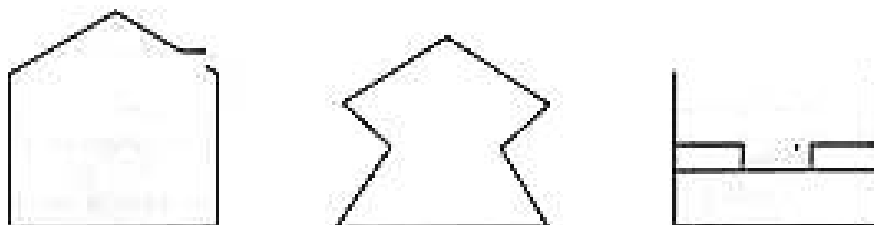


No. 115

TANKS - HOW TO OVERFILL THEM, SUCK THEM IN AND SINK THEIR ROOFS



115/1 Do you distinguish between alarms and reminders?

115/2 How to locate the vent and overflow lines on a tank.

115/3 Two more ways to suck in a tank.

115/4 A road tanker is emptied into the wrong tank.

115/5 How a floating roof sank.

115/6 How can we keep alive the memory of past accidents?

115/7 Where do your relief valves and vents discharge?

115/8 Leaks in badly ventilated buildings can cause explosions.

115/9 If I modify the plant after an accident, is this evidence that the original design was unsafe?

115/10 The modification chain reaction.

An Engineer's Casebook — Slip-on Flanges.



IMPERIAL CHEMICAL INDUSTRIES LIMITED
PETROCHEMICALS DIVISION

115/1 AN ALARM AND A REMINDER CONFUSED

As a result of an error in setting a valve, a tank overflowed. It was then found that the tank high level alarm light was glowing; this showed that the alarm had sounded and that someone had cancelled the hooter. The operating team had not done so, as none of them had been in the control room.

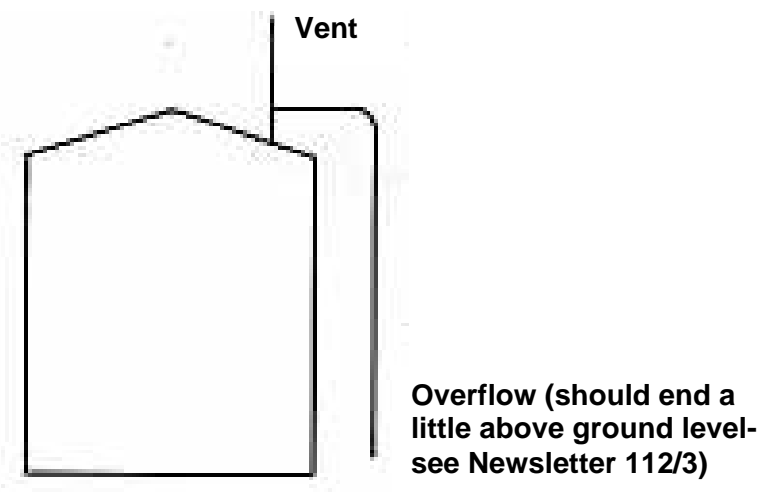
The alarm is on the same panel and has the same sound and colour as the low flow alarm on a tanker filling line which can operate 70 times per day, every time a driver starts to load a compartment of a road tanker. This alarm is installed to warn the operators that the flow is too low to drive the pump that adds dye to the load and it usually operates before the flow builds up to its normal rate. It is believed that someone passing through the control room heard the alarm hooter, assumed that the low flow alarm was operating and cancelled the hooter.

An alarm indicating an approaching hazard should be distinguished from a device that merely indicates a departure from normal process conditions.

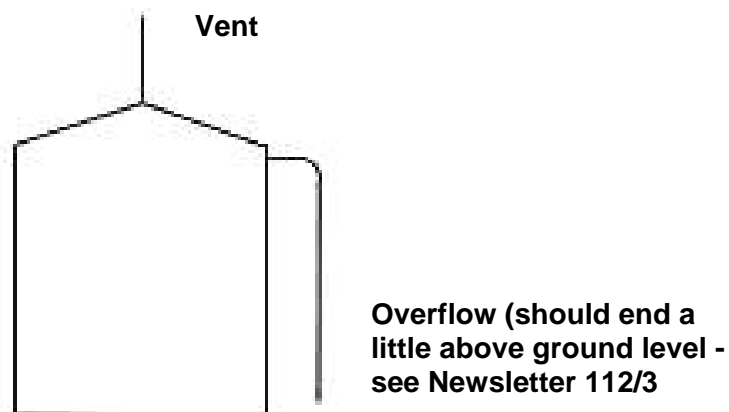
Note: In most control rooms, an operator is always present. This is not necessary in the control room where the incident occurred as it controls only storage and filling operations.

