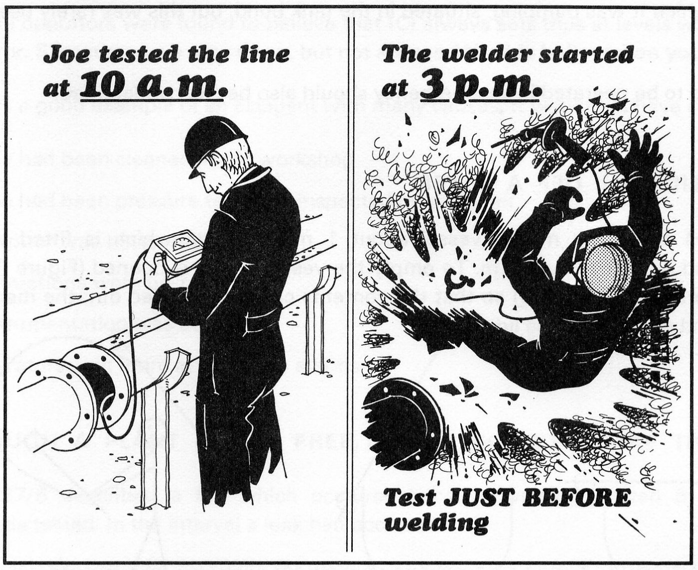
SAFETY NEWSLETTER

No. 145
OLD ONES, NEW ONES.....



IMPERIAL CHEMICAL INDUSTRIES LIMITED

PETROCHEMICALS DIVISION

145/1 TEST EMERGENCY VALVES REGULARLY, INCLUDING HAND-OPERATED ONES

These Newsletters have often pointed out that remotely-operated emergency isolation valves should be tested regularly, or they may not work when required.

A recent incident in another Division reminds us that **hand-operated** valves that need to be operated in an emergency should also be tried out regularly — weekly or monthly — or they may not work when required.

A pump leaked and caught fire. It was, of course, impossible to reach the suction and delivery valves until the fire was extinguished. There was another valve in the suction line, between the pump and the tank from which it was pumping, situated in the tank bund, but this was rarely used and was too stiff to operate.

Valves that need to be operated in an emergency should also be clearly identified.

145/2 THE LID FELL OFF A MIXER

Figure 1 shows a catalyst mixing vessel about 1 m^3 capacity, which is fitted with a hinged, counterweighted lid, 1.2 m by 1.5 m. To empty the vessel the lid is opened (Figure 2) and then the vessel and lid are tilted (Figure 3) so that the contents can be shovelled out; the men emptying the vessel thus stand underneath the lid.

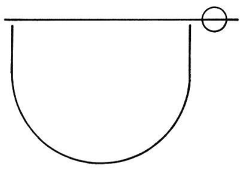


Fig 1

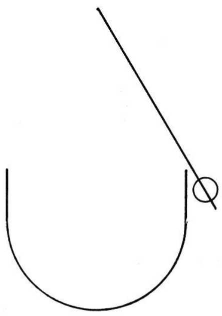


Fig 2

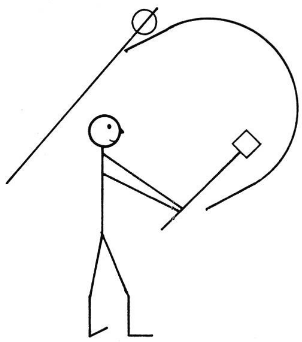


Fig 3

One day the lid fell off, catching one of the men.

The investigation concluded that:

1 The lid fell off because the welds between the lid support arms and their bosses cracked.

2 Cracking was caused by high-stress, low-cycle fatigue, probably arising from the opening and closing of the lid.

3 The stress in the welds was higher than in the original design because of modifications carried out in 1972. The effect of these modifications was not foreseen.

4 The strength of the welds and other parts of the lid support arrangements was deficient because the welding of replacement parts, fitted in 1979, was not designed and fabricated to a high enough standard.

