IMPERIAL CHEMICAL INDUSTRIES LIMITED
PETROCHEMICAL DIVISION

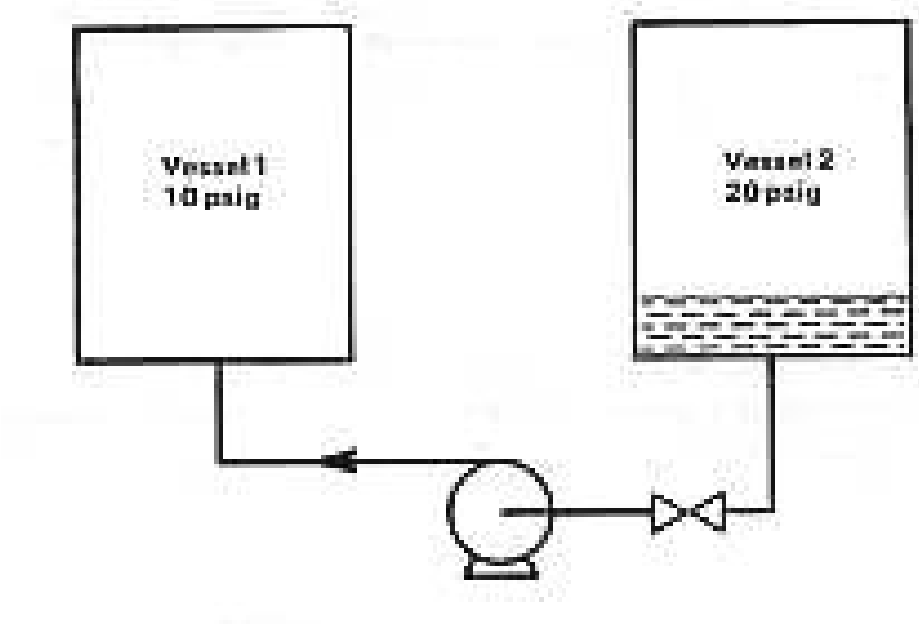
SAFETY NEWSLETTER No 79

79/1 MORE ABOUT PSI ABSOLUTE AND PSI GAUGE

Newsletter 76/5 tried to explain the difference between psia and psig. Hazards can arise if we cannot calculate the pressure in a vessel, so to test your understanding, try the following problem.

Vessel 1 contains nitrogen at 10 psig.

Vessel 2 contains a liquid of 20 psig vapour pressure.



A small quantity of liquid is transferred from vessel 2 into vessel 1. The reduction in the volume of the nitrogen is small and can be neglected.

What is the final pressure in vessel 1?

Answer in the next issue.

