TTE TRAINING LIMITED

Phase 1 Fabrication

Carousel 2

STEAM TRAPS AND STEAM UTILISATION

COURSE NOTES

(SPIRAX SARCO SERIES)

Steam and Condensate Systems

Steam

Like other substances, water can exist in the form of a solid, when we call it ice; as a liquid, when we call it water, or as a gas when we call it steam. This module concentrates largely on the liquid and gas phases and on the change from one phase to another.

To effect a change of phase, a sufficient amount of heat energy must be added to either the ice or water. If heat energy is added to water, its temperature rises until a value is reached at which the water can no longer exist as a liquid. This is called the “saturation” point and with any further addition of heat energy, some of the water will boil off as steam. This evaporation requires relatively large amount of energy, and whilst it is being added, the water and steam released are both at the same temperature.

Equally, if we encourage the steam to release the energy that was added to evaporate it, the steam will condense and water at the same temperature will be formed. So, by removing sufficient heat energy from water we will form ice. The temperatures at which the phase changes occur will as we will see later depend on the pressure under which the change takes place.

The Uses of Steam

The original use of steam was for cooking foodstuffs until the advent of the Industrial Revolution. At this point the potential of steam, as a tool for industry was realised and its flexibility and versatility has continued to be utilised wherever heating and power are needed.

Steam is produced by the evaporation of water which is a relatively cheap and plentiful commodity in most parts of the world. Its temperature can be controlled very accurately by adjusting its pressure, using simple valves; it carries relatively large amounts of energy in a small mass, and when encouraged to condense back to water, high rates of energy flow (into the material being heated) are obtained, so that the heat using plant does not have to be unduly large.

Steam in industry is used mainly for: -

a) Process Heating
b) Space Heating
c) Power

Process Heating

This is where the steam has a direct effect on the process.

Examples:

1) Jackets (Pumps, pipes, valves and vessels).
   To ensure the chemicals are kept at, or above a certain temperature e.g. to stop them solidifying.

2) Storage Tanks (Heating and Agitation).
   The coil set into the bottom of a storage tank may be used to heat chemicals or in some cases to generate circulation.

Steam is also used as a direct heat for chemical reactions:
-Stills
- Feed Heaters
- Reboilers
- Heat Exchangers
- Reaction Vessels
- Dryers

Space Heating

1) Radiators
2) Thermoliers
3) Convection Cabinet Heaters

There items are in common use in factory workshops, offices, canteens and warehouses. All make use of the heat given off from steam, to heat the space in which they are situated. Some like the thermoliers, make use of a fan to dissipate the heat from the heating unit and are sometimes referred to as forced draught heaters.

Convection cabinet heaters (NATURAL DRAUGHT) allow the hot air to flow from the top of the cabinet, drawing cold air into the bottom.

Power

Steam at one time had a major use as a source of power when it was used to drive compressors and beam engines, which were used to drive machinery within our factories. With the advancement of technology, this duty has been lost to steam, and replaced by the electric motor and steam being used to generate the electricity.

This is a field, where generally plant maintenance fitters do not get involved, so we will be looking at steam uses in Process and Space heating.

The Formation of Steam

If water is at 0 c in an open topped tank at atmospheric pressure is heated, its temperature will steadily rise until it reaches a temperature of 100 c. At this temperature, the water can no longer exist as a liquid and begins to form steam at 100 c. The heat which was used to reach this phase is called SENSIBLE HEAT.

If the water continues to be heated, the temperature will remain at 100 c until all the water has been converted into steam. This extra heat needed to convert all the boiling water into steam is called LATENT HEAT and it takes almost five and a half times as much heat to change one pint of water into steam, as it does to bring it to boiling point in the first place.

So although steam and boiling water are both at the same temperature 100 c, steam contains much more heat energy. This is due to the amount of heat energy it has absorbed whilst changing to steam. Therefore steam provides an excellent source of heat for our plants and buildings but it will also cause a much more severe burn than a scald from boiling water.

Temperature and Pressure

As we have stated before, the temperature of steam can be accurately controlled by altering its pressure. If we boil 1kg of water at atmospheric pressure until it has turned to steam, its temperature will be 100 c. The volume of the steam formed will be much greater than the water, by a factor of over 1600 times. Clearly the molecules of water are held together much more closely than the molecules of steam. The process of evaporation can be thought of as one of adding sufficient heat energy to each module that it can break the bonds holding it to its neighbours, so that it can leave the liquid in the container and move freely in the gas phase.

If we now fit a piston and a weight of 10 BAR into our container, this will now hold the molecules of water together much more tightly, requiring more heat to separate them.

Steam converted from water at this pressure would have a temperature of 184.13c so by increasing the pressure we have increased the temperature of the steam. Similarly by reducing the pressure, for example by applying a vacuum, we can cause the water to convert to steam at a temperature less than 100 c, such as boiling a kettle high up a mountain. The reduced pressure allows the molecule bond to be broken more easily.

So by referring to steam tables, which list temperatures against pressures, we can accurately adjust the temperature of steam by altering its pressure.

Condensation of Steam

As soon as steam leaves the boiler, it begins to give up some of its enthalpy to any surface at a lower temperature. In doing so, some of the steam condenses into water at the same temperature. The process is the exact reverse of the change from water to steam which takes place in the boiler when heat is added. It is the enthalpy of evaporation which is given up by the steam when it condenses.

Let us consider exactly what happens when steam is put to work in process or heating plants. Fig 6 shows a coil heated vessel which might be found in any steam using plant. The vessel is filled with the product to be heated, and steam is admitted to the coil. The steam then gives up its enthalpy of evaporation to the metal wall of the coil, which transfers it to the product. Hot water is formed as the steam condenses and runs down to the bottom of the coil. This ‘condensate’ as it is properly known must be drained away.

If the steam in the coil condenses at a faster rate than the condensate is able to drain away, the bottom of the coil will begin to fill with water as shown in fig 7. We call this water logging. Initially the temperature of the condensate will be the same as the temperature of the steam which has condensed. This fact may tempt us to allow water logging to occur without further consideration. A little though will show us that this may greatly reduce the effectiveness of the coil.

Although the temperature of the freshly formed condensate will be the same, the temperature of the condensate must fall if it gives up any of its heat to the coil wall and thence the product. This will reduce the temperature difference between the condensed water and the coil wall and the rate of heat flow will decrease.

This will initially result in a temperature drop in the product, and if not rectified will, as in fig 5 cause water logging of the steam system.

