IMPERIAL CHEMICAL INDUSTRIES LIMITED
PETROCHEMICALS DIVISION

SAFETY NEWSLETTER No. 83

MUST PLANT MODIFICATIONS LEAD TO ACCIDENTS?

This month the Safety Newsletter is devoted to a single topic — the control of plant modifications. The information in the following pages — some of which has appeared in earlier Newsletters — is based on the discussions held in the Division during 1975. Nearly every week from February 1975 onwards a group of managers and engineers discussed the incidents described in Part 1 and made the recommendations described in Part 2. This Newsletter therefore serves also as a record of those discussions.

Part 1 describes a number of incidents, some serious, which occurred because plant modifications produced results which were not foreseen. Part 2 discusses ways of preventing similar incidents in the future. The emphasis is on modifications to the equipment but the same principles apply to modifications to the process, such as a change in catalyst, raw materials or operating conditions.

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MUST PLANT MODIFICATIONS LEAD TO ACCIDENTS?

"I see you're admiring my little box" the Knight said in a friendly tone. "It's my own invention — to keep clothes and sandwiches in. You see I carry it upside-down, so that rain can't get in"

"But the things can get out" Alice gently remarked. "Do you know the lid's open?"

"I didn't know it" the Knight said, a shade of vexation passing over his face."Then all the things must have fallen out! and the box is no use without them."

From "Through the Looking Glass", by Lewis Carroll.

Like the White Knight we may have our minds so firmly fixed on the problem we are trying to overcome that we fail to foresee the side-affects of our solution. We are so pleased that we have managed to solve the problem that we do not search diligently for all the consequences.

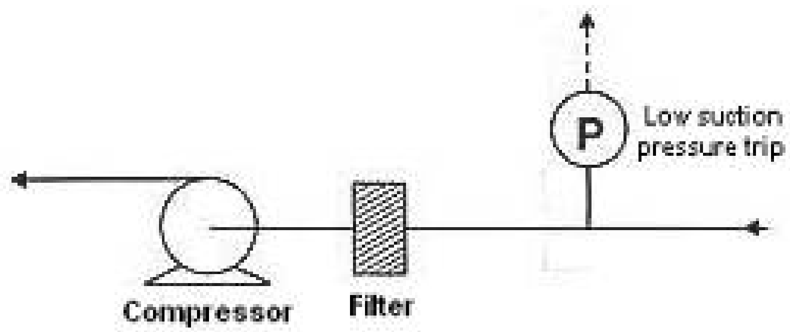
Part 1

ACCIDENTS WHICH OCCURRED BECAUSE THE RESULTS OF PLANT MODIFICATIONS WERE NOT FORESEEN

Modifications Made During or Just Before Start-up

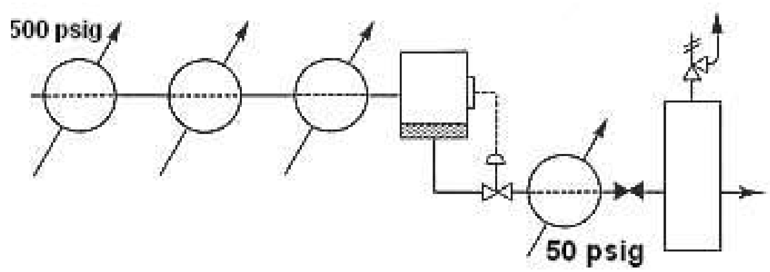
A Start-up is often a time when many modifications are made and always a time of intense pressure. It is therefore not surprising that some modifications introduced at this time have resulted in serious unforeseen consequences.

A1 One incident started when a temporary start-up filter was put in a compressor suction line. Unfortunately, it was placed between the compressor and the low suction pressure trip.



The filter choked, the compressor sucked a vacuum, some air was sucked in and this caused a decomposition reaction to occur further on in the process where the pressure was higher. This caused two pipe joints to spring, the escaping gas ignited and the succeeding fire caused over £100,000 damage and many months delay.

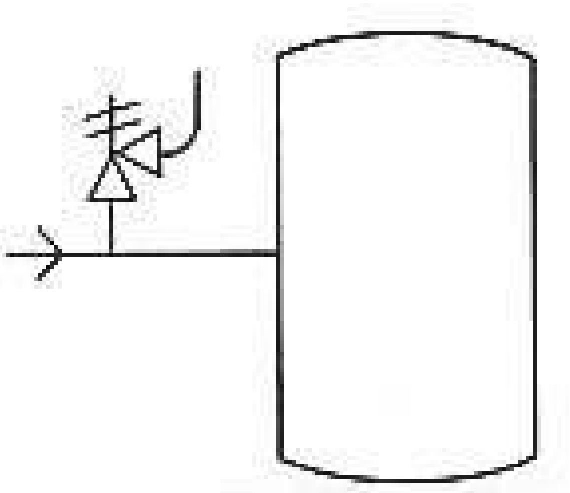
A2 Another incident occurred in another company. A process stream passed through a series of heat exchangers and a catchpot into a vessel. The relief valve on the vessel also protected the last exchanger.



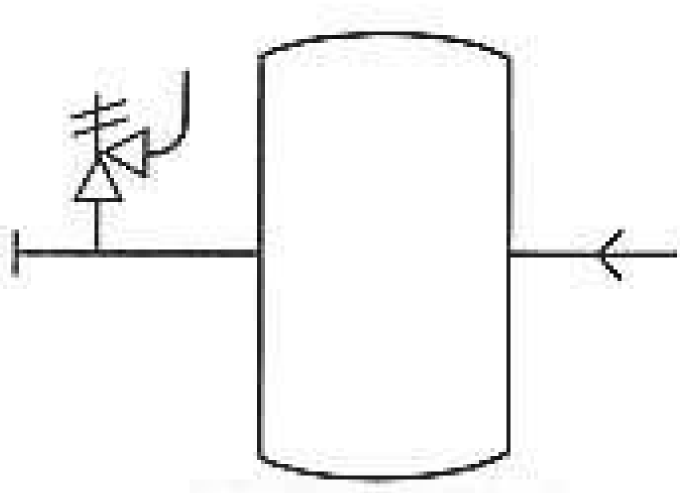
The start-up team had an extra valve fitted during construction; they decided it might be useful in preventing back-flow during start-up. The design contractor said that experience showed that the valve was unnecessary but he did not say that it was unsafe.