115/2 COMMENTS FROM READERS

Newsletter 112/5 showed a vent and overflow pipe on a storage tank.

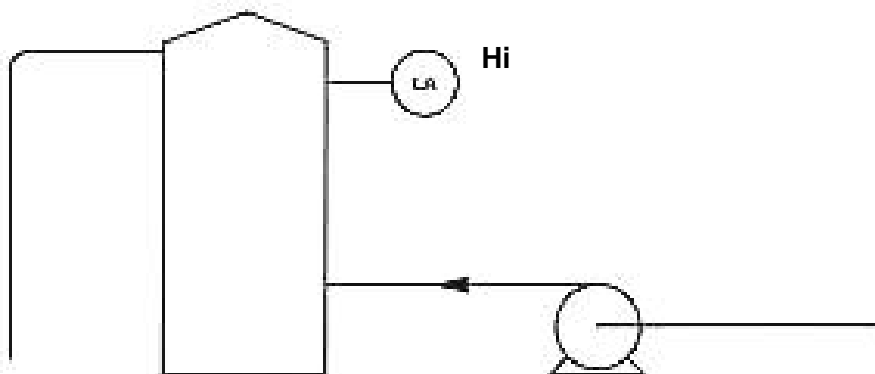


Several readers have pointed out that it would be better to arrange them as shown below, as then no hydrogen can accumulate under the roof and the liquid cannot rise above the top of the walls. The weld at the top of the walls is a "weak seam", designed to break if there is an explosion or excessive pressure in the tank and is not designed to withstand even a small head of liquid.



115/3 TWO MORE WAYS TO SUCK IN STORAGE TANKS

A tank, in another company, was fitted with an overflow pipe which came down to ground level.



The tank was fitted with a high level alarm but this was ignored as the operators had been asked to fill the tank as full as possible.

They overfilled it. The overflow line filled up and the contents of the tank siphoned out into the bund faster than the liquid was being pumped in. This produced a vacuum in the tank and it collapsed.

Low pressure storage tanks should have vents (or pressure/vacuum valves) on their roofs, as shown in the previous item.

Another incident in which a tank was emptied by a siphon was described in Newsletter 58/3.

In the second incident, which also occurred in another company, a 100 m³ tank was steamed out between batches. The operator did not give the tank time to cool before adding another batch of cold liquid and the tank caved in, even though it was fitted with a 6 inch vent.

Other ways in which tanks have been sucked in were described in Newsletters 96/1 and 2, 81/1, 78/8, 77/2, 47/5b, 42/1, 29/7 and 27/4.

Looking through old Newsletters, it becomes clear that many accidents cannot be prevented by writing rules or altering plants but only by increasing our understanding of the way equipment works and its limitations. It would be impossible to write a set of rules covering all the ways in which tanks might be sucked in. But we can try to increase people's understanding of the fact that tanks are fragile and that even a very small change in pressure can damage them. The cartoons by Brian Drummond distributed with Newsletters 9 and 56 were an attempt to do this. As many readers may not have seen them they are distributed again with this Newsletter.

115/4 ANOTHER ROAD TANKER IS DISCHARGED INTO THE WRONG TANK

Earlier Newsletters have described how road and rail tankers were emptied into the wrong tank. Now another incident has occurred, in another Division. A tanker carrying isopropanol arrived at a Works during the night and was directed to a certain plant.

The plant was expecting a load of ethylene glycol. When a tanker turned up the operators did not check to see if it contained the right material and they did not look at the delivery note. They simply emptied the tanker into the ethylene glycol tank and contaminated 100 tons of ethylene glycol.

Fortunately, in this case the two materials did not react; people who have emptied acid into alkali tanks have been less fortunate.