5 A situation in which men need to work underneath a heavy suspended object is not ideal. Apart from the failure which occurred, the securing mechanism might have failed.

Once again we see the need for modifications to be properly designed and for repairs to be carried out to a specified standard. In addition, equipment in which failure of a lid or other movable parts could cause injury or damage should be registered for regular inspection, either as part of the lifting gear registration system or as part of the vessel registration system.

145/3 A TUBE FAILURE WITH MANY CAUSES

Another Division has described how a pipe, sent to an outside workshop for bending, was returned plugged with sand and welded into the exit line from a furnace. Not surprisingly, the furnace tubes overheated and failed during start-up.

The pipe was returned to the plant with a warning that it might contain *some* sand; this was taken to mean that a few grains might be stuck to the walls, not that the pipe might be plugged with sand.

Contributing factors to the failure were inadequate training of the operator— he had not done this job for a year— out-of-date instructions and poor instrumentation.

In addition, the operators were found to believe that ICI always sets trips at levels which leave plenty in hand for error. Sometimes we may do so, but not always. **What is believed on your plant?**

This incident is a good example of an accident with many causes. It would not have occurred if:

— the pipe had been cleaned in the workshop

— the pipe had been pressure tested or inspected on the plant

— the operator was better trained

— the instructions were up-to-date

— the instrumentation was better

— the operators paid more attention to alarms

145/4 THOUGH A PLANT IS GAS FREE, IT MAY NOT STAY LIKE THAT

Newsletter 127/6 described a fire which occurred because welding started 5 hours after the atmosphere was tested. In the interval a leak had occurred.

Another company prepared an acid tank for welding and issued a permit. It was *40 days* before the maintenance team were able to start. In the interval a small amount of acid which had been left behind attacked the tank, producing hydrogen. No further test was carried out. An explosion occurred.

Test just before welding

Renew welding permits after 1 day

From *Chemical Safety Summary*, published by the Chemical Industries Association, July — Sept 1980, p 75.

Similarly, tests for toxic gases should be carried out just before work starts. Recently, in the Division, a test for benzene was carried out 8 hours before a job started. During this time the atmosphere changed.

145/5 WOULD YOU POUR WATER OVER EQUIPMENT?

At one time it was quite common to pour water over equipment which was too hot — or which was leaking fumes. The water was taken from the nearest convenient supply.

At Flixborough, there was a leak of cyclohexane vapour from the stirrer gland on one of the reactors. To condense the vapour, water was poured over the top of the reactor. Plant cooling water was used as it was conveniently available.

Unfortunately the water contained nitrates which caused stress corrosion cracking of the mild steel reactor. The reactor was removed for repair and the temporary pipe which replaced it later failed and caused the explosion.

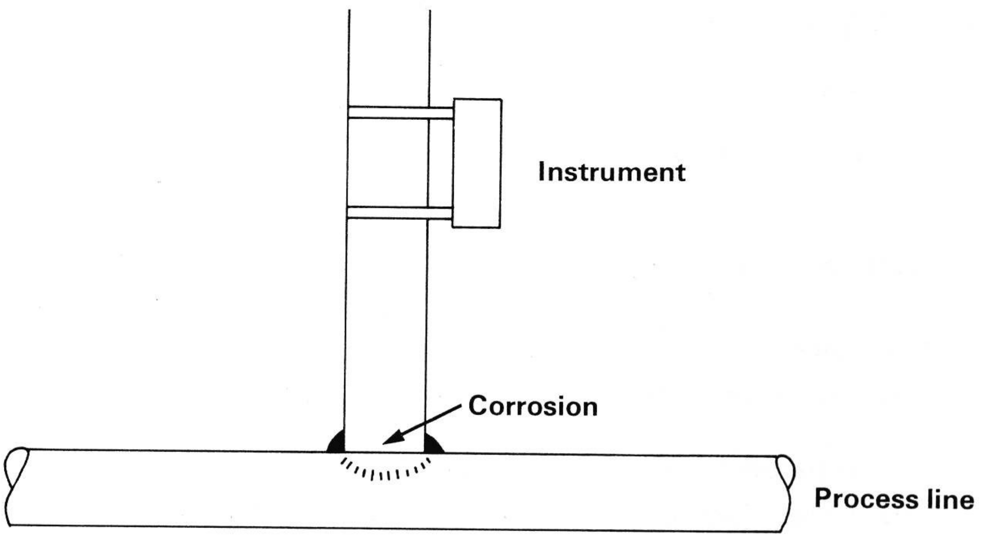
Nitrate-induced cracking is well-known to metallurgists but not to other engineers. Before you poured water over equipment — emergencies apart — would you ask what the water contained and what its effect would be on the equipment?