During start-up this valve was closed and the whole train of exchangers was subjected to the full upstream pressure. When the pressure in the last exchanger reached 400 psig, the exchanger, which was designed for 50 psig, burst. Here was a major fire and a big delay in start-up.

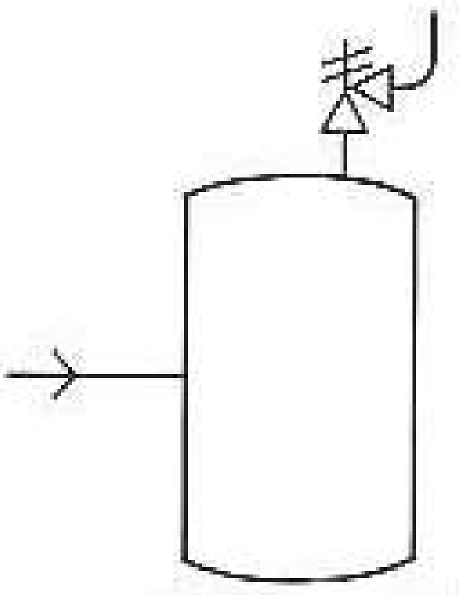
A3 On one plant a repeat relief and blow-down review was carried out one year after start-up. The start-up team had been well aware of the need to look for the consequences of modifications and had tried to do so as they were made. Nevertheless the repeat relief and blow-down review brought to light twelve instances in which the assumptions of the original review were no longer true, and additional or larger relief valves, or changes in the position of a relief valve, were necessary. The following are some examples.



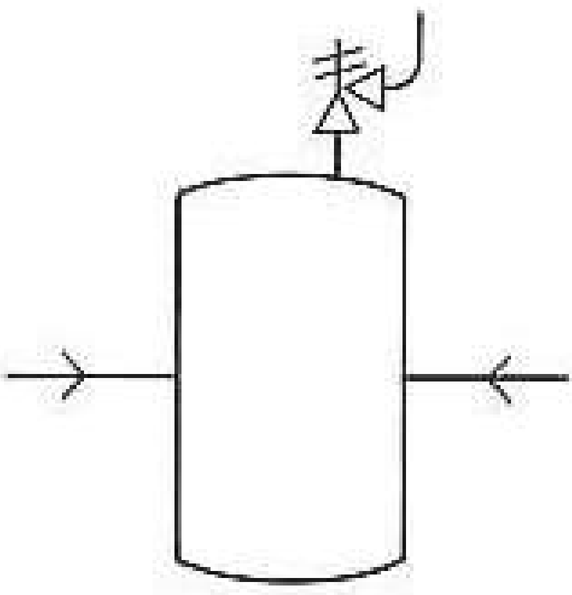
The relief valve was fitted on the inlet branch so that the flow would keep the branch clear



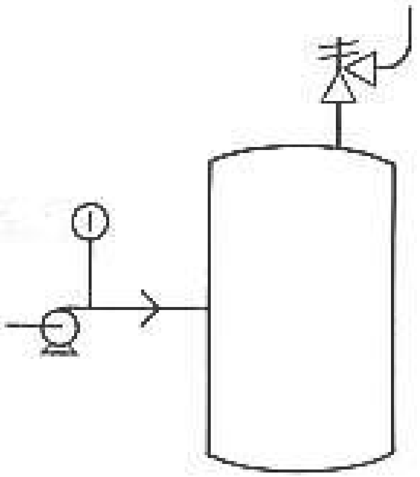
The inlet was moved to a new position leaving the relief valve on a ‘dead leg’.



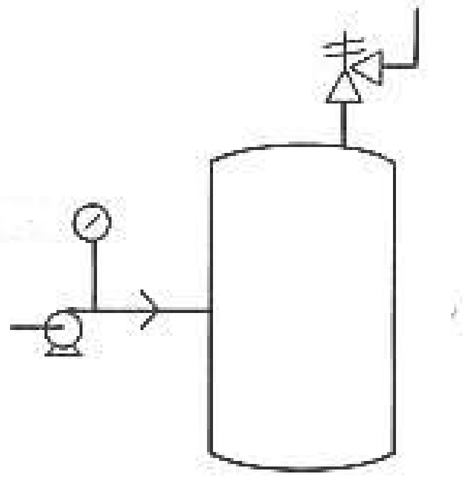
The relief valve was sized to take the full inlet flow with all exit lines closed.



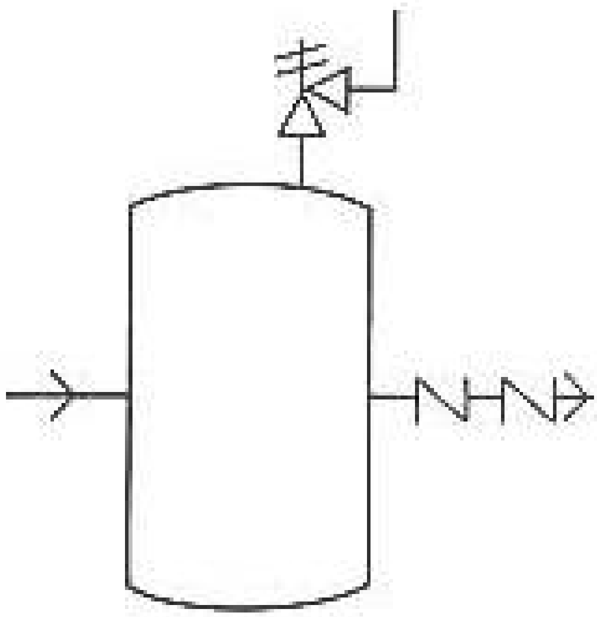
An extra inlet line was added. If both lines are used together the relief valve will be too small.