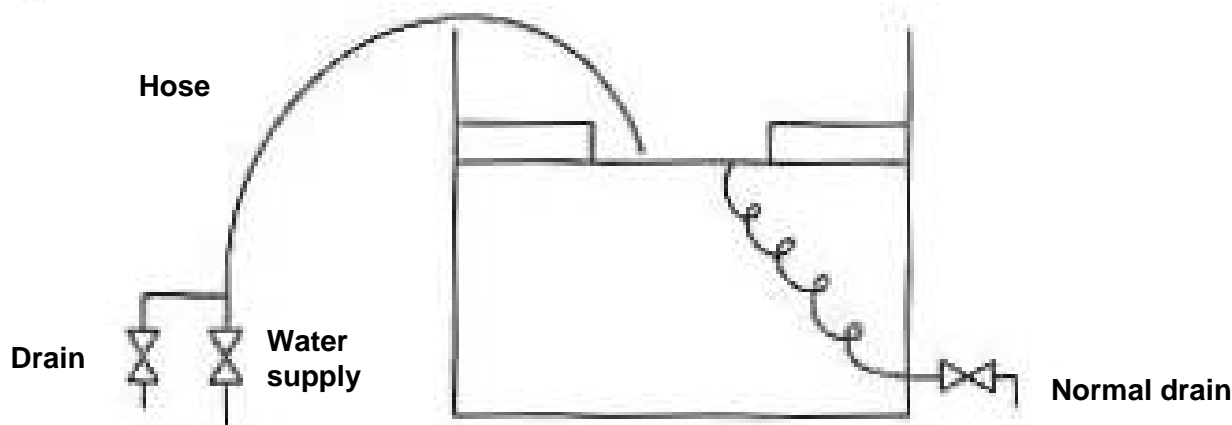
Reminder: Newsletter 59/3 described how prompt action by a clerk, who spotted an unusual cylinder delivery, prevented a plant using oxygen instead of nitrogen.

115/5 UNUSUAL ACCIDENTS No 80

The flexible roof drain on a floating roof tank choked (in another Company).

It was decided to drain rainwater off the roof with a hose.

To prime the hose and establish a siphon, the hose was connected to the water supply. It was intended to open the valve on the water supply for just long enough to fill the hose; this valve would then be closed and the drain valve opened.



However, the water valve was opened in error and left open, with the drain valve shut. Water flowed onto the floating roof and it sank in thirty minutes.

Temporary modifications should be examined with the same thoroughness as permanent ones.

115/6 HOW CAN WE KEEP ALIVE THE MEMORY OF ACCIDENTS THAT HAVE HAPPENED IN THE PAST?

Newsletters 108/7 and 72/5 suggested a plant black book — a collection of reports of accidents that have happened on the plant or on similar plants elsewhere, which is compulsory reading for all new managers.

One of our overseas companies has a better suggestion. The report on a recent dangerous incident states that a film of the incident damage will be shown at monthly safety meetings at regular intervals and to all new operators when they join the plant.

115/7 WHERE DO RELIEF VALVES AND VENTS DISCHARGE?

A relief valve on an ammonia refrigeration system lifted and discharged some ammonia vapour to atmosphere. The vapour was promptly pulled into the building by the air conditioning unit and distributed throughout the plant. Fortunately, there was no-one in the plant at the time and the man who went to investigate had access to breathing apparatus.

All relief valves and vents should discharge clear of air intakes and working platforms.

When flammable gases are handled, the area classification may draw attention to the poor location of vents and air intakes. Do we need a similar study for toxic gases?

Reminder: Newsletter 91/3 described how a man installing a new light was affected by fumes from a ventilation duct.

115/8 A LOOK BACK AT NEWSLETTER 14 (November 1969)

This year I have seen reports on three explosions in closed-in, badly-ventilated buildings, all of which had fatal consequences.

In the first incident, in Africa, briefly described in Newsletter 12/4a, a leak of light oil occurred in a pumphouse and was ignited by a diesel engine.

In the second incident, in Germany, a leak of ethylene oxide in a pumphouse was ignited by an unknown cause, possibly static.

In the third incident, in this country, a leak of gas in a compressor house was ignited by an unknown cause, possibly static, possibly faulty electrical equipment.

All these incidents show that causes of ignition cannot be completely eliminated and that mixtures of flammable gas or vapour with air may ignite.

All these incidents might have been prevented by better ventilation, by siting the equipment in the open air. There is no need whatever to put pumps in a pumphouse.

Compressors are more difficult; some protection may be necessary. We usually supply a roof and part-walls; there are no walls at compressor level; the walls start about 10 feet above the level of the compressor platform.

