Chapter 8

STEAM PIPING

STEAM

The use of steam in the piping business is extremely common and the efficient handling of steam lines is essential. The major consequence of running steam through piping is that as the pipeline cools, the steam loses heat and produces condensate which if left in the line will cause waterhammer and subsequent damage to the piping system and/or equipment.

Figure 8-1: Water Hammer Noise

Figure 8-2: New York Water Hammer Explosion

8.1 STEAM PIPING

All steam piping systems must be designed as follows:

Condensate must be removed from the steam line as soon as possible by the use of steam traps and drip legs (Figure 8-3). Drip legs collect condensate and are located at all low points in steam lines and at intervals in horizontal piping. A steam trap is connected to the drip leg and will open to allow the condensate to escape, then will close when it senses steam thereby not allowing any steam to escape from the line. Strainers must be provided upstream of the steam trap to prevent any scale or grit from entering the trap and causing them to stick in an open position. Some traps have built in strainers.

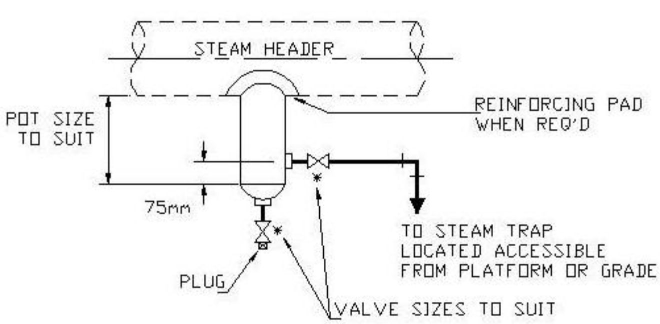

Figure 8-3: Typical Drip Leg

Figure 8-4: Drip Leg with Flanges

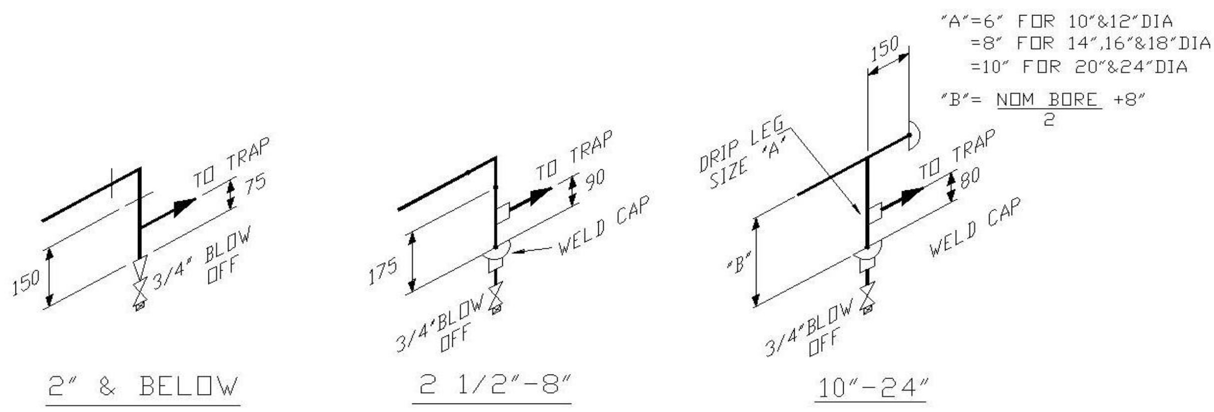

Figure 8-5: Typical Drip Legs at Header Ends

8.2 STEAM TRAPS

The first function of any steam trap is to remove air and non-condensable gases from the equipment to which it is assigned. If the air is not removed, steam will not be able to enter the equipment. Hence, heat transfer will not occur.

Or, if air is not removed as designed, you may get uneven heating among different components, poor steam distribution and possible corrosion.

The next job of the trap is to close in the presence of steam. There is a good reason for this. For example, 1 lb of water at saturation conditions (15 psig and 250°F) contains 218 Btu; 1 lb of steam at the same pressure contains 1,163 Btu. Of that, 945 Btu are in the form of latent heat. That is to say, as the steam condenses into a liquid, it gives up its latent heat you can see that much more energy can be removed from 1 lb of steam than from 1 lb of water. You do not want steam to leave the system or process before it gives up its latent energy.

The last job of the trap is to drain condensate. As the steam gives up its latent heat, it changes phase from a vapor into a liquid. This liquid is called *condensate*. This condensate must be removed from the heat transfer equipment. If it's not removed, then you have less heat transfer area for the steam, and possible water hammer upstream of the trap. Consequently, that means less heat will be transferred.

Steam Trap Purpose:

To remove condensate from live and exhaust steam lines, condensing equipment, reboilers, heating coils, non self draining steam tracing manifolds and single tracers.

Method of Installation:

By utilizing drip legs to collect condensate and to extract same by steam traps.

Location:

a. At every low point in a steam system
b. If there is a long horizontal run of pipe, as in a piperack, then it will be necessary to provide drip legs and steam traps at intermediate locations.