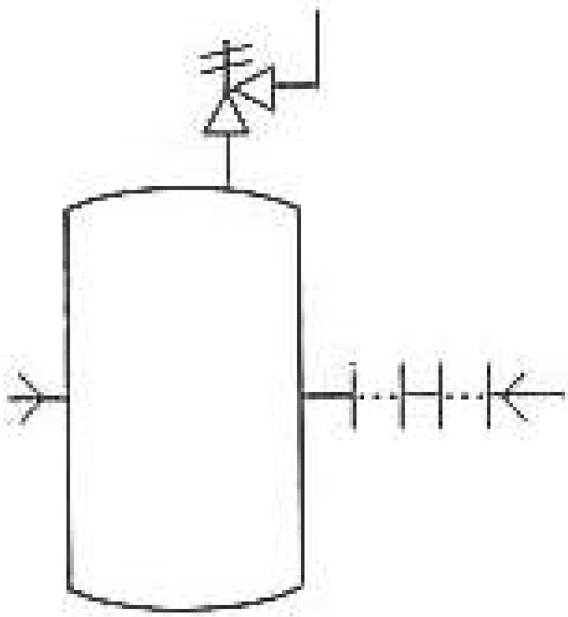
The vessel was designed to withstand the maximum pressure the pump could deliver. The relief valve was not designed to take the maximum flow from the pump



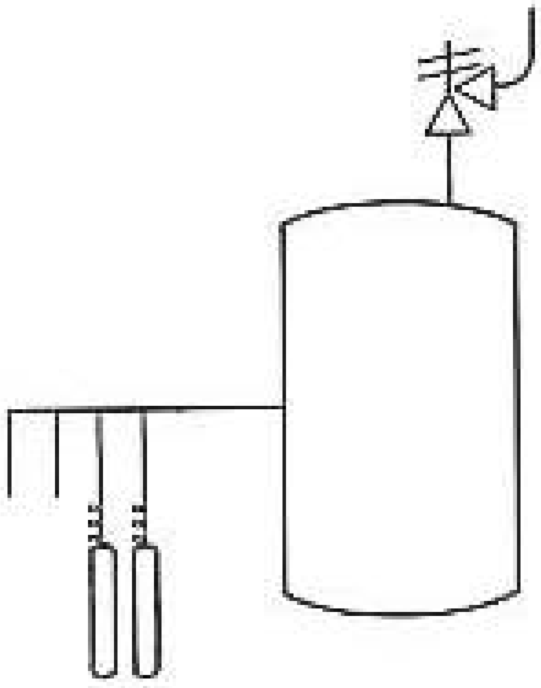
The pump actually proved capable of producing 20 psi more than design. If the exit from the vessel is isolated when the pump is running the vessel will be overpressured.



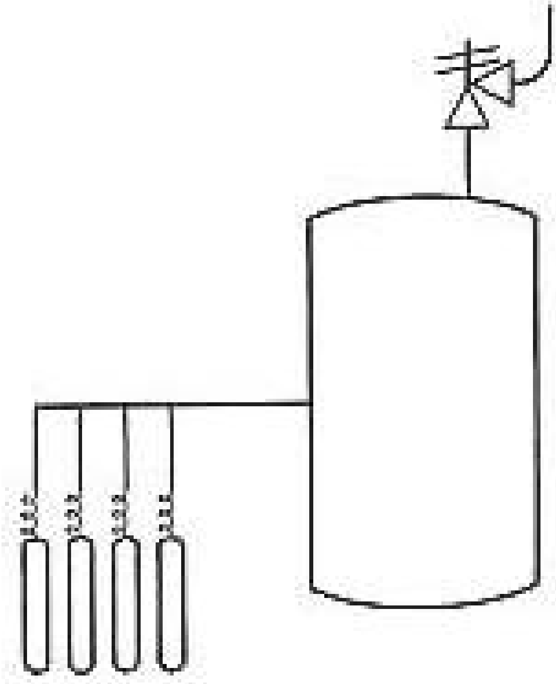
The relief was sized on the assumption that two non-return valves in series would prevent back-flow into the vessel.



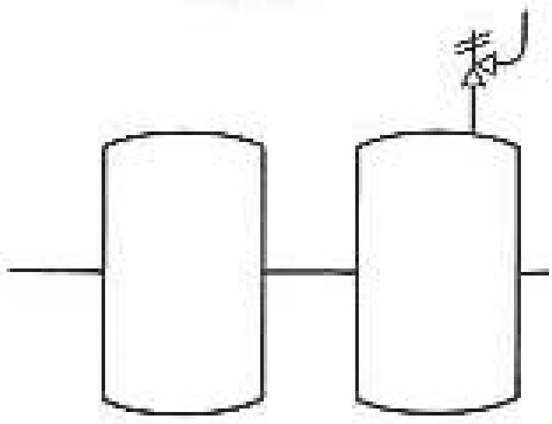
Both non-return valves corroded allowing back-flow to take place



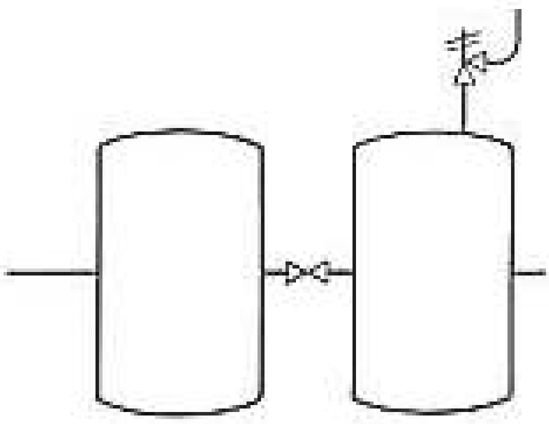
The relief valve was designed to protect two vessels which were connected together by a line without any valve or other restriction between them.



Inevitably four cylinders were connected up and sometimes used



A single relief valve was designed to protect two vessels which were connected together by a line without any valve or other restriction between them.



An extra isolation valve was fitted between the two vessels, thus making it possible to isolate the first vessel from the relief valve.
In another similar case, chokes occurred in the line between the two vessels.

The line diagrams had been kept up-to-date despite the pressures on the plant staff during start-up and this made it easier to repeat the relief and blowdown review. The plant staff were so impressed by the results that they decided to have another look at the relief and blowdown after another year.