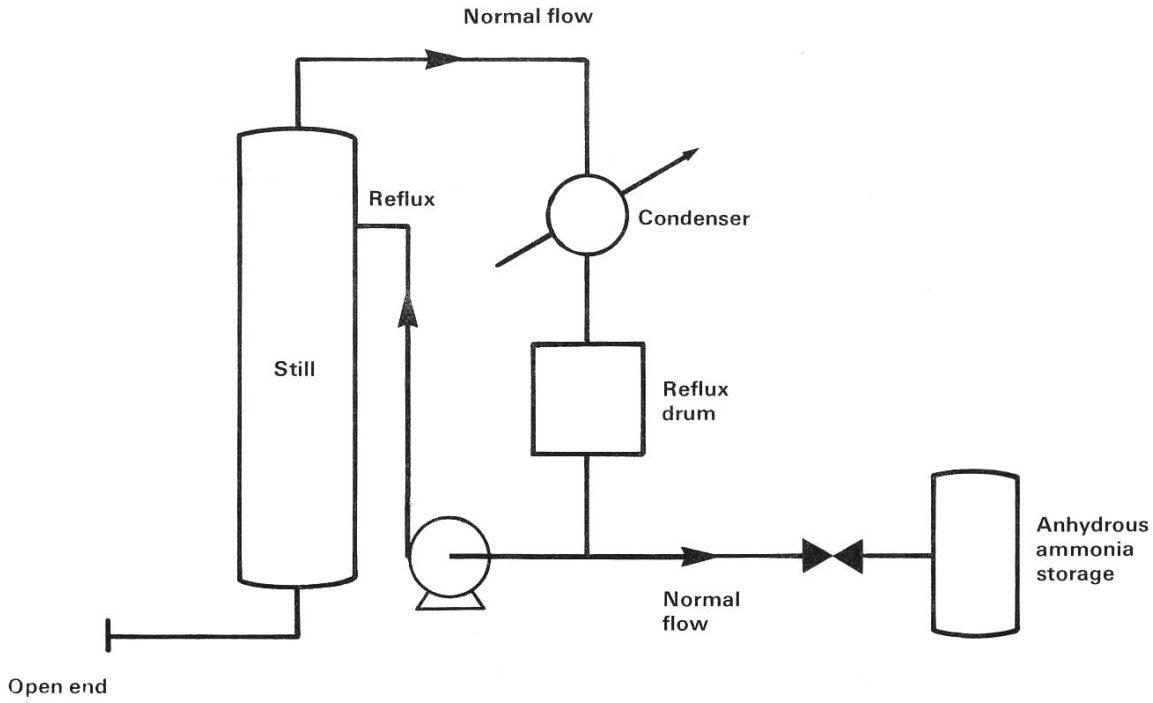
79/2 ACCIDENTS CAUSED BY REVERSE FLOW

Many accidents have occurred because we failed to foresee that gas or liquid might travel along a pipeline in the opposite direction to that intended. In all walks of life men expect movement to be forward. This is commendable but we must not forget that sometimes movement will be backwards unless we identify the situations in which this can occur and take steps to prevent it happening (or, more precisely, to make the chance of it happening acceptably low).

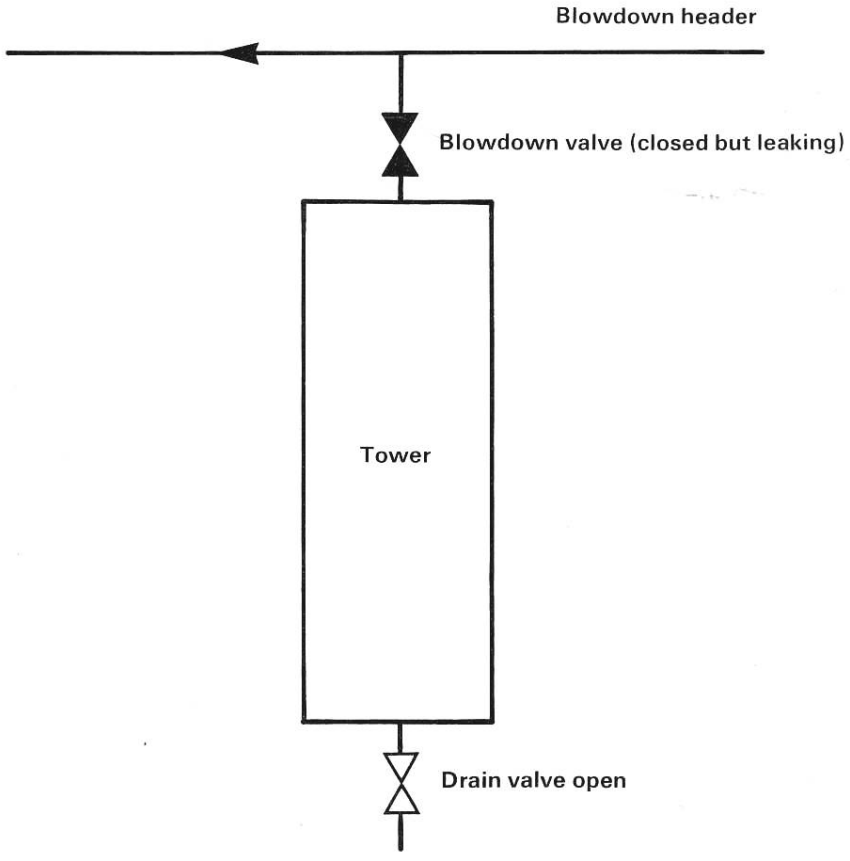
The following are some examples of accidents (in the process industries) caused by reverse flow.

(a) Flow into a plant from a storage vessel or blowdown line.
This is liable to occur when the plant is shut down and depressured.