Barriers to Effective Heat Transfer

Figs 6 and 7 show only steam and condensate in contact with the heating surface of a coil. It would appear from the drawings that the metal wall is the only obstacle preventing direct heat transfer from the steam to the product. However fig 8 is a rather more realistic representation of such a heating surface. Films of air, water and scale, cling to the metal wall and all act as barriers to efficient heat transfer.

On the product side of the wall is a stagnant film of product and perhaps also a layer of baked on product or scale. The heat flow is very greatly reduced by the resistance of these films. Regular cleaning is the obvious answer for the layer of solid scale or dirt, whilst agitating the product in some way will reduce the thickness of the stagnant liquid film.

On the heat supply side of the wall, there may again be a layer made up of rust and dirt by careful attention to the operation of the boiler and to the removal from the steam supply of any droplets to carry over moisture. The films of air and condensate shown in fig 8 require even closer attention.

We know that when steam comes into contact with the cooler heat transfer surface, it gives up its enthalpy of evaporation and condenses. The condensation may produce droplets of water, or a complete film may be formed immediately. Even if drop wise condensation takes place, the drops will very often run together and form a film and as the film thickens, the water begins to run down the wall. It is a fact that water has a surprisingly high resistance to heat transfer. Even a very thin film of water provides a significant obstruction. A film of water only 0.25 mm in thickness offers the same from the pipe work and perhaps of scale from the impurities carried over from the boiler in any water droplets. Again this effect can be minimised by regular cleaning, whilst the rate at which the layer builds up will be reduced resistance to heat transfer as a 25mm thick wall of iron or a 127 mm wall of copper. These figures underline still further the importance which must be attached to providing a steam supply which is as dry as possible, and of ensuring rapid removal of the condensate from the steam space.

The air film has an even more drastic effect on heat transfer. It is for this reason that the most effective lagging materials are made up of a mass of minute air cells, enclosed by non conducting fibres. It is generally accepted that a layer of air only 1mm thick can offer the same resistance to the flow of heat as a layer of water 25mm thick, a layer of iron 1320 mm thicker a layer of copper 13.2 metres thick. Full attention will be given to the removal of air from steam systems later in the course.

From this we can see how important it is to have an efficient steam system and to remove condensate and air before it can build up sufficiently to cause a temperature change. The removal of air and condensate from our steam systems must be carefully designed and planned, as we need to keep the live steam in the system to make full use of its latent heat. So it is not permissible to use an open cock or valve to drain air and condensate, as this would also evacuate live steam from the system, and as energy costs are high, any waste of steam is also a waste of money.

The most effective way of removing condensate and air from a steam system, is by the use of traps, the type which must be specifically chosen to suit the requirements of the system. The actual types and selection of suitable steam and air traps will be covered in a later selection.

Flashed Steam

As we have seen previously, steam temperature depends upon the pressure in the system, the greater the pressure; the higher will be the temperature of the steam. These two factors can be plotted against each other on a graph, the result of which is a steam curve.

When the condensate is evacuated from a steam system by a suitable trap, it will be at the same temperature as the steam left behind. If the steam inside the trap is at a pressure of 7 BAR (100 psi), the steam will condense to water at a temperature of 170.5 c. If the trap releases water to a drain at atmospheric pressure (1 BAR), the condensate will experience a pressure drop of 6 BAR.

When this condensate is released it is at a temperature of 170.5 c which is 70.5 c above the boiling point of water at atmospheric pressure. The excess temperature provides the heat which boils off, or re-evaporates part of the condensate to form flashed steam. This in turn condenses in the atmosphere to form the all too familiar clouds of “steam” wherever hot condensate is discharged.

An example of a liquid flashing into a gas can be observed with a domestic aerosol such a deodorant. The deodorant is kept in the form of a liquid inside a pressurised container as the nozzle is depressed, the valve opens allowing an amount of liquid to escape. This liquid experiences a pressure drop in the same way as condensate and flashes off into a gas.

A prudent designer will take account of this problem and ensure the flashed steam is collected for reuse. Flash steam can be as useful as steam from the boiler and using it will reduce the demand for steam. It will prevent the loss of untreated water and eliminate the unsightly clouds of white vapour which are synonymous with the steam utilisation.

Before discussing ways of recovering flash steam, there are two important practical points which should be noted:

Firstly, one kilogram of steam has a volume of 1.673 cubic metres at atmospheric pressure. This means that if a trap discharges 100 kilograms/hour of condensate from 7 BAR gauge to atmosphere, the weight of flash steam released will be 13.5 kilograms/hour, having a volume of 22.6 cubic metres. This will appear to be a very large quantity of steam and may well lead to the erroneous conclusion that the trap is passing live steam.

Secondly, as flash steam pressure builds up, it imposes a back pressure on the steam traps. This pressure must be kept low enough to ensure that condensate is not held back in the high pressure plant.

The actual formation of flash steam takes place within and downstream of the steam trap orifice where the pressure drop occurs. From this point onwards, the condensate return system must be capable of carrying this flash steam as well as condensate. High back pressure is a problem in many condensate return systems because inadequate allowance has been made for flash steam at the pipe sizing stage.

If the flash steam is to be recovered and utilised, it obviously has to be separated from the condensate. This is best achieved by passing the mixture of flash steam and condensate through what is known as a “flash vessel”. A suitable arrangement is shown in Fig 74.

The diameter of the vessel is such that a considerable drop in velocity takes place, allowing the condensate to fall to the bottom of the vessel where it is drained out. Adequate height above the inlet allows flash steam to be taken off at the top without picking up any droplets of water which may rise into the steam space by splashing. A ball float type steam trap is fitted to ensure prompt drainage of the condensate.

A number of basic requirements must be fulfilled if flash steam recovery is to be a viable proposition:

1. The first essential is obviously a supply of condensate at a reasonably high pressure. The traps supplying this condensate must be able to accept the back pressure which will be created by the operating pressure of the flash steam system.
2. The second requirement is a suitable user for the low pressure/flash steam. The demand for flash steam should preferably be greater than the available supply and should be in step in terms of time.
   If flash steam from process plant is used to augment steam for heating purposes, savings will be achieved for much of the year but the system will be ineffective in the summer when heating is not required. It is obviously preferable to use the flash steam on the plant providing the high pressure condensate, so that supply and demand are in step.
3. Flash steam should be utilised as close to its source as possible. Piping low pressure steams may involve relatively large pipe work and high radiation losses and it is possible that installation costs may outweigh the advantages of flash steam recovery if long runs are involved.