Tests show that even on a still day the ventilation in these part-open structures is many times (say 10-40 times) better than in a closed-in building supplied with forced ventilation.

One of the Division's new plants, not yet finished, was supplied with an almost fully walled-in compressor house; the walls were put there to cut down the noise outside.

After we saw the reports on the three incidents, we pulled down the new walls.

Note: Newsletters 35/2, 37/4, 93/2 and 112/1 described other explosions in badly ventilated buildings, while Newsletter 41/1 described a successful compromise between ventilation and weather protection, (now reprinted in "Loss Prevention and Safety Promotion in the Process Industries", Elsevier, 1974, page 369).

Occasionally pumps are put in a pumphouse but their electric motors are put outside in a "safe" area. Do not remove the walls without checking that the motors are suitable for a Zone 1 or Zone 2 area as appropriate.

115/9 WHAT THE LAW SAYS No.19

If I modify the plant after an accident, is this evidence that the original design was unsafe? The short answer is "No".

English law, ... although not entirely clear would appear reluctant to stigmatise machinery as defective or unreasonably dangerous merely on the ground that after an injury has occurred to an operative, remedial measures were taken of an accident-prevention nature. In *Hart v Lancashire and Yorkshire Co.* the court distilled the essence of the matter as follows: "it is not because the defendants have become wiser and done something subsequently to the accident, that their doing so is to be evidence of any antecedent negligence on their part in that respect Here the rail company had altered their way of changing points after an accident had occurred. It was held that this was not admissible to establish that the accident had been caused by negligence.

115/10 THE MODIFICATION CHAIN REACTION

Earlier Newsletters, especially 83 and 111, have described how changes often produce unexpected and unforeseen results. Sometimes there is a chain reaction. An initial modification leads to an unforeseen result; a further modification is then made; this produces more unforeseen results, and so on.

For example, in 1965 an enclosed sports palace, the Astrodome, was opened in Houston, Texas. It had a transparent plastic roof.

Unforeseen result: Baseball balls could not be seen against the roof.

Modification: The roof was painted black.

Unforeseen result: The grass died.

Modification: Plastic turf was laid down. It proved so popular and got so much publicity that it was also laid on over a hundred outdoor sports fields.

Unforeseen result: An increase in injuries.

Modification: Programmes were started to modify the turf and to devise special footwear for use on plastic turf.

From "Technology and Social Shock" by E W Lawless, Rutgers University Press, New Jersey, 1977, \$6.95.

115/11 DON'T CARRY GAS CYLINDERS IN A VAN

Cylinders containing oxygen, propane, acetylene or other flammable or toxic gases should not be carried in vans as even a small leak may quickly build up to a flammable or toxic concentration. They should be carried in open trucks.

115/12 GENKLENE

Newsletter 113/7 said:

"Do not use kerosene for cleaning. Use Genklene instead. But if you must use flammable solvents keep them in closed containers."

A reader points out that Genklene should also be kept in closed containers to reduce evaporation and keep down the concentration of vapour in the atmosphere.

For more information on any item in this Newsletter please 'phone ET (Ext. P.2845) or write to her at Wilton. 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.

September 1978

An Engineer's Casebook No 15

SLIP-ON FLANGES—AN UNUSUAL FAILURE

Slip-on flanges are considerably cheaper than weld neck flanges and are in widespread use on the less rigorous pipeline duties. As the name implies, the flange is slipped over the outside diameter of the pipe until the end of the pipe is short of the flange face by an amount equal to the pipe wall thickness. Fillet welds are then used to secure the pipe to the flange, the main strength being in the back weld to the hub. There is considerable diametral clearance between the inside diameter of the flange and the outside diameter of the pipe, 1/16 inch for 2 inch n.b. pipe increasing to ¼ inch for 24 inch n.b. pipe. This clearance aids alignment and fit up in the field.

Piping design codes BS.3351 and ASA B31 .3 both contain the following cautionary note:

‘The use of slip-on flanges should be avoided where many large temperature cycles are expected, particularly if the flange is not insulated.’

It will be noted that no quantitative guidance is given. What is “many”? 100, 1 000 or more? What is “large”? 200, 300, 400° C?

A plant using class 300 stainless steel slip-on flanges and thin wall stainless steel pipe ran into trouble after about eight year's life which represented about 1800 temperature cycles. Flange welds started to crack and ultimately major repairs were necessary to all the slip-on flanges in hot cyclic service.