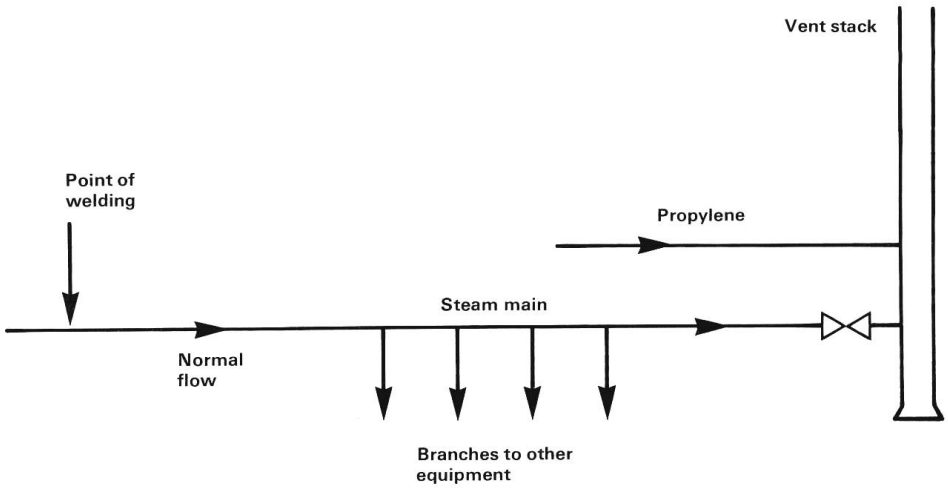
In one incident ammonia flowed backwards from a storage vessel, through a leaking valve, into a reflux drum, into a still and out of an open-end in the bottoms line. Fortunately there was no-one in the area at the time or he might have been killed (Newsletter 17/1).



In an incident in another company a poisonous gas in a blowdown header flowed through a leaking blowdown valve into a tower and out of the drain valve. The operator who was draining the tower was killed (Newsletter 17/2).



In a third incident, a steam main was blown-down for welding. As it cooled propylene was sucked in from a vent stack. When the welder started work an explosion occurred.



When equipment is prepared for maintenance we slip-plate or disconnect lines leading to other items of equipment. We must not overlook blowdown lines and the lines that take products to storage.

(b) Flow from a plant into service lines

This occurs when there is a fall in pressure in the service line. I have seen:-

— a steam line with ice on the outside after it had been blown down and liquefied gas had leaked into it

— a leak on a nitrogen line catch fire

— the paint dissolved in a cabinet that was pressured with nitrogen as acetone had leaked into the nitrogen

— an air line choked with phenol

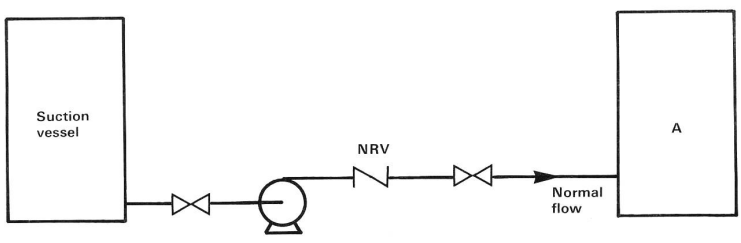
A service which is used intermittently should be connected to process equipment by a flex which is disconnected when not in use, or by double block and bleed valves (If you use a flex do not forget to provide a vent so that it can be depressured before it is disconnected)

If a service is in continuous use it may be connected permanently. If the service pressure is liable to fall below the normal process pressure, then a low pressure alarm should be provided on the service supply; if the process pressure is liable to rise above the normal service pressure then a high pressure alarm should be provided on the process side.

Non-return valves should be fitted on the service lines (Newsletter 21/6).

(c) Reverse flow caused by a failure of a pump

When the pump shown below tripped out, the non-return valve failed to work and the pump was driven backwards by the pressure and head of liquid in vessel A. The impellor disintegrated and the motor was damaged (Newsletter 30/3).



The first fatal acident to occur at Billingham (April 1924) was the result of a non-return valve failing and allowing gas at high pressure to pass backwards through a pump into a low pressure gas line (Newsletter 48/1-5).