A typical flash recovery system is shown in Fig 75. The flash steam is used in a preheat section added to a multi-bank heater battery. The low temperature of the air meeting this section means that the flash steam can usually be condensed very readily. The pressure in the flash vessel and preheater will find its own level but it may not ever reach atmospheric pressure unless the pre heat battery happens to be tightly sized.

The example in fig 75 clearly fulfils the basic requirements of having a flash steam supply which is in step with the demand. Only when the heater batteries are called upon to supply heat does flash steam become available and it can then be condensed in the first battery which is essentially a pre heater.

This simple arrangement ensures that the high pressure traps are not subjected to any back pressure on start up. However the flash steam battery is not fully utilised and there can be problems in draining the flash vessel due to the lack of differential pressure across the trap. For this reason it is advisable to fit a pressure reducing valve as shown in broken print in fig 75. This meets any deficiency in the supply of flash steam and effectively controls the flash steam pressure. It ensures that there is a useful contribution from the flash steam battery even when there is little or no flash steam available and provides a reasonable differential across the trap on the flash vessel at all times. The only problem is that the high pressure traps have to start up against a small back pressure and so it may be advisable to shut off the make up steam supply until the main batteries are up to pressure.

Similar arrangements can be made for large areas of heated by unit heaters or radiant panels. It is possible to separate 10 to 15 % of the heaters and supply them with flash steam generated from condensate collected from the remaining heaters. Supply and demand are again in step, as the peak heat requirement from all the units occurs at the same time.

The output of any equipment supplied with low pressure flash steam will be less than that of equipment supplied with high pressure steam, due to the difference in steam temperature. However this can normally be accepted and in any case a small increase in the heating surface will always compensate.

There are occasions when it is possible to make use of flash steam without having to install a flash vessel. In some cases, it is worth considering an arrangement along the lines of Fig 76.

A hot water storage calorifier is fitted with a secondary coil near the bottom where the cold feel water comes in. The condensate from the steam filled primary coil is passed through this secondary coil immediately after the trap and any flash steam present will be condensed, giving up its heat to the water. This ensures that use is made of the flash steam rather than simply allowing it to escape through the vent of a condensate receiver.

A useful extension if this idea for heating systems is the packaged calorifier unit shown in fig 77. Condensate and flash steam are discharged through the steam trap from the top unit which is a normal steam to water calorifier. They are then separated in the flash condenser below and both give up useful heat to the return water from the heating system before it reaches the main calorifier. The unit is completed by a pump which returns the condensate to the boiler feed tank.

Fig 78 shows a system where condensate from process plant is used to provide flash steam to augment the steam supply to a space heating system. This may be perfectly satisfactory for much of the year but flash steam will be blown to waste in the summer when heating is not required. This is a case where supply and demand are not in step. The arrangement is not ideal but the savings to be made during the winter may well justify the cost of the installation. Rather than allow the safety valve on the flash system to blow for long periods, it is better to by-pass the flash vessel in summer and return the condensate direct to the feed tank or a condensate receiver.

Continuous boiler blow down is another possible source of valuable flash steam which should not be neglected. In many modern boiler plants the heat exchange rate is high and both the water and steam capacities are low. It is imperative to keep the solids content within limits if the boiler is to operate satisfactorily. For this reason, a system of continuous blow down is used, whereby water is discharged from the boiler continuously during the whole of the time it is in operation and controlled at a rate equivalent to some 5 to 10% of the total boiler evaporation.

As the blow down water from a boiler contains a high percentage of solids, one of the most practical ways of making use of its heat content is to recover flash steam. The flash vessel must be generously sized to ensure that no solids are carried over with the low pressure steam. The most common use for flash steam recovered from continuous blow down is to pre-heat the boiler feed water.

STEAM DISTRITBUTION

The installation of a steam system is a task that needs careful consideration and planning, to minimise the faults and problems that can arise when the plant is made live. This is generally sorted out at the design stage, before the pipe work and equipment are ordered. The following are some of the problems and solutions encountered when designing a steam system.

The steam distribution is the important link between the steam source and the steam user. It must supply good quality steam at the required rate and at the right pressure. It must do this with minimum of heat losses and with the minimum of attention.

Dry saturated steam is generally used for heating purposes. The problem of superheated steam which is often used in power generation is rather more complex.

This account is therefore confined to dry saturated steam. It looks at some of the factors which have to be considered by the designer, namely;

- Selection of Pressure
- Pipe Sizing
- Alignment and Drainage
- Allowance for Expansion
- Reduction of Heat Losses

SELECTION OF PRESSURE

The first essential is to decide on the pressure at which steam is to be distributed. Unfortunately, there is a natural tendency to take steam from the nearest source or line with little or no regard for what the pressure should be.

Low pressure steam contains more latent heat, or enthalpy of evaporation, per unit of weight so is a better heat carrier. Perhaps even more important is the fact that condensate from low pressure steam is easier to handle with fewer problems due to flash steam. On the other hand steam must be at a reasonable temperature (and therefore pressure) if the heat transfer surface itself is to be kept within acceptable limits. Pressure may also be required to achieve the proper removal of condensate, especially if a lift is involved.

Unfortunately, low pressure steam occupies a large volume. To distribute low pressure steam requires large pipes so the general rule is to distribute at high pressure and reduce pressure at the point of usage. But this can only be a generalisation. High pressure distribution means higher surface temperatures and higher heat losses. If pipe work exists and generously sized, then again it will make sense to use the lowest possible pressure. Clearly the selection of pressure is too bound up with pipe sizing.

PIPE SIZING

Having selected the steam pressure it is necessary to size the pipe work. Again, there is a natural tendency to conform to existing sizes. If the boiler has a 6" crown valve then a 6" line seems obvious. If the heat exchange is provided with a 3" connection than a 3" feed must be adequate.

Over sizing is not always obvious but must be avoided for two main reasons. In the first place, oversized pipe work is more expensive than it should be. A check on a particular job showed that 3" pipe work installed had cost 44% more than 2" pipe which would have been adequate. The cost is not only that of the pipe, but of lagging, support and fittings.

Oversized pipe work is also more expensive to maintain. The 3” pipe has 50% more external surface than the 2” pipe. Heat losses will therefore be 50% greater and there will be 50% more condensate in the pipe needed removal. If this is not done, then the quality of the steam supplied to the plant will be reduced.