Pouring water over equipment is a change outside normal operating practice and should therefore be treated as a modification.

For a description of nitrate cracking of mild steel see “Guide Notes on the Safe use of Stainless Steel in Chemical Process Plants”, published by the Institution of Chemical Engineers.

145/6 A DESIGN WHICH ENCOURAGED CORROSION

After a leak of liquefied flammable gas had occurred, it was found to have come from a length of 2 inch diameter pipe which had been welded onto a process line as a support for an instrument.



Water collected in the 2 inch pipe and corroded the process line until — 4 years later — it leaked.

Supports for instruments should not normally be welded onto process lines. Look out for any on your plant and if you find any, ask the maintenance team to look at them to see if they should be repaired or replaced. Pay particular attention to hollow supports, such as lengths of pipe, in which water can collect.

145/7 AN UNUSUAL TANK FIRE AND COLLAPSE

A most unusual way of sucking in a storage tank is described in an article in a Romanian journal (A Povel, Revista de Chimie, 1980, Vol 31, No 7, p 675).

Workmen were cleaning an empty tank by pushing the sludge towards the exit pipe. When the sludge was disturbed it gave off some propane, which caught fire when one of the men lit a cigarette!

The propane did not explode, presumably because there was not enough present, but continued to burn. This used up the oxygen in the tank faster than air could enter and the tank was sucked in. Since burning produces an increase in volume the water vapour produced must have condensed.

One man escaped and another was killed.

Men should never be allowed to work in a tank or vessel where flammable gas is present at a concentration above 20% of the lower flammable limit. If sludge may give off gas when disturbed, the atmosphere should be monitored continually.

Newsletter 108/5 described some new materials for tank cleaning.

The article also described some other serious incidents in Romania. A pressure vessel exploded due to poor welding; a catalyst vessel exploded because hydrocarbons were allowed to get into it during regeneration with air; and an explosion occurred during welding near a cooling water tower, believed due to a burst tube in one of the exchangers supplied by the tower.

145/8 A LOOK BACK AT NEWSLETTER 45 (October 1972)

(a) A new tank blew up while filling with water

Another company reports that a new tank was being filled with water for hydrostatic test when an explosion occurred. Two welders who were working on the roof, finishing off the handrails, were injured, fortunately not seriously.

The tank was filled with water through a pipeline that had previously contained petrol. A few gallons of petrol had been left in the line and were flushed into the tank by the water. They floated on top of the water and the vapour was ignited by the welders.

Men should not be allowed to weld on top of a tank while it is being filled with water. One of the reasons for filling it with water is to make sure that the tank and its foundations are strong enough. So everybody should be kept out of the way while it is being filled.

(b) A cable was cut during an excavation

While excavating a hole in the ground (in another company) a contractor cut through a live 3,300 volt electric cable. The contractor had been given a Permit-to-Work stating that there were no cables underneath the area to be excavated. The Permit did not tell him that there was a live cable about a foot to one side and the contractor did not excavate his hole very accurately (who does?). What is the procedure on your works before men are allowed to excavate holes in the ground?