B Minor Modifications

This term is used to describe modifications so cheap that they do not require financial sanction. Often the only documentation associated with them has, in the past, been a workshop chit or just a clearance certificate (permit-to-work).

B1. A small leak of liquefied petroleum gas (LPG) from a passing drain valve on a pipeline produced a visible cloud of vapour about 5 feet across. The leak was soon stopped by closing a valve but the investigation brought the following to light:

1. There should have been two valves in series or a single valve and a blank.

2. The valve was made of brass, was of a type which is stocked for use on central heating and domestic water systems and is not of the correct pressure rating for LPG.

3. The valve was screwed onto the pipeline, although screwed fittings are not allowed on new installations except for domestic water lines and certain small bore instrument lines.

4. Since the LPG fire at Feyzin in 1966, which killed 18 people and injured 81, the Division has drawn up standards for LPG, tried to publicise them and carried out numerous inspections to see if the equipment is up to standard. £30,000 had been spent on the plant concerned on improving the safety of the LPG handling equipment. Nevertheless, subsequently someone installed a sub-standard branch. Presumably the detail on the branch was not specified correctly, if at all, on the chit placed on the plumbers; in addition, neither the man who installed the branch, nor the supervisor who handed the job back, nor the man who accepted the clearance back, none of the men who used the branch and none of the men who passed by, noticed anything wrong.

   Like the plants in our gardens, our plants grow unwanted (and often unhealthy) branches.

B2 In another incident, a modification so simple that it required only a clearance certificate, resulted in the end blowing off a tank and fatal injuries to two men who were working in the area.

The tank was used for storing, in the liquid form, a product which melts at 97°C. It was therefore heated by a 100 psi steam coil. At the time of the incident the tank was almost empty and was being prepared to receive some product. The inlet line was being blown with compressed air to prove that it was clear — the normal procedure. The air was not getting through and the operator suspected a choke in the pipeline.

In fact, the vent on the tank was choked. The air pressure (75 psig) was sufficient to burst the tank (design pressure 5 psig).

Originally the tank had a 6 inch diameter vent but at some time this was blanked off and a 3 inch diameter dip branch was used instead as the vent.

There were several other things wrong. The vent was not heated; its location made it difficult to inspect; most important of all, neither manager, supervisors or operators appreciated that if the vent choked the pressure of the air was sufficient to burst the tank.

Nevertheless, if the 6 inch vent had not been blanked the incident would not have occurred.

B3 Other minor modifications which have had serious affects on plant safety are:

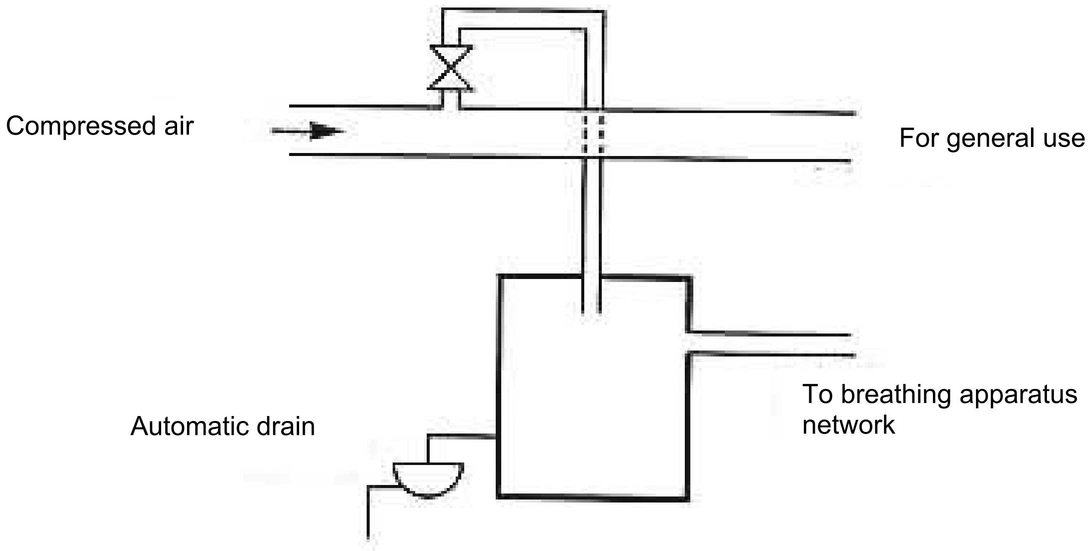
Removing a restriction plate which limits the flow into a vessel and which has been taken into account when sizing the vessel's relief valve.

Fitting a larger trim into a control valve when the size of the trim limits the flow into a vessel and has been taken into account when sizing the vessel's relief valves.

C Modifications Made During Maintenance

Even when systems for controlling modifications have been set up, modifications often slip in unchecked during maintenance — someone decides, for what he thinks is a good reason — to put the plant back slightly differently.

Thirty years ago a special network of air lines was installed for use with breathing apparatus only. A special branch was taken off the *top* of the compressed air main as it entered the Works.



For thirty years this system was used without any complaint.

Then one day a man got a faceful of water while wearing a face mask inside a vessel. Fortunately, he was able to signal to the standby man that something was wrong and he was rescued before he suffered any harm.

On investigation it was found that the compressed air main had been renewed and that the branch to the breathing apparatus network had been moved to the *bottom* of the main. When a slug of water got into the main, it all went into the catchpot which filled up more quickly than it could empty. Unfortunately, everyone had forgotten why the branch came off the top of the main and nobody realised that this was important.

A very similar incident occurred on a fuel gas system. When a corroded main was renewed, a branch to a furnace was taken off the bottom of the main instead of the top. A slug of liquid filled up the catchpot and extinguished the burners.

D Temporary Modifications

The most famous of all temporary modifications is the by-pass pipe installed at the Nypro factory at Flixborough in March 1974, which failed two months later, causing the release of about 50 tons of hot cyclohexane, an unconfined vapour cloud explosion and the loss of 28 lives. The by-pass pipe was built by men who did not know how such pipes should be designed — very few engineers have the specialised knowledge necessary to design highly-stressed piping — but in addition they did not realise that specialised design was necessary — they did not know what they did not know.