The problems of undersized pipe work are more obvious. The lines are unable to supply steam at the required rate and steam starvation at the using end is indicated by reduced pressure. The result is a reduction in output from the heaters or process plant. At the same time the high pressure drop brings with it high steam velocities. These can cause problems due to erosion and increase the possibility of water hammer.

There are two methods of sizing pipes, both of which have an unknown factor which must be assumed.

ALIGNMENT AND DRAINAGE

It is a sad fact that the steam distribution system will often give more trouble than any other pipe service. These troubles arise from the failure to realise that the pipe work contains not steam, but steam and water

As soon as steam leaves the boiler, some of it starts to condense as heat losses take place from the pipe work. The rate of condensation will be particularly heavy at start up when the pipe work is cold while condensation will continue under working conditions, however well insulated the pipe work may be.

Fig .1 is a diagrammatic representation of the way in which droplets of condensate can build up in a straight pipe. Ultimately they can form a solid slug. Moving at steam velocity the resultant water hammer can cause severe damage to pipe work and fittings.

The creation of water hammer will be accelerated if the pipe work is allowed to sag. This can occur when pipe hangers fail or when support is inadequate. There is the same sort of danger when water is allowed to collect at low points in the pipe work.

Fig.2 shows and example where the pipe work is half flooded. This means quite simply that steam velocity will be doubled in the remaining free areas of the pipe. The chance of slugs of water being picked up to create water hammer conditions is thereby increased. At the same time the restricted free area will mean high pressure drops even though the pipe work was sized correctly in the first instance.

Proper alignment and drainage means observing a few simple rules.

1. Steam lines should be arranged with a fall in the direction of flow. A fall of around 40mm is 10m or ½" in 10 ft is generally adequate. This ensures that condensate is carried easily by the steam flow towards the next drain point. At shut down it ensures complete drainage of residual condensate. If horizontal pipe work is absolutely necessary due to site conditions or to reversible flow then more frequent drainage will be necessary.
2. Saturated steam lines should be drained at regular intervals. The distance between drain points will depend on line size, location and the frequency of start up but intervals of 30-50m (100-150ft) are usual. Lines should also be drained at any low point where condensate can collect.
3. Drain points are most effective where pipe work changes direction. Long lengths of pipe work over horizontal ground call for relay points as shown in fig.3. These make ideal drain points since the change of direction helps to separate out entrained droplets of moisture.
4. When drainage has to be provided in a straight length of pipe then a large bore pocket should be provided as shown in fig.4. Droplets of water are generally carried along the pipe wall and these will be carried past the small bore trapping. Full bore pockets are ideal and are practical in pipe work up to 100m (4") diameter. In larger sizes the pocket can be 2 or 3 sizes smaller than the line being drained.
5. Pipe work should be arranged so that pockets where water can collect are avoided. Fig 5 shows the incorrect use of concentric reducer which allows condensate to collect. The correctly installed eccentric reducer will ensure that condensate can flow to the next drain point. Similar problems can occur with some valves and fittings. The strainer shown in Fig.6 is a potential cause of water hammer while much of the screening area is ineffective, being out of the steam flow. Strainers above say 25mm (1") in size should be fitted to their side to avoid these problems. Globe valves having under and over construction can also form a weir and prevent condensate from flowing to the next drain point when fitted in the 'normal' position in a horizontal line. Again this can be avoided by fitting the valve on its side.
6. Branch connections should always be taken from the top of any main so that the driest possible steam is supplied. A connection from the bottom is the worst possible arrangement. Such a connection would act as a drain pocket and the result would be a very wet steam supply. Where a branch line drops say from a high level main to serve a plant at floor level then the low point before reaching the machine should also be drained as fig 7. This is particularly so if a control valve or reducing valve is fitted in line – a valve designed for steam cannot work efficiently in a pool of water.

7. At the point of usage the use of a separator should be considered. This provides a very adequate drain point for any droplets of moisture which are being dragged along the pipe wall. In addition, the slower velocity through the separator body and the arrangement of the baffles will ensure that droplets of water carried along in the main stream flow will also be separated out. This ensures the supply of dry steam- particularly important for highly rated plant or for equipment like sterilizers where steam comes into contact with the load or product. Two types of baffle type separators are shown in Fig 8.
8. Because there is always a risk of water hammer in steam mains, traps should be fairly robust. The thermodynamic type shown in Fig.9 is a good choice as is the inverted bucket steam trap in Fig 10. If the traps are to be fitted in an exposed position then it is useful to fit the thermodynamic trap with an insulating cover or isotub to slow down its rate of operation, while the bucket trap should be properly lagged.

If the lines are large or subject to frequent start up then additional air venting should be provided. A very good point is the end of any steam line as shown in Fig 11.

As with most rules governing steam systems, these comments must be regarded as being for guidance only and there will always be exceptions. A case in point is provided by the problem of running a steam line across rising ground. Figure.12 shows one arrangement, following the suggestions made in paragraph 3. However, this means more frequent relay points and it may be necessary to run a line with a rise rather than a fall in the direction of flow. Velocity and frequency of draining need watching here. The condensate will be trying to run down hill against the steam flow. What we must do is to reduce the steam velocity so that it doesn’t try and force the water uphill again. Over these lengths of rising main it may be necessary to increase bore of the main so that the velocity is reduced to below 15m/s (50 ft/s) and at the same time install drain pockets at more frequent intervals so as to prevent an accumulation of condensate in the line.

ALLOWANCE FOR EXPANSION

A particular problem with the steam main arises from the way in which it expands at start up. Steam services operate at relatively high temperatures. There is no point in laying a pipeline with proper falls id expansion and distortion throw the whole thing out of line when steam is turned on.

The problem is well illustrated by table 4 which shows the approximate expansion of steel pipes when installed at 16C (60F).

Wherever there are long runs of straight pipe some provision must be made for expansion.

Sometimes this is done by stressing the main when cold, 'cold draw' as it is known, but it is much more common to use an expansion fitting, in conjunction with fixed anchor points. Some expansion fittings are discussed briefly in the following sections.

Full Loop (Fig.13)

This is simply one complete turn of the pipe and should preferably be fitted in a horizontal rather than a vertical position to prevent condensate building up.

The downstairs side passes below the upstream side and great care must be taken that it is not fitted the wrong way round. When full loops are to be fitted in a confined space, care must be taken in ordering; otherwise wrong handed loops may be supplied.

The full loop does not produce a force in opposition to the expanding pipe work as in some other types but with steam pressure inside the loop, there is a slight tendency to unwind, which puts an additional stress on the flanges.