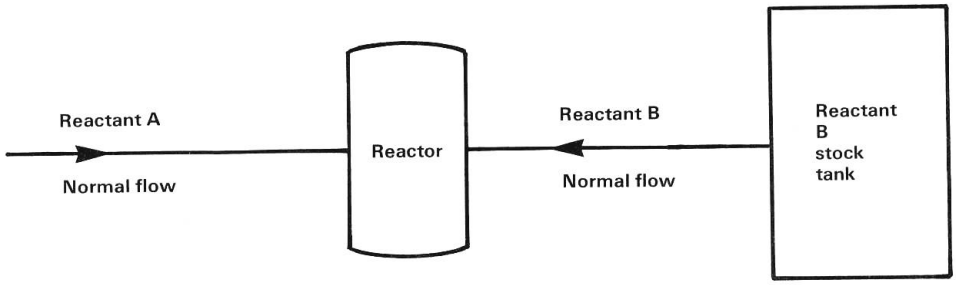
When failure of a non-return valve could have serious consequences, as in these cases, it should be registered for regular inspection. The use of two in series should be considered, preferably of different types to try to avoid common mode failures. Reverse rotation locks on pumps should be considered.

(d) Reverse flow in drains

Reverse flow in drains has frequently caused flammable liquids to turn up in unexpected places. Some years ago construction involving welding had to be carried out next to a compound of small tanks. As sparks were liable to fall into the compound all flammable liquids were removed from the compound. Nevertheless, a small fire occurred. A tank full of water was drained in another part of the plant. The water flow was too great for the capacity of the drains and the water backed up into the compound of small tanks, taking some light oil with it.

(e) Reverse flow from reactors

The most serious incidents resulting from reverse flow have occurred when reactant A has passed back up the reactant B feed line and reacted violently with B in the stock tank.



One incident was described in “Hydrocarbon Processing”, March 1973, p.113. Paraffin wax and chlorine were reacted at atmospheric pressure. Some paraffin wax travelled from the reactor back up the chlorine line and reacted with liquid chlorine in a catchpot that had been installed to collect residue. The catchpot exploded with great violence — bits were found 100 feet away — and other equipment was seriously damaged.

A more serious explosion was described in “Loss Prevention”, Volume 2, 1968, p.125. Ethylene oxide and aqueous ammonia were reacted in a tubular reactor to produce ethanolamine. Some ammonia found its way back into the ethylene oxide storage tank; to do so it had to pass several non-return valves in series and a positive pump; it got past the pump through the relief valve which discharged into the suction line. The ammonia reacted with 30 m^3 of ethylene oxide in the storage tank. There was a violent rupture of the tank followed by an explosion of the vapour cloud which caused damage and destruction over a wide area.

When such violent reactions can occur it is not sufficient to rely on non-return valves. In addition:

(1) The reactant(s) should be added via a small break tank so that if reverse flow occurs only a small quantity reacts and not the main stock

and

(2) The pressure drop in the pipeline should be measured and if it gets too low a trip valve should close automatically This system should have a high reliability and some duplication of components may be necessary.

Conclusions

In an operability study (see the paper by H G Lawley in “Chemical Engineering Progress, April 1974, p.45) reverse flow is one of the deviations considered. Operability studies on new plants should reduce in the future the number of accidents due to this cause.

79/3 SYMBOLS AND THEIR MEANINGS

When cartons of goods are sent abroad instructions such as “fragile” or “this way up” may not be understood. For this reason people often use symbols. However, symbols can also be misunderstood, as shown by the following story from one of our overseas companies.

A storeman asked the meaning of the wine glass symbol which was printed on a number of cartons. He was told that it meant that the contents were fragile, like wine glasses, and should be treated with great care.

Later he found cartons marked with a broken wine glass and said he knew what this meant. “These things are broken already so it doesn’t matter how I handle them now”.

Later the same man found some boxes marked with pictures of an umbrella, indicating that the boxes must not be allowed to get wet. He took it to mean that the boxes must be kept out of the sun.

A few days later he found a large box which had on the outside a picture of a woman carrying a pitcher on her head; the picture meant that the box had to be kept “This way up”. He asked if English women carried large boxes on their heads.

79/4 UNUSUAL ACCIDENTS NO.49

While a new cooler was being pressure-tested (in another company), using an air-driven water pump, a plug blew out and the jet of water injured the fitter and his assistant.

The pressure in the cooler had been raised far above the normal test pressure because the pressure gauge had been fitted to the air supply driving the pump instead of the cooler.

79/5 SOME QUESTIONS I AM OFTEN ASKED

14 — ARE WE EXPECTED TO LEARN THE LESSONS OF ACCIDENTS WHICH HAVE OCCURRED SOMEWHERE ELSE?

