

SAFETY INVESTIGATIONS

No. 148 SOME UNSEEN HAZARDS



Some hazards, such as compressed air, are invisible. Others are unseen because we do not look for them. See 148/1 & 3.

- 148/1 Testing trips and alarms — some errors that might be missed.
- 148/2 The hazards of compressed air.
- 148/3 A lamb turns out to be a lion.
- 148/4 ‘Foreign’ pipelines — who issues the clearance certificate?
- 148/5 Microwave ovens.

An Engineer’s Casebook — Fabrication defects in thick-walled pressure vessels at attachment welds.



IMPERIAL CHEMICAL INDUSTRIES LIMITED
PETROCHEMICALS DIVISION

148/1 TESTING TRIPS AND ALARMS — SOME ERRORS THAT MIGHT BE MISSED

On many Works the plant managers are expected to watch the testing of a number of trips and alarms every month. The following are some of the errors in equipment or procedures noticed by the plant managers on one Works in the Division during a period of 6 months. Of course most errors are picked up by the men doing the test but sometimes the manager notices something that they have missed.

1. On an oxidation plant three oxygen analysers (Nos 1, 2 & 3) are connected to a voting system; two out of the three have to register a high oxygen concentration before the trip operates.

While watching the test the manager realised that if No 2 and No 3 are selected to activate the test trip, a fault in No 1 will not be detected.

2. A confined space is fitted with an emergency cord that sounds an alarm. The manager noticed that it was not being tested.

3. An accidental trip during testing was observed to be due to poor methods of communication between those involved.

4. While observing the test of a low temperature trip the manager noticed that the process flow was not routed through the usual lines but through lines not suitable for use at low temperatures.

5. Several examples of poor labelling were noticed.

6. Two pumps are fitted with autostart. One is tested each month. The manager noticed that no note was kept of which one had been tested.

7. A manager noticed that an old procedure was in use, not the new one he had issued some weeks before.

8. A manager noticed that on a hot day the high temperature trip on a pump had to be defeated before the pump could be started. The trip could be left defeated and therefore either the trip setting should be revised or the defeat should incorporate a time delay which re-activates the trip after, say, 20 minutes.

9. A manager noticed that the trip setting on the test sheet was not the same as on the plant instructions and that the actual setting was different again.

10. A manager noticed that an alarm was set so near the operating level that frequent spurious alarms were inevitable and the alarm was therefore ignored.

11. A manager noticed that it was impossible to set certain pressure trips to the required accuracy.

12. A manager noticed that the register of trips by-passed was not always complete.

13. A manager noticed that a trip was responding but too slowly.

14. A manager noticed that the test routine had not been changed since start-up.

Do you watch the testing of trips and alarms on your plant?

148/2 THE HAZARDS OF COMPRESSED AIR

Newsletter 147/3 described the dangers of inert gas. Compressed air is also dangerous.

Recently, at Wilton, a man was repairing an air-operated valve in a workshop. Some air, trapped inside the equipment, was vented onto his hand and entered it, producing small blisters.

Equipment which has contained compressed air (or any other compressed gas or liquid) **should be vented before work is done on it.**

The following, taken from the Mond Division Safety Report for May 1974, is a useful summary of the hazards of compressed air:

DON'T Use compressed air to blow your bench or machine clear of filings, swarf, or chips, either metal or wood.

why Because particles can enter the eyes, ears or the skin of yourself or your workmates.

DO Remove particles with a brush and brush them off gently

DON'T Use compressed air to remove dust from your clothing. In other words, "Don't blow yourself down"

why Because the fabric of clothing offers no resistance to the pressure, and dirt can be force blown into the body, and, even worse, air can be forced into the blood stream, with disastrous effects.