145/9 SOME QUESTIONS I AM OFTEN ASKED — No 39
WHY DOES ICI TOLERATE SUCH DIVERSITY BETWEEN DIVISIONS AND WORKS?

Visitors from other companies are often surprised that each Division and sometimes each Works has its own clearance certificate system or modification control procedure. ‘Why not an ICI System?’, they ask.

The usual answer is:-

(a) Different systems having been developed in the past, the advantages of a common system would not justify the upheaval of a change.

(b) Each Division or Works has different needs.

(c) Each Division or Works is committed to a system it has developed itself but might resent a system imposed on it from HQ.

A fourth reason is suggested by an article by B Trapnell in the *Daily Telegraph* for 15 December, 1980. Quoting a French anthropologist, C Levi-Strauss, he writes:-

Why was it that some societies had ossified and remained immobile for many hundreds of years, whereas others had been able to adapt and develop?

His answer was that civilised societies are pluralistic and always contain more than one viewpoint, more than one possibility of action, whereas primitive societies are monolithic, the existing viewpoint or the existing way of doing things, unquestioned. To put the matter another way a civilised society pluralism creates a tension and a debate which produces forward movement.

In the primitive society, it seems as if the gods have given a once-for-all blueprint as to how things are to be done. In other words, the ideal has been laid down in the past and the necessity is to look backwards over one's shoulder and see what it consists of. In the civilised society heaven lies in the future — it is something to be reached out to. Heaven always lies ahead.

145/10 UNUSUAL ACCIDENTS No 105— Explosive Food

We all know that flour and sugar will explode if dispersed in air and ignited. Now "Health and Safety Research 1979", (paragraphs 72-76), published by the HSE, reports that two men were killed by the explosion of pork!

Pork scratchings were cooled with liquid nitrogen to make them easier to mince. Air condensed on the cold pork. As oxygen has a higher boiling point (-183°C) than nitrogen (-196°C), the condensed 'air' was rich in oxygen — it actually contained over 70% oxygen — and reacted violently with the pork. The source of ignition was probably frictional heating in the mincer, which was shattered by the explosion, killing two men.

Similar incidents might occur with almost any organic material if it is cooled by liquid nitrogen while in contact with air and then ground. See Loss Prevention Bulletin No 029, published by the Institution of Chemical Engineers.

The pork explosion reminds us that food processing is a branch of the chemical engineering industry and subject to similar hazards. I recently read a report of an explosion in a beef processing plant which was caused by a leak of ammonia from the refrigeration equipment. A welded cap came off the end of a pipe. The ammonia was ignited by arcing at a standard electric plug and socket and damage was extensive.

In another incident 32 m^3 of concentrated fruit juice was spilt when a tank overflowed. The operator forgot to watch the level gauge.

Recommendation: Fit a high level alarm.

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.

March 1981

An Engineer's Casebook No 145
GUIDE TO FAULT ANALYSIS: DIRECT DRIVE CENTRIFUGAL PUMPS

The centrifugal pump is a common piece of equipment on a modern chemical plant, so common it is often taken for granted. The Division has thousands of centrifugal pumps of various designs and duties.

In recent years, the centrifugal pump has undergone developments which have improved its performance. Pump manufacturers would have us believe that their pumps seldom fail and, when they do, it is our fault because we did not read in full the small print in the operating instructions.

However, pumps do fail and those failures cost the Division hundreds of thousands of pounds per year in labour, materials and lost production.

Failure can often be attributed to one or more of the following causes:-

1 *Incorrect specification of duty and materials:* This is not always the fault of the design engineer. Sometimes process conditions are changed slightly, for example, a slight change in operating pressure or temperature can alter the corrosion rate of some pump or seal materials. Note: Some seal "O" ring materials are limited to an operating temperature of 150°-200 °C.