<u>The horse shoe or lyre loop</u>

Where space is available this type is sometimes used. It is best fitted horizontally so that the loop and main are all in the same plane.

Pressure does not tend to blow the ends of the loop apart but there is a very slight straightening out effect. This is due to the design but causes no misalignment of the flanges.

In other cases, the 'loop' is fabricated from straight lengths of pipe to 90 bends. This may not be as effective and requires more space but it meets the same need.

If any of these arrangements are fitted with the loop vertically above the pipe then a drain point must be provided on the upstream side.

<u>Sliding joint</u>

These are often used because they take up little room but it is essential that the pipeline is rigidly anchored and guided. This is because steam pressure acting on the cross sectional area of the sleeve part of the joint tends to blow the joint apart in opposition to the forces produced by the expanding pipe work. Misalignment will cause sliding sleeve to bend, while regular maintenance of the gland packing is also needed.

Bellows

A simple bellows has the advantage that it is an in line fitting and requires no packing as does the sliding joint type. But it does have the same disadvantage as the sliding joint in that pressure inside tends to extend the fitting so that anchors and guides must be able to withstand this force.

The bellows can however be incorporated into properly designed expansion fitting as shown in fig.17 which is capable of absorbing not only axial movement of the pipeline, but some lateral and angular displacement as well.

If expansion fittings are to work as intended, it is essential that the steam line is properly anchored at some point between the expansion fittings. Guiding is also important to ensure that any movement does not interfere with the designed fall towards the drain points.

Detailed design is clearly outside the scope of this bulletin but fig.18 shows some typical anchor points utilising pipe flanges or lugs welded onto the pipe.

REDUCTION OF HEAT LOSSES

Again, details of lagging are outside the scope of this Bulletin. However, the point must be made that if steam distribution is to be efficient, then heat losses due to radiation must be cut to a minimum. Table 5 gives information on heat losses from pipes in still air at 10-20 C (50-70F). These losses can be increased by 3-5 times in exposed locations. Proper insulation should mean that any losses are reduced by 75-85%. Much will depend on the lagging material and the thickness installed. Since most materials depend for their effectiveness on minute air cells it is important that lagging is not crushed or allowed to become water logged. Adequate protection and waterproofing are therefore essential, especially in outside locations.

It Is also worth remembering that the heat loss from a steam pipe to water (or saturated lagging) can be 50 times greater than the same pipe losing heat to still air. Particular care must therefore be taken with lines running through water logged ground or in ducts liable to flooding. Another source of loss is provided by unlagged flanges and fittings. In the cases of flanges the actual amount will depend on the way lagging is finished off on the adjacent lengths of pipe. However, as a guide it can be assumed that the heat loss from a pair of flanges is equal to the loss of 0.3cm (1FT) of unlagged pipe. Purpose made boxes or prefabricated insulation is generally available to provide proper insulation of flanges and fittings but retaining the necessary access for maintenance.

CONDENSATE RETURN

The importance of effective condensate removal from steam spaces has been stressed throughout this course. It maximum plant efficiency is to be achieved, and then the best type of steam trap must be fitted in the most suitable position for the application question. Having considered how best to utilise any flash steam which may be available, we must now decided what to do with the condensate which remains.

There are a number of reasons why condensate should not be allowed to run to drain. The most important consideration is the valuable heat which it contains even after flash steam has been recovered. It is possible to use condensate as hot process water but the best arrangement is to return it to the boiler house, where it can be used as boiler feed water without further treatment, saving fuel, raw water and the chemicals needed for boiler feed treatment. This threefold saving will be even greater in the cases where effluent charges have to be paid for the discharge of valuable hot condensate down the drain. Although there are financial benefits for using hot condensate as boiler fee water, it is not always practical to return condensate from chemical plants due to possibility of contamination. Perforated coils in an acid vat or oil tank might allow these harmful substances to reach the boilers where considerable damage would occur.

However, even in cases where contamination is likely, condensate can still be returned to the boiler feed tank if suitable precautions are taken. Filters can be installed which will cope with oily condensate, while the presence of harmful acids can be signalled by suitable detection equipment.

In extreme cases it may be safer to run the condensate to waste, but useful enthalpy can still be extracted by first passing it through a coil in another process vat. Alternatively, it is common practice in plating processes to run the condensate directly into hot rinse tanks. This provides the hot water necessary for final rinsing of articles that have been treated and produces a saving live steam that would otherwise be needed to heat the water.

The valve of a thermostatic air vent will be wide open when the plant is started from cold and large quantity of air must be discharged quickly.

It will shut off before steam temperature is reached but if air collects during the normal running of the plant it will open periodically in response to the drop in temperature.

SELECTION OF TRAPS

It can be claimed that the majority of steam trap types will 'work' on any application (provided that the operating conditions fall within the pressure range and condensate discharge capacity of the trap). However, we do not just want steam traps which 'work' moderately well. We must aim to achieve maximum output and efficiency from all steam using plant. This means selecting the best trap to suit each particular job.

The following list contains a number of important questions which should be considered when choosing a steam trap:

a) Must condensate be discharged immediately it forms: Some traps hold back condensate making use of its heat.
b) Is well condensate return line higher than the steam heated unit: will cause water logging.
c) Are there water hammer conditions in the steam supply line?
d) Is there vibration, or excess movement in the plant
e) Does condensate contain corrosive substances: will cause damage to pipes and equipment?
f) Will the trap be in exposed position: some traps will freeze in the winter?
g) Is the steam supply superheated: some traps are not suitable for excessive temperatures?
h) Is air likely to be present in any quantity?
i) Is steam locking possibility
j) Is the insulation made up of several heated units

We can look at some of these points in more detail

By definition the steam trap must trap or hold back steam whilst at the same time allowing the removal of air, incondensable gases and condensate. The basic requirements of good steam trappings have already been outlined and it is worth reiterating the fact that the performance of the plant is paramount. It is no good having trouble free stream traps if the performance of the plant is impaired. It is no good reducing trap maintenance if this results in leaks from the system or water logging and corrosion of plant.

Guidance on a whole range of applications is given in Spirax Sarco handbook 'Practical Steam Trapping' and it is worth mentioning the fact that in almost every case a choice is available. This section will not repeat that guidance but simply discuss some of the more important factors in trap selection. These start on the basis that the requirements of pressure, condensate load and air venting have been met in the provisional section.

WATERHAMMER

Water hammer from whatever cause can damage steam traps and cause them to malfunction. It is therefore important that the possibility is recognised and the trap selected accordingly.