The detailed story of the Flixborough explosion is too well known to need repetition. Instead, two other temporary modifications will be described.

D1 The first incident, two years before Flixborough, was handled impeccably.

One Sunday morning in 1972 vapour was seen coming through the lagging on a large cyclone which separates catalyst dust from a stream of flammable vapour at about 400°C and 10 psig. The plant was immediately shut down and the lagging removed from the area. A small hole, about 3/8 inch long and 1/8 inch wide, was found in the vessel. A full internal and external examination of the vessel and associated pipe-work was carried out. It was found that severe erosion had occurred in the vessel, but the pipework was OK. At a meeting held on the following Wednesday it was decided to remove the vessel for repair and replace it with a temporary by-pass pipe.

The Engineering Department worked late that day designing the temporary pipe and supports. It was 10 p.m. when they finished.

By the following Sunday morning the workshops had fabricated the pipe and supports and installed them on the plant. Feed was started on the following day and by Tuesday the plant was fully on line and on specification.

The temporary pipe was 36 inches in diameter, 15 feet long and contained two bends.

The whole incident occupied nine days, several days longer than on Flixborough, but during this time:

1 The by-pass pipe and supports were properly designed in the drawing office.

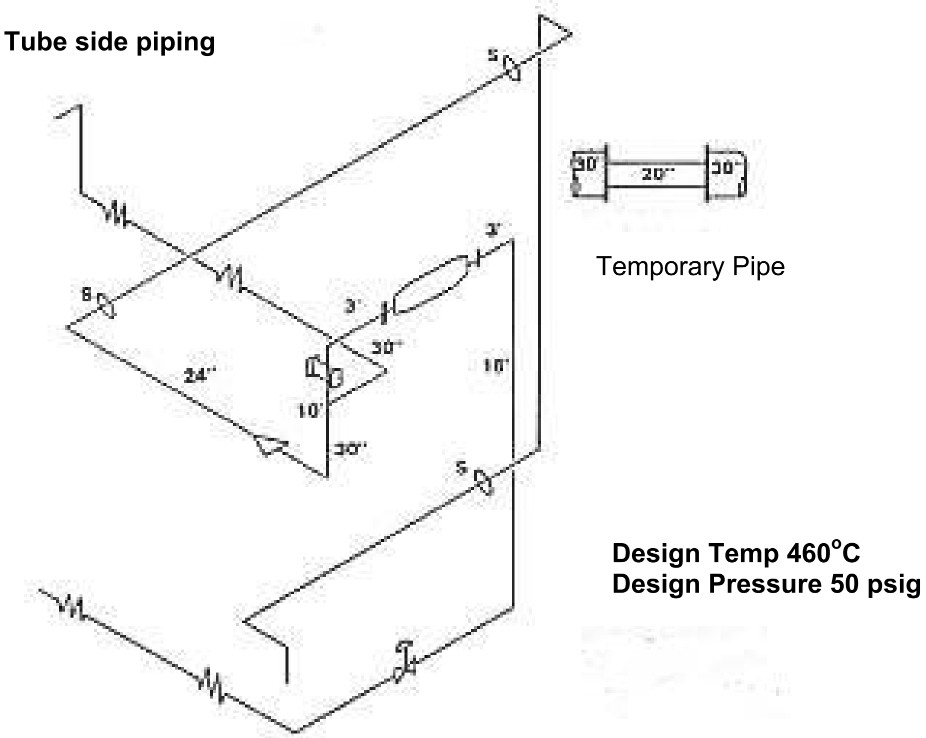
2 All the associated equipment which might have eroded was examined.

D2 The second incident was handled less successfully. A fouled heat exchanger containing a gas stream at about 400 °C and 20 psig had to be removed and replaced by two temporary by-pass pipes. On the tube side, the exchanger was replaced by a straight length of 20 inch piping.

As seen from the isometric drawing, the tube side is connected to 30 inch piping and bellows are provided to take up the stress which develops when the pipe warms up. The exchanger sits on the floor and supports the piping. However, when the exchanger was replaced by an unsupported length of pipe, the 30 inch pipes had to support it and a sideways thrust was imposed on the bellows which they were not designed to take.

Fortunately, a few days before start up, a senior engineer looked round the plant. He questioned the design and it was found that it had not been checked by piping experts. A support was then supplied for the 20 inch pipe.

The plant engineer had not considered it necessary to consult the piping experts as the pipe was straight, without any bends, unlike the pipes at Flixborough or in the last incident. As at Flixborough there was a failure to recognise the circumstances in which expert advice should have been sought.

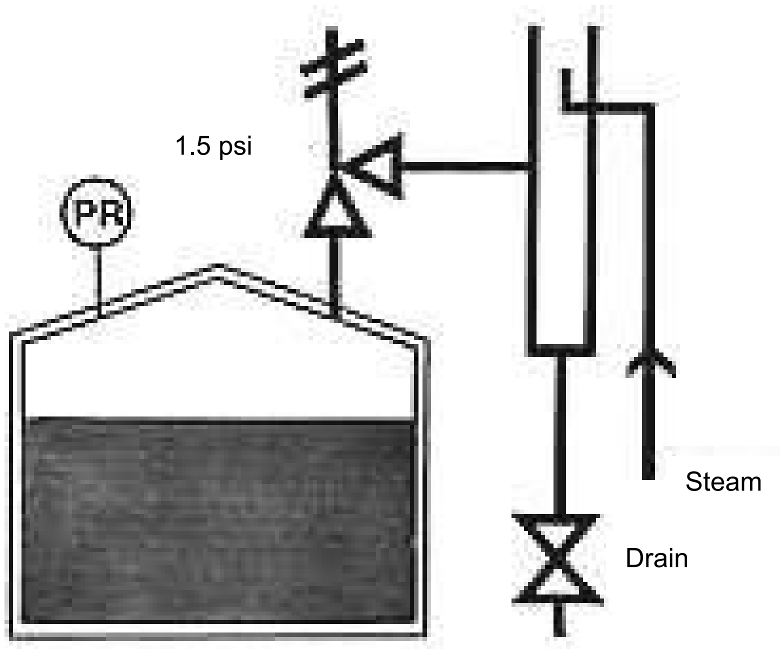


E Sanctioned Modifications

This term is used to describe modifications for which the money has to be authorised by a works manager, director or other official, or perhaps by a committee. They cannot therefore, as a rule, be done in a hurry. Justifications have to be written out and people persuaded. Although the systems are, or have been in the past, designed primarily to control cost rather than safety, they usually result in careful consideration of the proposal by technical personnel and unforeseen consequences may come to mind (though not always; sometimes sanction is obtained before detailed design has been carried out and the design may then escape detailed considerations). It is therefore harder to find examples of serious incidents caused by sanctioned modifications and the following might almost rank as a start-up modification. Though the change was agreed over a year before start-up, it occurred after the initial design had been studied and approved.