A few simple calculations demonstrated that very high stresses were induced in the welds between the pipe and flange by differential thermal expansion as the system warmed up. The thin wall pipe used had a low heat capacity and was in direct contact with the process fluid. The flange, on the other hand, had a large capacity and was relatively slow to respond to rising fluid temperature. The use of stainless steel, which has a coefficient of linear expansion about half as much again as carbon steel, aggravated the problem.

In this particular case a differential temperature well in excess of 100°C was measured between the pipe wall and flange hub as the system warmed up to its operating temperature of 450°C. The corresponding thermal strain gave rise to a stress level of over 1500 N/mm² (more than 100 tons/sq inch) in the welds. This stress, though applied for only a few minutes, resulted in total rupture, by cracking, after 1800 cycles.

Guidance given in design codes whereby the allowable design stress can be used without reduction up to a cyclic life of 7000 applies only where the actual level of stress is within that allowable by the code for the particular material used.

E H Frank

WHO'S WHO IN SAFETY



No 26 - Mr J R COCKERILL

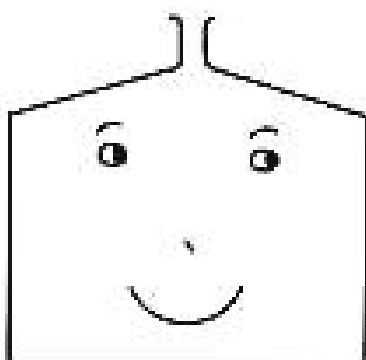
Dick Robertson (Who's Who in Safety No 4, Newsletter 87) retired last year and has been succeeded as Fire Design Engineer by Bob Cockerill.

Bob is a country boy, born in Whitby, and raised in Northallerton. He joined ICI as an apprentice in 1952, and later joined Engineering Department, working on Power Station design. Subsequently he worked on several plants at Wilton, Billingham and North Tees and spent a period in Research Department.

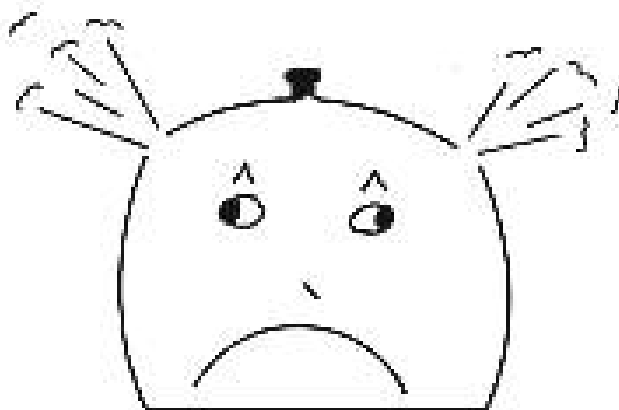
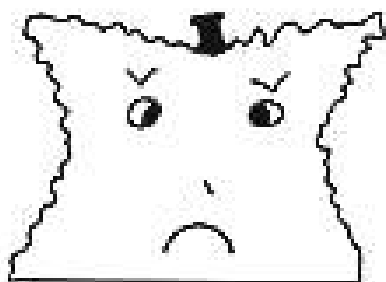
Recently he spent two years commuting to Madrid as liaison engineer for a phenol project and claims to know every excuse in the British Airways and Iberia repertoire for delays, diversions, lost luggage etc.

Having recently joined the Fire Design Section he appreciates the help provided by the experienced members of the fire-fighting community, especially Dick Robertson, but believes that his project engineering experience will bring a different and worthwhile slant to the job of Fire Design engineer.

Bob is married with two daughters and a son. His hobbies include drawing and golf.



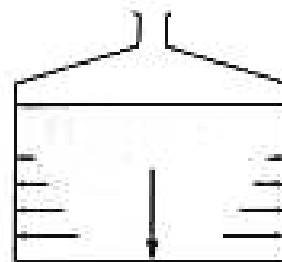
HOW STRONG IS A STORAGE TANK?



A STORAGE TANK IS DESIGNED:—

1 TO HOLD LIQUID

Liquid exerts pressure on the sides and base of the tank
Pressure = head of liquid

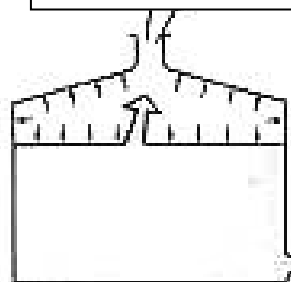


Air and vapour
which were in tank

2 TO BE FILLED

For liquid to get in air and vapour must get out. If they can't the tank will be pressurised. For air and vapour to be pushed out the pressure in the tank must be slightly above atmospheric pressure.