Yes, legally and morally we are expected to learn the lessons of accidents that have occurred somewhere else, provided the information is readily available. This is expressed in the old saying, “Every dog is allowed one bite”. Until it has bitten somebody we could plead that we did not know it was liable to bite. As far as industry is concerned we are expected to muzzle our dog if a similar dog has bitten someone.

What is meant by “readily available”? Nobody would expect us to know about an accident described in the Journal of the Outer Mongolian Chemical Society— it does not circulate widely in this country and not many people can read the language it is written in. But information published in well-known British and American journals is certainly “readily available”. If an accident has been described in, shall we say, “Loss Prevention”, published by the American Institute of Chemical Engineers, or the “Loss Prevention Bulletin”, published by the Institution of Chemical Engineers then it is reasonable to expect us to know about it. So far as Petrochemicals Division is concerned I see it as one of my responsibilities to keep readers informed of incidents that have occurred in other companies, on which information is made available to us through publication or in other ways.

We try to do our duty and tell other Companies about incidents which have occurred in ICI, by sending them copies of these Newsletters and by contributing to the “Loss Prevention Bulletin” and other publications.

Now we are making more information available. We have prepared a training package on accidents caused by the over-(and under) pressuring of vessels. The package is based on. the discussions held in the Division in which a group of managers, supervisors or operators discuss some incidents which have occurred and the action which **they think** should be taken to prevent them happening again. Each package contains:-

— Notes for the discussion leader

— Slides illustrating the incidents

— Notes to give afterwards to those present

Each package costs £25 (including VAT and postage) and will be despatched on receipt of a job number or, outside ICI, a cheque payable to ICI.

79/6 WHAT WOULD YOU DO IF YOU SAW A WHITE FOG ON THE ROAD?

What would you do if you were driving along the road in the middle of the day and you saw a white fog ahead of you? Would you assume it was a patch of mist and continue, or would you turn round and drive away?

This question occurred to me after reading a report of an incident in the United States earlier this year where a leak occurred on a liquefied petroleum gas pipeline. The cloud of escaping vapour formed a white fog. A car drove into it and set it alight, and the occupants of the car were killed.

There have been a number of similar incidents in the United States, but no similar incident has occurred in this country. In the United States there are a lot of old pipelines in use which are built to lower standards than those used today, though this particular failure occurred on a new pipeline due to damage to the pipe which was not spotted when it was installed.

Petroleum gas is not visible, but when it escapes from a pipeline it expands and cools, and this causes the water vapour in the air to condense and form a fog. An LPG leak therefore looks like a patch of mist.

79/7 RECENT PUBLICATIONS

(a) On a number of occasions pressure vessels have burst when they got too hot, even though they were protected by pressure relief valves. There was nothing wrong with the relief valves, but the vessels were weakened by the heat to such an extent that they burst at a pressure below the set point of the relief valve. Process Safety Guide No 2 (available from Division Reports Centres by asking for Report No HO/SD/740010/2) explains how vessels can be protected against the effects of heat.

(b) A report (No MDF/1 1/74/A) from one of our overseas companies shows that people can remain for thirty to forty minutes without undue discomfort in a closed room surrounded by an atmosphere containing 2% or 3% ammonia. They could probably remain longer if the gap under the door (8 mm) and the gaps round the door and window were sealed with tape or a wet cloth. (A wet cloth will, of course, only work for gases such as ammonia which are soluble in water). When there is a leak we are usually advised to close all doors and windows, switch off the ventilating fan arid stay indoors. These experiments suggest that this advice is sound.

However, the report suggests that if a person is upwind of a spill it is better to keep heading upwind than to seek refuge in a room.

(c) Report No PC.200,823/A, “The Generation, Spread and Decay of Flammable Vapour Clouds”, available from Division Reports Centres, describes methods of calculating the rate at which a gas, a liquid or a flashing liquid will escape through a hole of known size and the distance the leak will take to disperse to the lower flammable limit. The report deals with leaks close to the ground while Report No 0.200,801/A (mentioned in Newsletter 69/8B and reprinted in the “The Chemical Engineer”, Oct 1974, p 629) deals with high level discharges. It shows how to calculate the minimum velocity at which flammable gases can be discharged safely to atmosphere; it also shows how to calculate the size of the flammable zone and the gas concentration in neighbouring buildings.

For more information on any item in this Newsletter, please write to E.T. at Wilton, or phone ext P2845. If you do not see this Newsletter regularly and would like your own copy, please ask Mrs T to add your name to the circulation list.

August 1975