EI A low-pressure refrigerated ethylene tank was provided with a relief valve set at about 1.5 psig and discharging to a vent stack. After the design had been completed it was realised that cold gas coming out of the stack, would, when the wind speed was low, drift down to ground level where it might be ignited. The stack was too low to be used as a flare stack — the radiation at ground level would be too high — and was not strong enough to be extended. What could be done?

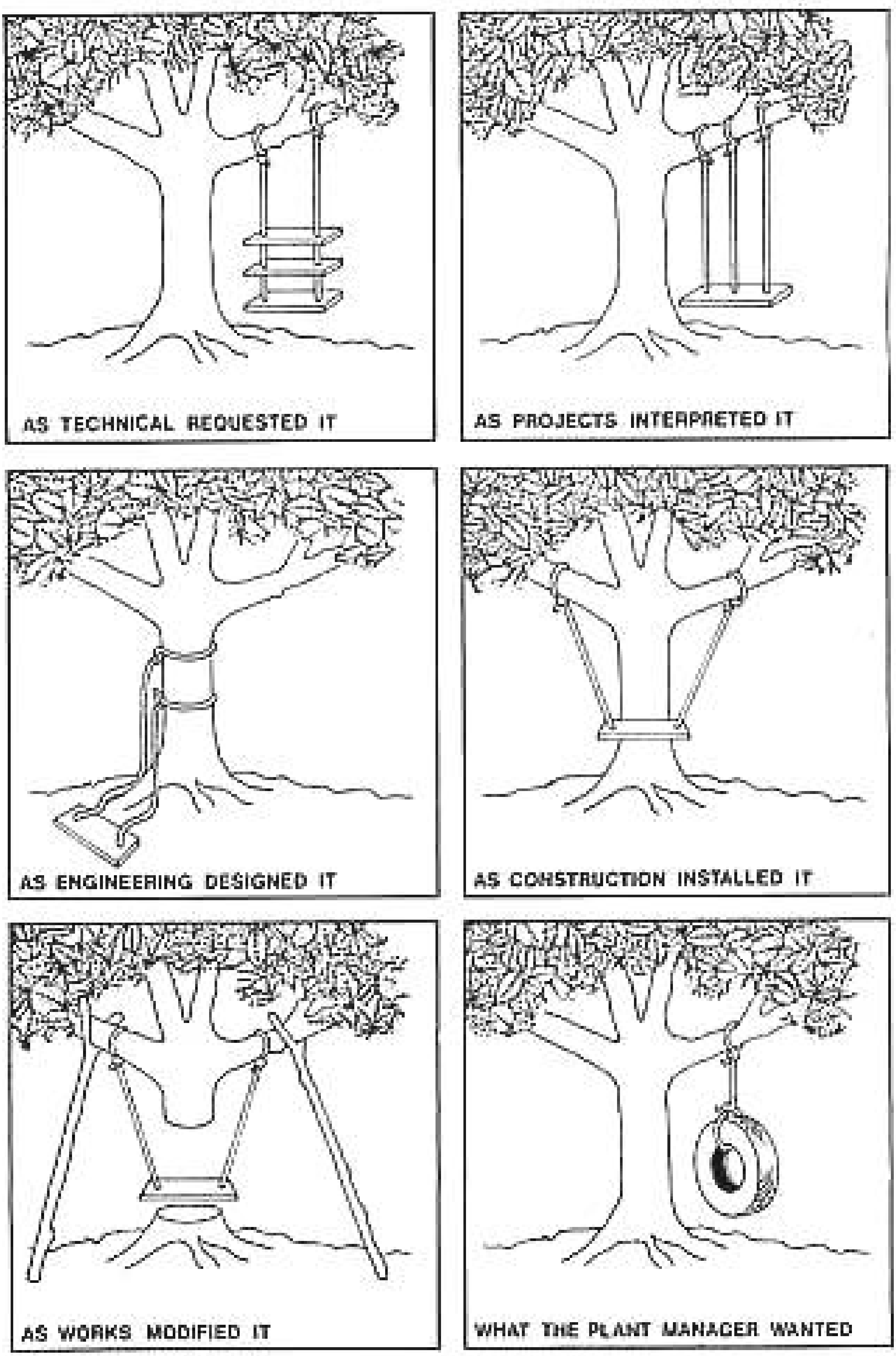
Someone suggested putting steam up the stack to dispense the cold vapour. This seemed a good idea and the suggestion was adopted.



As the cold vapour flowed up the stack it met condensate flowing down. The condensate froze and completely blocked the 8 inch diameter stack. The tank was overpressured and ruptured. Fortunately the rupture was a small one, the escaping ethylene did not ignite and was dispersed with steam while the tank was emptied.

Should the design team have foreseen that the condensate might freeze?

E2 Sometimes a modification results in unforeseen consequences because the various people involved did not fully understand each others requirements or intentions. There is an illustration of this on the next page.


AS TECHNICAL REQUESTED IT
AS PROJECTS INTERPRETED IT
AS ENGINEERING DESIGNED IT
AS CONSTRUCTION INSTALLED IT
AS WORKS MODIFIED IT
WHAT THE PLANT MANAGER WANTED

PART 2

PREVENTION

None of the incidents described in Part 1 occurred because of a lack of knowledge of methods of prevention; they occurred because no-one saw the hazards, because no-one asked the right questions. To prevent similar accidents continuing in the future, a three-pronged approach is therefore necessary.