DO Brush clothes with a proper brush or a pad of foam rubber

DON'T Push the end of a compressed air line into the pocket of a workmate's clothing or down the collar of his shirt, down his trousers or up the leg of his trousers

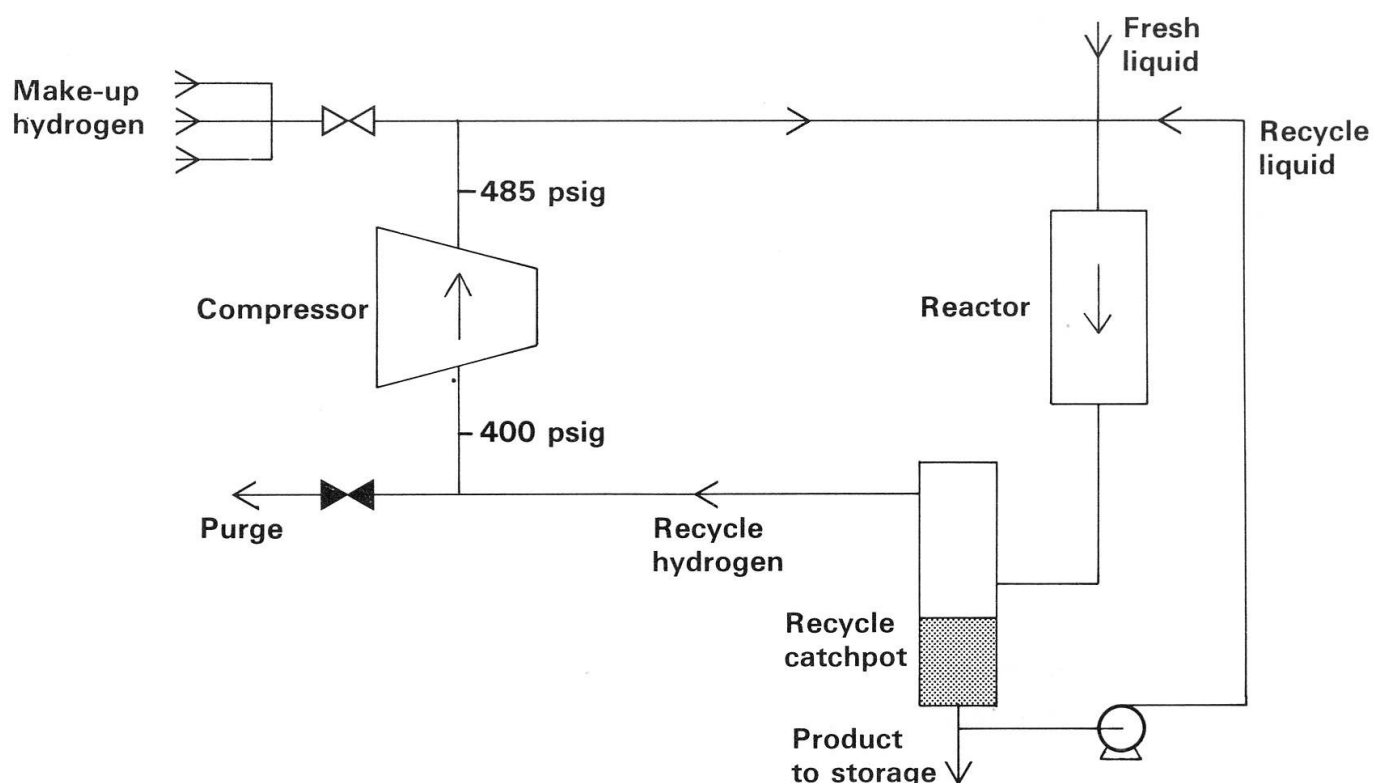
why Because the force of air can damage vital internal organs of the chest, stomach or bowel, and shock alone can kill.

DO Regard compressed air as an aid to industry and "Play it safe".

148/3 A LAMB TURNS OUT TO BE A LION

A runaway reaction occurred in a hydrogenation reactor which had operated without serious incident for 14 years. Everyone concerned believed that the reaction, like most hydrogenation reactions, was easy to control, but unfortunately the reaction was a "lion in sheep's clothing".

A simplified diagram of the plant is shown below



During a start-up the level in the recycle catchpot was lost and the flow of recycle liquid stopped. The operation of a trip stopped the flow of fresh liquid as well.

The recycle gas flowmeter showed that there was a small flow of gas through the reactor. However there was a zero error on the flowmeter and the hydrogen was much purer than usual. The centrifugal compressor was designed to handle gas of molecular weight 16 but the actual molecular weight was only 4. Consequently the machine was so far from its design condition that the recycle gas flow was insignificant.

The hydrogen and liquid in the reactor reacted together and the temperature rose well above its normal value of 235°C. As there was no indication of high temperatures — reactor exit temperatures only were measured — the operators restarted the recycle liquid feed to the reactors. However *unknown to anyone on the plant, temperatures within the reactor were above 450°C and a different reaction to the normal one — cracking of the feed — was taking place*. The recycle liquid, instead of quenching the reaction, fuelled it.