2 *Incorrect installation or maintenance:* Common faults are incorrect fitting of bearings, seals or rotating units or badly fitted pipework, giving rise to large distorting forces; also, it is worth checking that the pump is rotating in the correct direction.

3 *Maloperation:* For example, starting the pump without bleeding all the air out and priming, or starting with the delivery valve open or the suction valve closed. It is quite common to find a suction strainer or an oil filter choked or missing. This results in bearing or seal failures.

4 *Manufacturing faults:* It is wise to inspect a new pump thoroughly before installation, making sure that the pump received is the pump ordered, particularly with respect to material composition.

Before the failure rate of a pump can be improved, the particular cause of failure needs to be established. It is hoped that the following chart may help in this. It is not comprehensive and is intended as a guide for new engineers and supervisors.

I C Bell

The Casebook is now being written by a different engineer each month. In this way we hope to spread some of our accumulated expertise.

15 Mechanical seal leaks	14 mechanical seal/Gland box overheats	13 Noisy pump	12 Pump does not prime	11 Irregular delivery	10 Siezed pump	9 Motor heats up	8 Bearings wear rapidly	7 Bearings overheat	6 Excessive vibration of pump	5 Pump overloads driver	4 Pump loses liquid after starting	3 Pump does not deliver rated pressure	2 Pump does not deliver rated capacity	1 Failure to deliver liquid	**SIGN** / **POSSIBLE CAUSE**
	●		●									●		●	1. Wrong direction of rotation
	●				●									●	2 Pump not primed/filled with liquid
	●										●			●	3 Suction line not filled with liquid
	●	●		●					●		●		●	●	4 Air/vapour pocket in suction line
	●	●							●		●		●	●	5 Inlet or suction pipe insufficiently submerged
	●	●		●					●		●		●	●	6 NPSH required - NPSH available > 0
	●											●	●	●	7 Pump not up to rated speed
	●												●	●	8 Applied head > Head thrown by pump
		●	●	●							●		●		9 Air leaks in suction line/Mechanical seal
						●						●	●		10 Viscosity of process fluid greater than design
												●	●		11 Bearings worn
										●		●	●		12 Impeller damaged/off
										●		●	●		13 Internal leakage (gaskets)
	●	●		●					●	●	●	●			14 Gas or vapour in liquid
						●				●					15 Speed too high
				●						●					16 SG higher than rated
	●	●							●						17 Starved suction
●	●	●					●	●	●						18 Misalignment
●		●							●						19 Worn/loose bearings
●		●							●						20 Rotor out of balance
		●							●						21 Impeller/passages blocked
●	●	●					●		●						22 Bent shaft

15 Mechanical seal leaks	14 mechanical seal/Gland box overheats	13 Noisy pump	12 Pump does not prime	11 Irregular delivery	10 Siezed pump	9 Motor heats up	8 Bearings wear rapidly	7 Bearings overheat	6 Excessive vibration of pump	5 Pump overloads driver	4 Pump loses liquid after starting	3 Pump does not deliver rated pressure	2 Pump does not deliver rated capacity	1 Failure to deliver liquid	**SIGN**
		●							●						23 Improper location delivery control valves
		●							●						24 Foundation not rigid
								●							25 Insufficient cooling water
								●							26 Oil level too low/high
							●	●							27 Wrong grade of oil
							●	●							28 Dirt in bearings
								●							29 Moisture in oil
								●							30 Bearings too tight
							●								31 Excessive axial thrust
							●								32 Lack of lubrication
							●	●							33 Too much grease in bearings
			●	●				●			●	●			34 De-aeration cocks not operated
●					●		●	●	●	●					35 Badly fitted pipework
●															36 Seal "O" rings failed
●					●										37 Foreign matter pump/seal
●	●														38 Seal faces overloaded - bad fitting
	●														39 Seal CW shut off
	●														40 Rubbing of Rotary unit on gland box
	●														41 Flush pressure too low/shut off
●															42 Corrosion - Wrong seal/shaft materials