First**, there must be a rigid procedure for making sure that all modifications are authorised only by competent persons**, who, before doing so, try to identify all possible consequences of the modification and then specify the modification in detail.

Second**, there must be some sort of guide sheet or check list to help people identify the consequences.**

Third, an instruction and aids are not enough. People will carry out the instruction and use the aids only if they are convinced that they are necessary. **A training programme is essential.**

2.1 Procedures

Within Petrochemicals Division we have decided that before any modification, *however cheap,* temporary **or** permanent, is made to a plant or process, it must be authorised in writing by a competent manager *and* engineer, normally the plant manager and engineer. Where alterations to instruments or electrical equipment are involved an instrument manager or electrical engineer must also approve the modification. Before authorising the modification, particular attention should be paid to making sure that:

(i) The number and size of relief valves required are not changed (or any necessary changes are specified).

(ii) The electrical area classification is not changed (or any necessary changes to the electrical equipment are specified).

(iii) There are no effects on trips or alarms (or any necessary changes are specified).

(iv) There are no other effects which might reduce the standard of safety.

(v) The appropriate engineering standards are followed.

(vi) The right materials of construction and fabrication standards are used.

(vii) Equipment is not subjected to conditions beyond its design basis without checking that it can withstand the new conditions.

(viii) Any necessary changes in operating conditions are made.

The definition of a modification must be wide enough to catch all the modifications described in Part 1, for example,

"Any change in, or addition to, the equipment (including instrumentation) which may affect the process or system (under normal or abnormal conditions) by increasing or decreasing flow, temperature, pressure, composition or corrosivity. It thus includes any change in, or addition to, the pipework and introduction, removal, change in size or resting of any valve, restriction plate, heat exchanger, pump, etc. It does not include changes in engineering equipment which are not in contact with the process and cannot affect the process or the integrity of the plant except that modifications to supporting structures or foundations are included."

In certain circumstances there may be pressures to avoid or short cut the procedure and special care is needed in the following circumstances:-

(a) During and just before the start-up of a new plant

At these times the start-up team are under great pressure and may be reluctant to carry out lengthy checking procedures before making modifications. They may feel that it is unlikely that the modification will have any unforeseen consequences. It is therefore advisable to have all modifications checked by a “modifications man” who stands apart from the normal pressures on the commissioning team. If a modification has to be made during the night it is checked the next morning.

A member of the project design team is often well-qualified to act as “modifications man”, as he is familiar with the reasons for the existing design.

Despite this system, all the consequences of all modifications may not come to light. About one year after start-up, therefore, there should be a repeat of the relief and blowdown review carried out during the design stage (see Section A3 of Part 1).

(b) When the modification is so cheap that it does not need financial authorisation

Part 1 described several incidents which resulted from modifications so cheap that they were authorised only by a foreman’s chit or by a clearance certificate. Particular care is needed that the whole system for checking modifications is not by-passed by well-meaning supervisors, or even operators, who want to help production.

Where supervisors have in the past been allowed to authorise simple modifications they may feel that their status and authority are being reduced. It is therefore important to involve them in designing modifications and discussing their consequences, even though they do not take the final decision on whether or not the modification goes ahead.

For a supervisor to play a full part in checking modifications, he should have some knowledge of the Company’s standards and access to further information. They do not always have this knowledge.

Because a modification is simple it is often done quickly. Modifications are rarely so urgent that we cannot STOP and THINK.

It may be a useful reminder to supervisors to print on the clearance certificate or permit-to-work:

“Is this a modification?

If so, has it been authorised?”

(c) When the modification is made while the plant is being repaired

There is often a temptation to put the plant back in a better or simpler form, thus saving maintenance costs and getting a better plant at the same time. Some of the consequences of doing so have been described in Part 1. The temptation to modify the plant as part of a repair job must be resisted. The plant should be put back exactly as it was, unless a modification has been authorised.

Of course, maintenance teams should be encouraged to *suggest* modifications, but not to make them on their own authority.

(d) When the modification is temporary

The Flixborough explosion and the incidents described in Part 1 are sufficient evidence of the need to treat temporary modifications with the same care as permanent ones. The main recommendation of the official enquiry into the explosion at Flixborough on June 1 1974 is:

> *"Any modification should be designed, constructed, tested and maintained to the same standards as the original plant."*
>
> *(Paragraph 209).*

Modifications made as part of an experiment must be treated in the same way as other modifications. The word "temporary" is best avoided. There are only modifications.

The responsibility of those managers and engineers who authorise modifications does not end when they have authorised them. When a modification is complete, they should inspect it to see that their intentions have been followed, that all necessary testing has been carried out and that the modification looks right — what does not look right is usually not right.

Finally, a comparison with clearance certificates. Every oil and chemical company, large and small, operates such a clearance system, and considers failure to use the system as a serious matter. The systems for authorising modifications need to be treated with the same respect.

All systems lapse after a while unless they are monitored and it is necessary to check, from time to time, that the system for controlling modifications is, in fact, operating as intended.

2.2 Guide sheets and check lists

If a person is given responsibility to check a modification, he cannot be expected to stare at a drawing and hope the faults will show up. Some sort of aide is necessary and this often takes the form of a check-list.

The disadvantage of a check-list is that items not on the list do not get checked — the list therefore is extended until it gets so long, and contains so many items irrelevant to a particular problem, that it is discarded as too much of a burden.

For new plants, operability studies (HAZOP) have been therefore developed as a more "open-ended" approach. A short list of guide words is used in such a way that they stimulate free-ranging thought by a group of people. An operability study is, however, too cumbersome for minor modifications — a team of people cannot be assembled every time a small change is made to a plant.

(a) The Safety Assessment

The attached form is an attempt to modify the operability study technique so that it can be applied to plant modifications. The top part of the form is intended to help the people concerned to clarify their thoughts about the factors that have changed, while the lower part is a check-list of questions. The lower part alone is insufficient; unless some attempt is made to widen horizons by thinking about the first part, the completion of the second part could soon deteriorate into a perfunctory series of ticks.