Water hammer will occur as slugs of water are picked up at high speed in badly laid out steam mains or pipe coils. It will occur when there is a lift after steam traps. Even when steam pressure appears to be adequate to overcome the lift, problems will occur at start up or when the plant being drained its temperature controlled. Discharging condensate into a pumped return line can produce its own brand of water hammer.

The thin walled bellows or element of the traditional balanced pressure thermostatic trap was clearly vulnerable to damage by water hammer.

However, this possibility is almost eliminated with some stainless steel elements such as the one show in Fig 19. The bimetal trap is nevertheless the more robust trap in those cases where a thermostatic trap is selected.

Of the mechanical traps, the inverted bucket type is far more resistant to water hammer than the ball float type. The miscellaneous types are generally impervious to damage by water hammer.

DIRT

Dirt is another major factor which must be considered in trap selection. Although steam condenses to give distilled water, there are many cases where priming in the boiler causes the carryover of boiler feed treatment compound. Apart from that there are the problems of initial pipe muck at the time of installation and the products of corrosion during subsequent running.

An intermittent blast action is the one least likely to be affected by dirt. In thermostatic traps this means that the balanced pressure thermostatic trap is to be preferred although the larger flat valve associated with some diaphragm traps can cause difficulties. The dribbling action of bimetallic traps, coupled with the arrangement of valve stem passing through the seat, means that these are most prone to malfunction or even to blockage. Claims are sometimes made that a particular element can be readily cleaned and is not subject to fouling. However, fouling of the element is rarely a problem and the vulnerable part is the valve and seat.

Mechanical traps are moderately successful. The valve and seat of the float traps are submerged below the water level which might protect them from the dirt at the water surface or which sinks to the bottom of the trap. On the other hand, the loose sand and gravel which cause problems when draining concrete curing auto claves can be carried through large float traps quite successfully, no doubt due to the high mass flow.

In the case of inverted trap the claim is sometimes made that the main valve is above the water level and unaffected by dirt. This ignores the fact that the most vulnerable orifice is the air vent hole in the bucket. Blockage here can cause the trap to air bind and fail in the closed position. It is a well known fact (?) that some traps operate better after being struck with a heavy object (!). In the case of the inverted bucket this can mean dislodging a bit of scale blocking the air vent and producing an instant cure.

The thermodynamic is another type well suited to dirty conditions. Although disc and seat must be clean to ensure correct operation, they are normally kept in this condition due to the high velocity across them. There is also the positive snap action. This, incidentally, obviates any chance if wiredrawing as there is no question of the two parts working close together. Suggestions that this type does suffer from wire-drawing are ill-founded and mischievous.

By contrast the impulse trap is unsuitable for dirty conditions. The fine clearances between plug and tapered sleeve do not enjoy the benefits of high velocity flow and the plug will frequently stick in an intermediate position. The trap thereafter provides a fixed orifice which may or may not be noticed.

The orifice place is of course the device least suited to the dirty conditions. The hole is almost invariably small and frequently blocks within hours of installation. Enlarging the hole as is sometimes done in desperation makes a nonsense of the original sizing. It is wasteful and in some cases merely delays the time blockage will occur. A strainer is sometimes fitted but this has to be extremely fine if it is to be effective. The problem then is frequent blockage of the strainer screen.

STEAM LOCKING

The possibility of steam locking can be a deciding factor in the selection of steam traps. It can occur whenever a steam trap is fitted remote from the plant being drained. It can become acute when condensate is removed through a siphon or dip pipe.

Fig 20. Shows the removal of condensate from a drying cylinder. In fig (i) the steam pressure is sufficient to lift condense up the siphon pipe, through the steam trap and away. Fig (ii) shows what happens when the level of condensate at the bottom of the cylinder falls below the end of the siphon pipe. Steam enters the siphon pipe and causes the steam trap (in this case a float type) to close.

The trap is thereafter 'steam locked'. Heat loss from the cylinder will result in the formation of more condensate which is unable to reach the trap. Fig. (iii) Shows severe water logging of the cylinder which will result in a reduced drying rate from the cylinder and increase in the power required to turn the cylinder. In extreme cases the cylinder may well fill to the centre line and damage may then be caused as water reaches rotary joints.

Fig. 21 shows a float trap fitted with 'steam lock release'. This is a needle valve which allows the steer locked in the siphon pipe to be bled away past the main valve. It is the only type of trap with this facility and is the only choice on such things as heavily loaded drying cylinders. Because the needle valve is only cracked open to avoid steam wastage it has limited capacity to vent air. Traps of this type are often provided with separate air vents while fig.22 shows a trap which combines steam lock release and thermostatic air vent facilities.

Clearly any trap which opens regularly as a result of heat loss will eventually cope with a steam lock. However, the resultant drainage will be erratic and the method is only acceptable with small, non-critical condensate lines.

SERVICING

The steam trap incorporates a valve and seat together with moving parts. Wear or fatigues are inevitable and account must be taken of the need to service the trap.

Many traps are designed for easy maintenance. Fig.23 shows a typical bimetallic trap where the entire internals can be removed by unscrewing the seat thread. As discussed earlier small mechanical traps are sometimes designed so that the cover and internals can be readily removed to the workshop for attention as shown in fig.24.

A recent development is the sealed unit which precludes any kind of maintenance or proper cleaning. Since the entire trap has to be replacing whenever the internals require renewal, it is essential that provision is made for this when the trap is installed.

STEAM TRAP TYPES

There are four main steam trap types:

THERMOSTATIC GROUP

This type identifies steam and condensate by temperature difference which operates a thermostatic, valve-carrying element. Condensate must cool down below steam temperature before it can be released.

MECHANICAL GROUP

Traps of this type operate mechanically, sensing the difference in density between steam and condensate. The movement of the 'float' or 'bucket' operates the valve.

THERMODYNAMIC GROUP

This group works on the difference in velocity between steam and condensate flowing through the trap. The valve consists of a simple disc which closes to higher velocity steam but opens to lower velocity.

MISCELLANEOUS GROUP

This group consists of traps which cannot be place in any of the above categories. These traps are unlikely to be found on our plants but are mentioned as a point of interest.

What do we need from the steam trap?

The first concern of an engineer of designer must always be for the plant being drained. Steam trapping is not an end in itself and the overall performance of the plant must be paramount. Having said that, the selection of steam traps is by no means straightforward. A trap must be selected to carry out a given function under given conditions. These may involve variations in operating pressure, load or back pressure. Traps may be subjected to extremes of temperature or water hammer, while corrosion or dirt is other common hazards.