Temperatures rose to over 600°C and the reactor was damaged.

The questions of general interest which come out of the incident are:

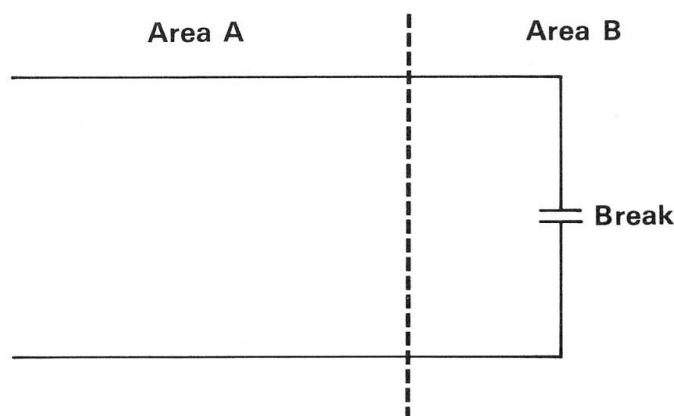
1. Do you know what happens to your reactants at higher temperatures than those normally reached? Do your instructions cover this situation? (Newsletter 98/1 described how a product was allowed to stand in a batch reactor; it got too hot and a runaway reaction occurred).
2. The plant instructions gave the action to take if the liquid flow is lost or if the gas flow is lost but did not say what should be done if *both* are lost. What do your instructions say?
3. If you compress gas, does everyone realise that if the molecular weight of the gas changes, then the mass throughput will change? On the plant concerned a nitrogen injection system has now been provided so that the molecular weight of the recycle gas can be increased when necessary.

4. Do you know the temperatures inside your reactor beds? On the plant concerned the reaction was considered so tame that the bed temperature was not measured, only the reactor exit temperature. When flow stops this tells nothing about conditions in the reactor. Temperature points have now been installed in the beds.
5. If you have a circulating gas stream, do you measure the purity at the compressor inlet or exit? On the plant concerned, the purity was measured on the purge line, which is a dead leg during start-up when the purge is not in operation.

148/4 WHO ISSUES CLEARANCE CERTIFICATES FOR JOBS ON FOREIGN PIPELINES WHICH PASS THROUGH A PLANT?

A recent incident in the Division draws attention to an old problem. Suppose a plant is divided into two areas, A and B, which are under the control of different supervisors.

Suppose a pipeline belonging to area A passes through area B and that this pipeline has to be opened up in area B.



The man doing the job is exposed to two distinct hazards, namely

- (i) Those due to the contents of the pipeline: these are understood by Supervisor A.
- (ii) Those due to other work going on in Area B: these are understood by Supervisor B.

If the clearance certificate for the work on the pipeline is issued by Supervisor A then Supervisor B should countersign it; if it is issued by B then A should countersign it. The system should be covered by local instructions and clearly understood.

In the recent incident Supervisor A issued a clearance for work to be done on a flow transmitter in a pipeline in area B. Supervisor B issued a clearance for grinding in area B. He checked that no flammable gas was present and had the drains covered. He did not know about the work on the flowmeter and a spark set fire to a drain line on the flowmeter which had been left open.

What would happen on your plant?

148/5 UNUSUAL ACCIDENTS No 108

A Baltimore doctor recently reported a new hazard with microwave ovens to the *New England Journal of Medicine*. A boy, ravenously hungry, rushed home from school for his afternoon snack. The first edible item within reach in the freezer was a jam-filled doughnut, which he promptly placed in the microwave oven for one minute. The outer crust was comfortably warm when he removed the

doughnut, which he gulped down quickly. He immediately felt a searing pain in his gullet. The jam in the centre of the doughnut had been heated to a much higher temperature than the covering dough and was hot enough to produce burns.

Microwaves are absorbed by water, so the more water there is in a food the hotter it will get.

148/6 NEWS FROM ABROAD

The Federal Meat Inspection Service ordered a packing company to put an opening in a sausage conveyor line so inspectors could take out samples to test. No sooner was this done than the Occupational Safety and Health Administration ordered that the opening be closed as a safety hazard. Each agency threatened to close the plant if their demands were not met.