The tank is designed for an internal pressure of 8 ins water gauge (W.G.)

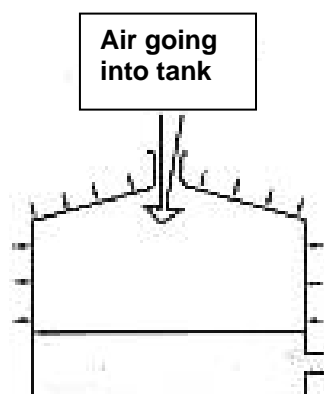


Liquid
in

3 TO BE EMPTIED

For liquid to get out air must get in. If it can't the tank will be under-pressured. For air to be sucked in the pressure in the tank must be slightly below atmospheric pressure.

The tank is designed for an external pressure (or vacuum in the tank) of 2~ ins W.G.



Liquid
out

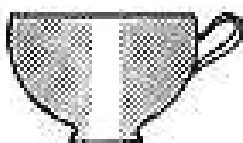
WHAT ARE INCHES WATER GAUGE?

They are a measurement of pressure, used for very low pressures:-

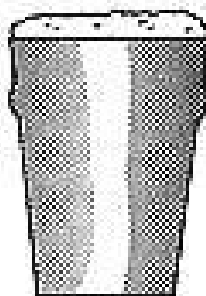
8 ins W.G. = 1/3 pound/square inch

2 1/2 ins W.G. = 1/10 pound/square inch

Or put another way

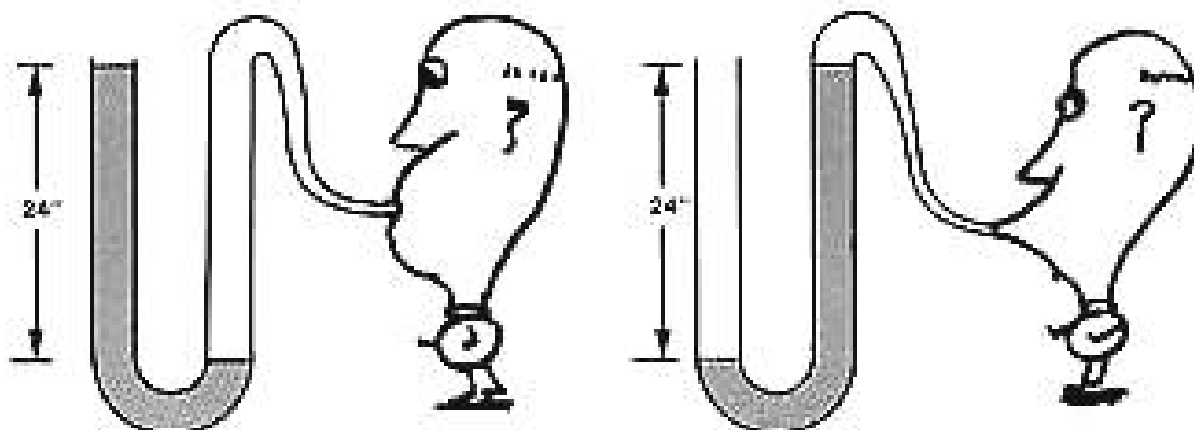


2 1/2 ins W.G. is the pressure at the bottom of a cup of tea



8 ins W.G. is the pressure at the bottom of a pint of beer.

YOU CAN BLOW OR SUCK ABOUT 24 INS W.G.



That means by just using your lungs you could over- or under-pressure a storage tank.

(Because of the volume of air it would take you a long time).

If you don't believe it, because storage tanks always look big and strong, just study the table below.

If a Heinz baked beans tin has a strength of 1, then:-

	SHELL	ROOF
Heinz Baked Bean tin (small)	1	1
40 Gallon drum	1/2	1/3
50 m ³ tank	1/3	1/8
100 m ³ tank	1/4	1/11
500 m ³ tank	1/6	1/33
1000 m ³ tank	1/8	1/57

Next time you eat baked beans just see how easy it is to push the sides or top with your fingers - *and then look at the table again.* (Any small tin will do if you don't like baked beans).