There can be no universal steam trap and it is only those manufacturers with a very limited range who would make this claim. The following sections discuss some of the many factors involved in trap selection.

Air Venting

At start up the trap must be capable of discharging air. Until air is displaced, steam cannot enter the steam space and warming up becomes a lengthy business. Standing losses increase and plant efficiency falls. Separate air vents may be required on larger or more awkward steam spaces, but in most cases air in a system is discharged through the steam traps. Here thermostatic traps have a clear advantage over other types since they are fully open at start up. Float traps with inbuilt thermostatic air vents are also acceptable, while the sizeable orifice in some thermodynamic traps means that they too can handle a reasonable amount of air. The small bleed hole in the inverted bucket trap or the orifice plate generally means poor air venting capacity.

Condense Removal

Having vented air, then the trap must handle condensate. If the steam space is small and output is critical, then condensate must be discharged immediately and at steam temperature. Water logging is one of the main causes of reduced output from steam heated plant. It is also a significant factor in tube plate failure in shell and tube heat exchangers and causes leaks in gilled tube heater batteries.

Mechanical traps are clearly the first choice on this count. However, the frequent operation of other types may mean that they can be accepted. The discharge of condensate below steam temperature using thermostatic traps should only be contemplated when the steam plant being drained can accept a degree of water logging.

Thermal Efficiency

The basic requirement of air and condensate removal having been considered, attention may well turn to thermal efficiency. This is often simplified into a consideration of how much heat is profitably used in a given weight steam. On this basis the thermostatic trap may appear to be the best choice. These traps hold back condensate until it has cooled to something below saturation temperature. Provided that the heat is given up in the plant it, to the space being heated or to the process, then there is a real saving in steam consumption. Indeed, there is every inducement to discharge condensate at the lowest possible temperature. On the other hand, if cool condensate is then returned to a feed tank which requires preheating the ‘efficient’ trap has done little for the overall efficiency of the steam system. Care must also be taken in evaluating any application involving a cooling leg. Draining through a bimetallic steam trap may look attractive in terms of lower temperature discharge and reduced loss of flash steam. On the other hand, if heat is being lost to atmosphere through an unlagged cooling leg, then the net gain in thermal efficiency is probably zero. Without a cooling leg condensate will be held back within the plant and the main reservation must be whether the plant itself will accept this water logging. It is permissible with non critical tracer lines or oversized coils. As already indicated, it can be disastrous in the case of heat exchangers.

Reliability

Reliability is undoubtedly a major consideration. Reliability means the ability to perform under the prevailing conditions with the minimum attention. The prevailing conditions may be predictable or unpredictable. Corrosion due to the condition of the condensate or of the surrounding atmosphere may be known and can be countered by using particular materials of construction. Water hammer due to a lift after the trap may be overlooked at the design stage and can lead to the premature failure of otherwise reliable traps. Dirt can be another major factor. A trap selected to meet all the obvious criteria may be thoroughly unreliable in a system where water treatment compound carried over from the boiler, or pipe dirt, are allowed to interfere with trap operation. The prime requirement however is the adequate removal of air and condensate. This requires a clear understanding of how traps operate.

HOW TRAPS OPERATE

In order to appreciate trap selection, so called 'losses' or even maintenance, it is essential to know how steam traps operate. There are three basic types.

Thermostatic

In the steam space, steam loses some of its heat to produce condensate at steam temperature. Continuing heat loss will mean that the temperature of this condensate will fall. The thermostatic trap senses temperature and moves a valve in relation to a seat to release condensate.

Mechanical

These rely for their operation on the difference in density between steam and condensate. In the ball float trap the ball rises in the presence of condensate to open a valve. The inverted bucket floats when steam reaches the trap and shuts a valve. Both are essentially 'mechanical' in their method of operation.

Thermodynamic and 'Change of State'

The third type is not so easily recognised as such and consists of a number of apparently unrelated devices. This group includes thermodynamic, impulse and labyrinth traps and ever the simple orifice plate. All rely on the fact that hot condensate; released in pressure, can 'flash off' to give a mixture of steam and water. It is worthwhile to consider these types in more detail.

Liquid Expansion

This is one of the simplest thermostatic traps and is shown diagrammatically in fig 1 an oil filled element expands when heated to close the valve against the seat. The adjustment allows the element to be moved relative to the seat which effectively alters the temperature of the trap discharge. The problem is that the temperature of steam varies with pressure. The trap on the other hand can only be set to operate at a fixed temperature. Fig 2 shows the saturation curve for steam together with the response line of the liquid expansion trap and illustrates the problem. At pressure P1 condensate would have to cool by only small amount and trapping would be acceptable. However, if pressure is increased to P2 then condensate has to cool appreciably before passing through the trap and serious water logging will take place. At reduced pressure P3 the trap will blow live steam. Although this type provides a useful device for discharging condensate at a fixed temperature, it can only be used as a steam trap on those applications where significant water logging can be tolerated.

Balanced Pressure

An improvement is provided by the balanced pressure trap shown in Fig 3. As the name suggests, this is ‘balanced’ to cope with pressure (and therefore temperature) variations. The oil filling is replaced by an evacuated element containing a small quantity of a liquid with a boiling point somewhat lower than water. In the cold conditions which exist at start up the element is contracted. The valve is off its seat and is wide open, allowing the prompt removal of air. This is a feature of all thermostatic traps and explains why they are also used as air vents. As condensate passes through the trap, heat is transmitted to the liquid in the element. Before steam reaches the trap this liquid boils. The vapour pressure within the element causes it to expand and the trap shuts. Heat loss from the trap cools the water surrounding the element and the filling condenses. The element contracts to open the valve and releases condensate until it again approaches steam temperature when the cycle is repeated. The temperature below steam temperature at which is sometimes susceptible to damage due to water hammer. This can be countered by the use of stainless steel while other designs use a completely filled element. Fig 5. Shows a modern element with considerable resistance to damage by water hammer or corrosion.