From a US Safety Bulletin.

148/7 RECENT PUBLICATIONS

(a) An Engineer's Casebook No 36 in Newsletter 36 described the failure of a thick walled pressure vessel in hydrogen service. A translation of a detailed report on the incident is now available.

(b) "After the Investigation", presented at a recent symposium on accident investigation, suggests that we should avoid talking about 'causes', pay more attention to the software and consider how we will prevent the software corroding. (This is not a misprint for hardware; software also corrodes).

(c) 'New Technologies — New Safety Hazards', presented at a symposium on "Changes in the 1980's — Demands on Professional Chemists".

(d) 'Is Safety too Expensive', presented at the RoSPA Annual Conference, suggests that safety officers get money too easily and do not look for cheaper ways of providing safer plants. This occurs because they are not involved sufficiently early in the development of projects.

(e) "One Organisation's Memory — the use of a computerised system to store and retrieve information on loss prevention".

(f) "Loss Prevention in the Process Industries" by F P Lees was reviewed in Newsletter 134/10. An errata slip, listing about 20 misprints, is available from Professor Lees, Department of Chemical Engineering, University of Technology, Loughborough LE11 3TU. Please send a stamped addressed envelope.

For copies of these items (except the last) 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.

June 1981

An Engineer's Casebook No 48

FABRICATION DEFECTS IN THICK-WALLED PRESSURE VESSELS AT ATTACHMENT WELDS

An incident in Petrochemicals Division (described in item 148/3) has highlighted the value of NDT techniques for the detection of defects in thick walled pressure vessels.

Following a thermal runaway in three reactors, a full NDT survey was initiated to determine the extent of necessary repair work. Crack defects, associated with the original fabrication in 1965, were found at the skirt to shell attachment. The defects had not propagated in service, but stress analysis predicted that some could have done so had the reactors been subjected to a full pressure test.