Note too:- The bigger the tank the more fragile it is.
The roof is weaker than the shell.

Up to 1000 m³ tank shell and roof are only as thick as the line under these words.



IF ALL THAT'S TRUE - IS A STORAGE TANK STRONG ENOUGH?

Yes A 1000 m³ tank has a factor of safety of 2 against failure (smaller tanks have bigger safety factors) - provided it is operated within the very low pressures allowed.

Most of the pressures we have available are *many times bigger* than the allowable pressures, that is 8 ins W.G. inside, 2½ ins W.G. outside

FOR EXAMPLE

Full atmospheric pressure outside = 150 times bigger

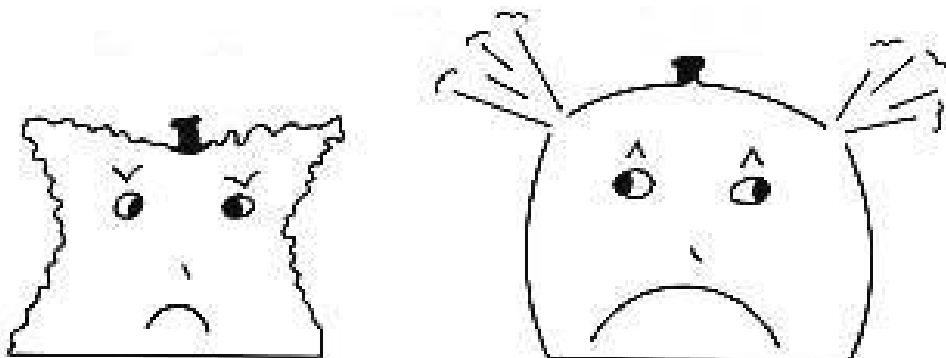
Transfer pump head inside = 120 times bigger

40 p.s.i. Nitrogen inside = 120 times bigger

100 p.s.i. Steam inside = 300 times bigger

All of these pressures or even a small part of them will cause the tank

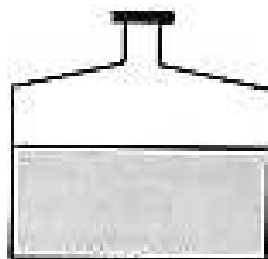
To **IMPLODE** or **EXPLODE**

**HOW DO WE STOP THIS HAPPENING?**

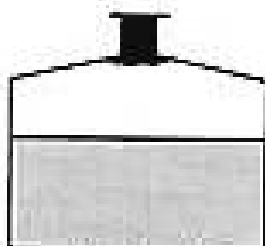
By making sure that:-

- 1 The tank has a vent big enough to relieve all sources of pressure that might be applied to it.
- 2 The vent is always clear.
- 3 The vent is never modified without the authorisation of the plant or section engineer.

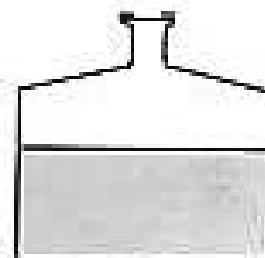
Here are some typical faults in vents which should never happen.



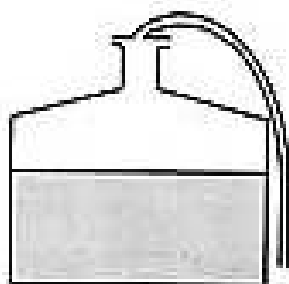
Vent blocked



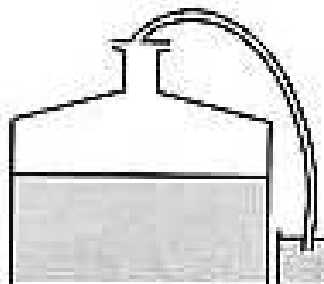
Vent bunged up



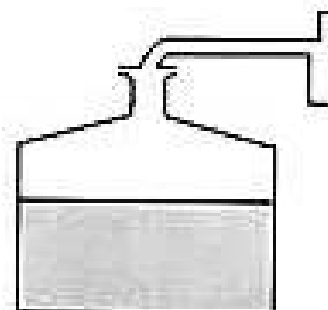
Flame trap choked



Flex connected to vent



Vent connected to water seal



Vent modified

Don't look surprised — One (or more?) of these has almost certainly happened on your plant in the last year — it could have had serious consequences.

ONLY KNOWLEDGE AND VIGILANCE WILL STOP IT HAPPENING AGAIN