLETTER NO 66

WHAT HAPPENED AT FLIXBOROUGH?

It is now possible to add a little to the information given in *Safety* Newsletter No 65. The pipe which broke, causing a big leak of cyclohexane, was a temporary pipe. One lesson we can learn is that temporary modifications, particularly on large equipment, must be checked with the same thoroughness as permanent modifications Earlier Newsletters (65/2 and 63/2) described incidents which occurred because start-up modifications and minor modifications were not thoroughly checked. All modifications, major or minor, permanent or temporary, on new plants or old plants, must be thoroughly checked to make sure there are no unforeseen effects on relief and blowdown, trip systems and area classification, to make sure the correct materials of construction are used and to make sure that the appropriate engineering standards are followed.

Another lesson we can learn is that everyone, as they walk around the plant, should keep an eye open for anything that looks unusual.

The process operated on Flixborough is similar to one we operate in the Division and uses the same raw material cyclohexane. There is nothing particularly dangerous about the process or about cyclohexane. The differences between one plant and another do not lie in the process or in the materials used but in the safety features that are added to the plant, such as emergency isolation valves and in the operating methods used, for example, the methods used for checking modifications, preparing equipment for maintenance, testing alarms and trips and so on. If we continue to install the safety equipment we have installed in the past and continue to follow the correct procedures then we need not worry.

To repeat what I said in Newsletter 65, there is nothing special about cyclohexane that makes it particularly liable to leak or explode. It cannot explode by itself but only when it is mixed with air in certain proportions. It is no more dangerous than petrol, naphtha and many of the other materials we handle

Trevor A Kletz
Division Safety Adviser   1 August 1974