The form is best completed by two or three people together, rather than by an individual alone. Much of the value of the operability study technique comes from the conflict of minds. The form should always be accompanied by a simple line diagram — no matter is so simple that this is unnecessary (see item AI of Part 1). Remember, however, that a line diagram does not show all the information necessary for assessing the consequences of a modification.

A useful precaution against any tendency to dismiss the questioning as unnecessary is to assume that every isolation valve or other restriction will isolate a piece of equipment from its protective device, for example, a vessel from its relief valve, until it has been proved innocent. Similarly, it should be assumed that every new line will result in some unwanted contamination or the over-pressuring of some equipment, or in the introduction of more flow into some equipment than the exit pipes can handle.

Completion of the form just described, or any similar form, is not a sausage-machine that will automatically produce the right answer. It is a way of harnessing the knowledge and ability of the plant staff in a systematic way so that the chance of missing significant consequences is minimised. The results will be no better than the knowledge and ability of the staff concerned.

There are three questions which should be answered before the form is even started: They are;

"Is the modification necessary?"

"Is it worth the cost? and

"What else could we do instead?"

(b) Piping Modifications

The majority of plant modifications are pipe-line modifications, yet these in the past have been most subject to do-it-yourself jobs by engineers who were not piping specialists. Few engineers would modify a machine without consulting a machine specialist, yet the same engineers have, in the past, often modified large pipelines carrying hazardous materials at pressure and as temperature without reference to piping specialists (see Item D2 of Part 1). Within Petrochemicals Division we have developed and implemented a Piping Code of Practice for the use of plant staff. This gives guidance on the standards of design, construction, maintenance and inspection of piping. For example, any modification to a pipeline 3 inches and above, carrying hazardous materials, must be checked by drawing office staff.

As a further safeguard it is hoped that the plumbing organisation will not modify pipework unless the engineering standards, material of construction, etc. are specified in detail and, where appropriate, the proposed change has been checked by a drawing office. Back-of-an-envelope sketches may be suitable for narrow bore, low pressure water lines, but that is all.

(c) Record keeping

Paper records should be kept of all modifications and they should be marked on the line diagram, as the vetting of later modifications is often made difficult by the absence of up-to-date diagrams. After the incidents described in Section B of Part 1 it was impossible to discover when the modifications were made or by whom. None of the four shifts, A, B, C or D had apparently made them, so presumably they were made by a mythical E shift.

Remember, however, that a line diagram does not show all the information necessary for assessing the consequences of a modification.

2.3 Training

We live in a society where people are reluctant to do what they are told, merely because they are told to do it. Therefore, it is *not* sufficient to issue the instructions described in Section 2.1 and give out the forms described in Section 2.2. We must also convince all concerned, supervisors as well as managers, that these procedures are necessary. One way of doing so is by describing incidents such as those in Part 1. A better way is for groups of people to discuss them and decide what *they think* should be done to prevent similar incidents happening again.

2.4 Resources

The procedures recommended above require considerable time and effort. Shall we need more staff?

Alternatively, we can carry out fewer modifications with the same staff. Some companies have a reputation for making more modifications to their plants than other companies making similar products. (It has been said that ICI means I've Changed It.) Many of these modifications result in higher output or efficiency or in ability to meet a demand for product of higher purity; without a willingness to make modifications a company cannot survive in changing market conditions. But not all modifications are essential for these purposes and experience shows that the procedures described in 2.1 and 2.2 result in fewer modifications as well as better ones.

Safety Assessment

Plant **Title** **Reg no**

Underline those factors which have been changed by the proposal.

Process conditions
temperature
pressure
flow
level
composition
toxicity
flash point
reaction conditions

Operating Methods
start up
routine operation
shutdown
preparation for maintenance
abnormal operation
emergency operation
layout and positioning of
controls & instruments

Engineering Methods
trip and alarm testing
maintenance procedures
inspections
portable equipment

Safety equipment
fire fighting and detection
systems
means of escape
safety equipment for
personnel

Environmental conditions
liquid effluent
solid effluent
gaseous effluent
noise

EEngineering hardware and design
line diagram
wiring diagram
plant layout
design pressure
design temperature
materials of construction
loads on, or strength of:
foundations
structures
vessels
pipework/supports/bellows
temporary or permanent
pipework/supports/bellows
valves
slip-plates
restriction plates
filters
instrumentation and control
systems
trips and alarms
static electricity
lightning protection
radioactivity
rate of corrosion
rate of erosion
isolation for maintenance
mechanical-electrical
fire protection of cables
handrails
ladders
platforms
walkways
tripping hazard
access for
operation
maintenance
vehicles
plant
fire fighting
underground/overhead
services
equipment

Within the categories listed below, Does the proposal action is recommended to minimise it.	Yes or no	What problem has been created which affects plant or personnel safety and what	Signed Date
Relief and blowdown 1 Introduce or alter any potential cause of over/under pressuring (or raising or lowering the temperature in the system or part of it? 2 Introduce a risk of creating a vacuum in the system or part of it? 3 In any way affect equipment already installed for the purpose of preventing or minimising over or under pressure? **Area classification** 4 Introduce or alter the location of potential leaks of flammable material? 5 Alter the chemical composition or the physical properties of the process material? 6 Introduce new or alter existing electrical equipment? **Safety equipment** 7 Require the provision of additional safety equipment? 8 Affect existing safety equipment? **Operation and design** 9 Introduce new or alter existing hardware? 10 Require consideration of the relevant Codes of Practice and Specifications? 11 Affect the process or equipment up stream or downstream of the change? 12 Affect safe access for personnel and equipment, safe places of work and safe layout? 13 Require revision of equipment inspection frequencies? 14 Affect any existing trip or alarm system or require additional trip or alarm protection? 15 Affect the reaction stability or controllability of the process? 16 Affect existing operating or maintenance procedures or require new procedures? 17 Alter the composition of, or means of disposal of effluent? 18 Alter noise level?			

Safety Assessor………………………date…………………………………

Checked by……………………….. Plant Manager Checked by………………………Engineer