Bimetallic

The most robust thermostatic traps are those using bimetal strips of dissimilar metals welded together which deflect when heated. Fig 6 shows a simple bimetal steam trap. The trap is wide open when cold and will vent air. As condensate passing through the trap increases in temperature the bimetal deflects so that valve modulates the flow. The setting or temperature response depends on the position of the valve relative to the seat. As with the liquid expansion trap, the adjustment can be used to set the trap to close at a predetermined temperature. Because of this limitation bimetal steam traps commonly use a downstream valve as shown in fig 7. Again, condensate passing through the trap will defect the bimetal to pull the valve against the seat while line pressure will tend to push the valve away from the seat. As the temperature (and pressure) of the condensate increases there is an increased closing force working against an increased opening force. The result is the sloping response line show in fig 8 (i). This is an improvement on fig.2, but is still a long way from following the saturation curve. Use is therefore made of different types of bimetal in a single stack to get the response line to change as shown in Fig.8 (ii). One set of bimetal deflects to five the response AB. At higher temperature a second set of bimetal leaves contributes to give response BC. At still higher temperature the third set of bimetal deflects to produce CD. The purpose is to follow the saturation curve as nearly as possible. Unfortunately bimetal does age and can take up something of a permanent set. Other designs use shapes, stacked in pairs to pull the valve onto the seat as shown in fig 9. One particularly successful shape is shown in fig.10 which indicates the way in which the three legs of different length come into operation at different temperatures. The response line can be effectively moved up or down by adjusting the position of the valve relative to the seat and there is a temptation in some cases to set the trap close to the saturation line. This is unwise on several counts. In the first place, bimetal suffers from hysteresis, as shown in Fig 8 (iii). Bimetal will deflect and close a valve when the surrounding water is at a somewhat higher temperature than the bimetal. It will only open again when the surrounding water has cooled to a lower temperature than the bimetal. There is therefore a difference closing and opening temperatures and there is no question of setting the trap at a precise temperature. Similarly, the setting depends on a balance between the closing force provided by the bimetal an opening force provided by line pressure. Clearly any back pressure acting on the downstream side of the valve can upset this balance. Unfortunately many condensate return systems do impose a back pressure which varies with load conditions so the trap setting will vary. Obviously if this type of trap is set to operate close to steam temperature then there is the danger that under certain conditions it will blow live steam as shown in fig 8 (iv). Furthermore, operating around steam temperature can produce wiredrawing of the valve and seat so that they are incapable of complete closure. Bimetallic traps are therefore set down to ensure that they will hold back condensate at all times.

In many ways the float trap with thermostatic air vent is closest to the ideal steam trap. It will handle easily and will get rid of condensate just as soon as it is termed. It will do this regardless of changes in steam pressure. Unfortunately the trap is comparatively large while the ball float and valve mechanism can be damaged by water hammer.

Inverted Bucket

The inverted bucket trap is shown diagrammatically in fig 13. As the name implies the working portion consists of an inverted bucket attached through a lever to a valve. An essential part of the trap is the small air vent hole in the top of the bucket. Fig 14 shows the method of operation. In (i) the bucket hangs down pulling the valve off its seat. Condensate flows under the bottom edge of the bucket, filling the body and flowing away through the outlet. When steam reached the trap it collects in the top of the bucket making it buoyant. The bucket then rises as shown in (ii) and closes the valve. The trap remains shut until the steam in the bucket is dissipated. This occurs due to radiation loss from the body while some bubbles into the top of the trap body. In (iii) the bucket is about to lose its buoyancy. It will then sink, pulling the main valve off its seat. Accumulated condensate is released and the cycle is repeated. Air reaching the trap at start up will also give the bucket buoyancy and close the valve. Air will not condense so the air vent hole is essential to allow air to escape into the top of the trap. The hole is small so the trap is relatively slow at venting air. At the same time it can waste steam and give a dribbling action under low load conditions. Because steam and condensate are discharged into the inside of a cylindrical bucket, the trap is generally more robust than the ball float type. On the other hand the trap is poor at venting air while the intermittent operation means that the flow of condensate is not always continuous. When the steam pressure in chamber D acting over the full area of the disc exceeds the incoming condensate pressure acting on the must smaller inlet area, the disc snaps shut covering the inlet orifice. This snap action is important. It removes any possibility of wiredrawing the seat, while the seat itself is tight, ensuring no leakage. This stage of affairs is shown in (iii) and will persist until condensation in the control chamber reduces the pressure over the disc. As shown in the control chamber pressure and the disc will be raised starting the cycle all over again. The rate of opening clearly depends on steam temperature and also on ambient conditions. Most traps will stay closed for between 20 and 40 secs. If the trap open too frequently, due to perhaps to a cold and windy location, the rate of opening can be slowed down by the simple expedient of fitting an isotub or insulating cover, something which is standard on high pressure traps.

Some manufacturers take this to extremes and use a steam jacket to make good the radiation losses from the top cap. This means that the steam in the control chamber can never condense so a radial groove is provided on the underside of the disc which allows this steam to leak away. The problem here is that the groove constitutes a permanent leak. The trap is unable to give a tight shut off and tends to work too frequently. The inevitably large steam jacketed cap is also more wasteful than the provision of an insulating cover on a more conventional trap.

Impulse

The impulse trap is shown diagrammatically in fig 17. It consists of a hollow piston A with a piston disc. B working inside a tapered piston C which acts as a guide. At start up the main valve rests on the seat D leaving a passage of flow through the clearance between piston and cylinder and whole E at the top of the piston. Increasing flow of air and condensate will act on the piston disc B and lift the main valve off its seat to give increased flow. Some condensate will also flow through the gap between piston and disc, through E and away at the trap outlet. As the condensate approaches steam temperature some of it flashes to steam as it passes though the gap. Although this is bled away through whole E it does create an intermediate pressure over the piston, which effectively positions the main valve to meet the load. The trap can be adjusted by moving the position of piston C relative to the seat but the trap is affected by significant back pressure. It has a substantial capacity, bearing in mind its small size. On the other hand the trap is unable to give complete shut off any problem however the fine clearance between the piston and cylinder is. This is readily affected by dirt normally found in a steam system. Usage relatively small so the type is not considered some subsequent sections. By definition the steam trap must trap or hold back steam whilst at the same time allowing the removal of air, incondensable gases and condensate. The basic requirements of good steam trapping have already been outlined and it is worth reiterating the fact that the performance of the plant is paramount. It is no good having trouble free stream traps if the performance of the plant is impaired. It is no good reducing trap maintenance if this results in leaks from the system or water logging and corrosion of plant. Guidance on a whole range of applications is given in spirax sarco handbook 'Practical steam trapping' and it is worth mentioning the fact that in almost every case a choice is available. This section will not repeat that guidance but simply discuss some of the more important factors in trap selection. These start on the basis that the requirements of pressure, load and air venting have been met in the provisional selection.