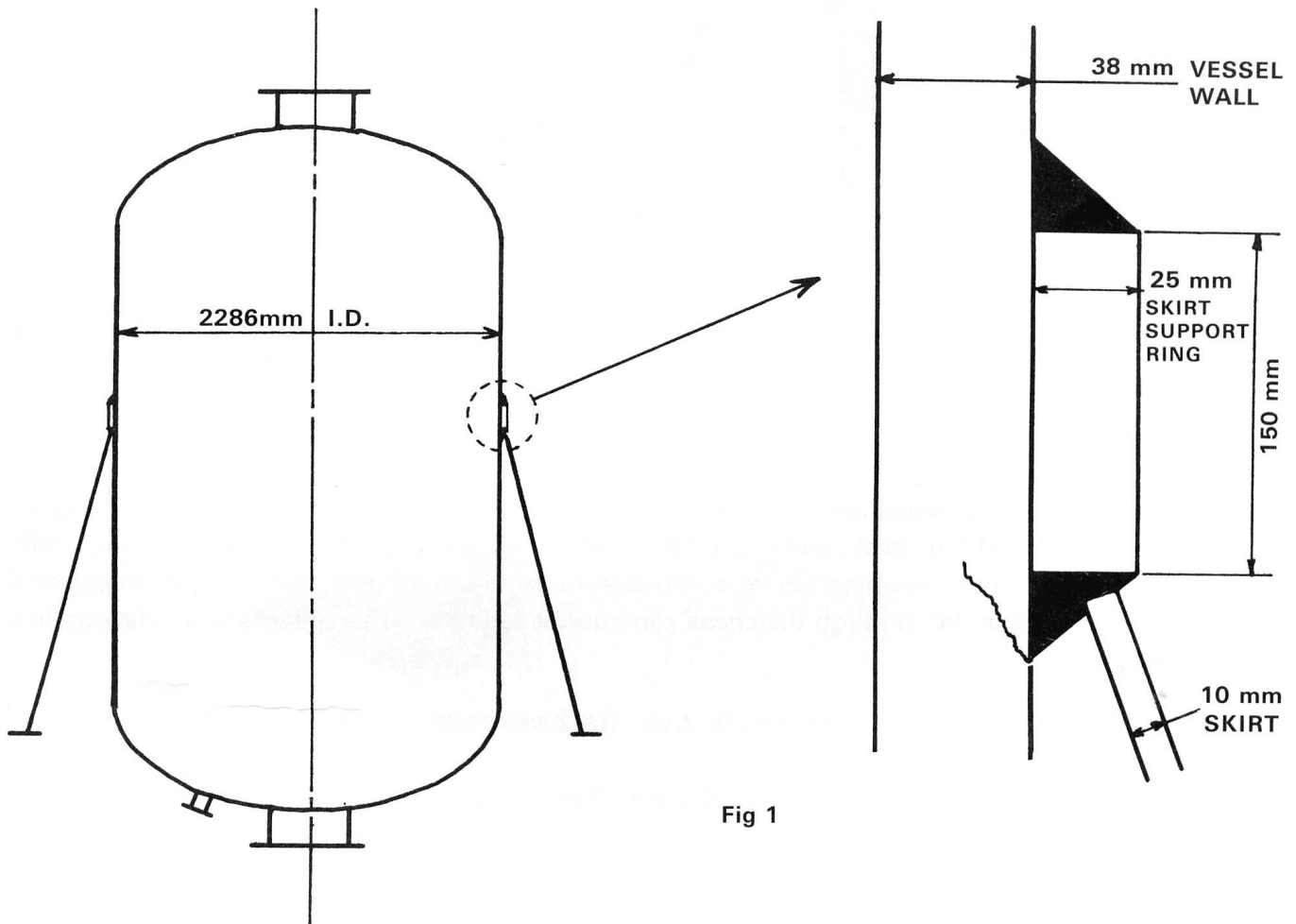
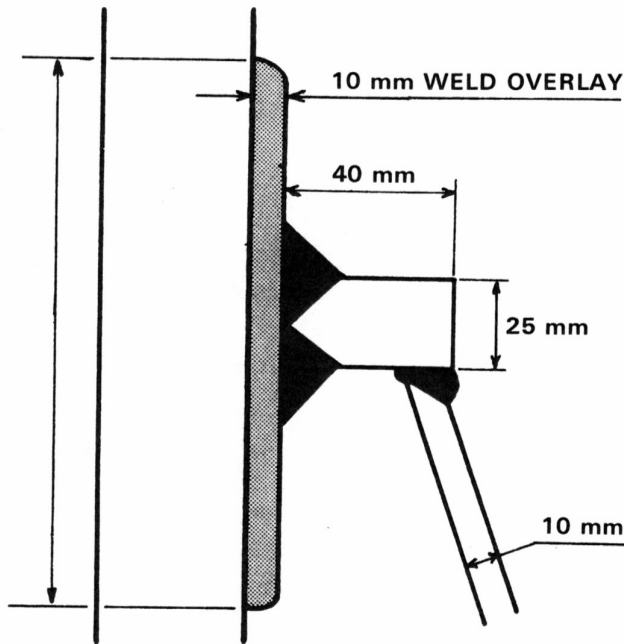


Fig 1

The defects, varying in size up to 13 mm radial penetration into the 38 mm thick vessel wall, had not been detected during fabrication, owing to the less sophisticated NDT techniques available at the time and the absence of testing requirements on attachment welds in the design and fabrication codes.

The three reactors were constructed in CMn steel (BS 1501-221) to the ASME Code, Section VIII, which called only for 100% radiography of the main vessel seams. Even had radiography of the skirt attachment welds been specified, it is possible that these defects would not have been detected due to the thickness of the vessel wall (which would reduce the sensitivity of the radiograph) and because the design of the skirt attachment precluded crack detection of the completed weld assembly by visual, magnetic particle or dye penetrant methods.

The extensive nature of the cracking which covered up to 60% of the vessel's circumference necessitated that the reactors were repaired, the skirt and support ring being replaced using a modified skirt attachment detail, as shown in Fig 2.



This attachment detail was chosen because it minimised the probability of lamellar* tearing, which was thought to have contributed to the original defects, and gives improved access for both ultrasonic and magnetic particle crack detection.

Fig 2

Does your plant have any thick walled vessels with attachment welds like this which have not been checked?

J D Inman

*Lamellar tearing is a common fabrication defect on large fillet welds on to thick plate material, especially when over 30 mm thick, and characteristically takes the form of a stepped fracture under the welded joint, where a combination of strain due to weld contraction and inferior mechanical properties of the steel in the 'through thickness' direction leads to a series of tears which link up in a stepped form.