Steam trap suppliers such as Armstrong and Spirax Sarco are extremely knowledgeable and offer excellent instructional information.

Steam Traps fall into three categories:

- Mechanical Two Types - Ball Float, Inverted Bucket
- Thermodynamic - also called impulse or controlled disc
- Thermostatic - temperature sensitive

Ball Float Valves

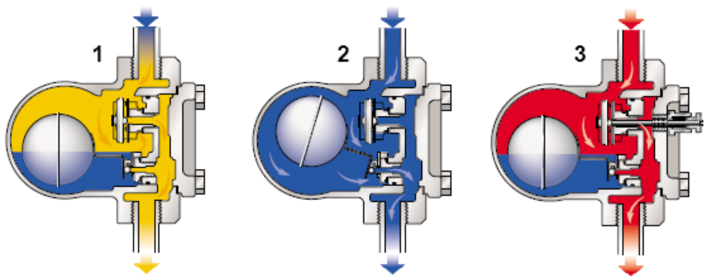

Figure 8-6: Ball Float Trap
(Courtesy Spirax Sarco)

Figure 8-7: Ball Float Trap
(Courtesy Spirax Sarco)

- On start up a thermostatic air vent allows air to bypass the main valve .
- As soon as the condensate reaches the trap, the lever mechanism opens the main valve. Hot condensate closes the air vent but continues to flow through the main valve.
- When all condensate is removed the float drops and closes the main valve, which remains at all times below the water level, ensuring that live steam cannot be wasted.

Inverted Bucket Traps

The inverted bucket is the most reliable steam trap operating principle known. The heart of its simple design is a unique leverage system that multiplies the force provided by the bucket to open the valve against pressure. Since the bucket is open at the bottom, it resists damage from water hammers, and wearing points are heavily reinforced for long life

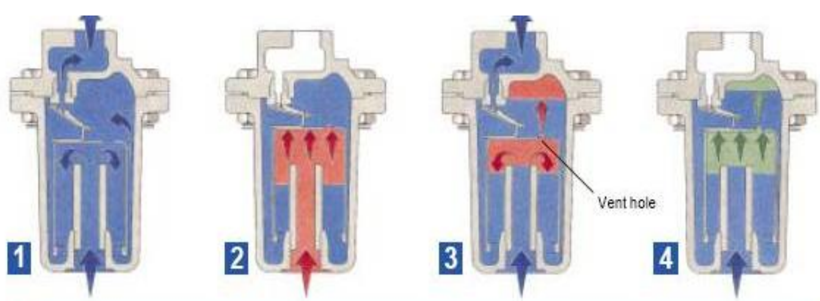

Figure 8-8: Inverted Bucket Traps
(Courtesy Spirax Sarco)

1. As condensate reaches the trap it forms a waterseal inside the body. The weight of the bucket keeps the valve off its seat. Condensate can then flow around the bottom of the bucket and out of the trap.
2. When steam enters the underside of the bucket it gives buoyancy and the trap rises. This positions the lever mechanism such the main valve snaps shut.
3. The bucket will lose its buoyancy as the enclosed steam condenses and steam escapes through the vent hole. Once this happens the weight of the bucket will pull the valve off its seat and the cycle is then repeated.
4. Any air entering the trap will give the bucket buoyancy and close the valve and prevent condensate flow. The small vent hole in the bucket will bleeds the air into the top of the trap.

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Thermodynamic Traps

The thermodynamic trap is a robust steam trap with simple operation. The trap operates by means of the dynamic effect of flash steam as it passes through the trap.

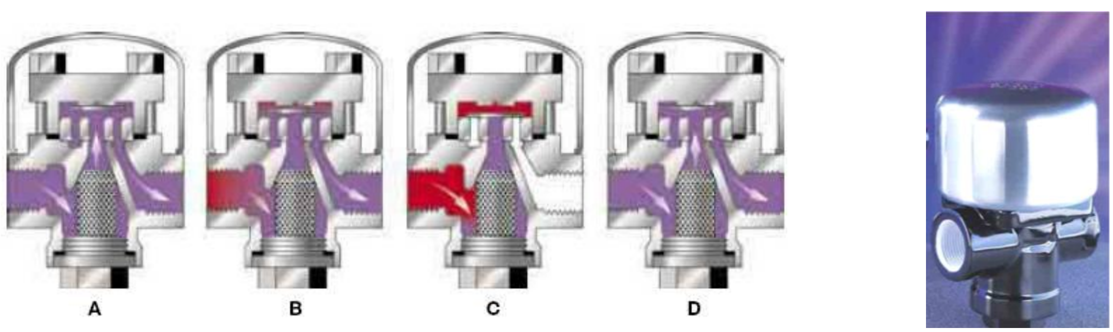

Figure 8-9: Thermodynamic
(Courtesy Spirax Sarco)

- On start up, upsteam pressure raises the disc, and cooled condensate plus air is immediately discharged.
- Hot condensate flowing through the trap releases flash steam at high velocity which creates a low pressure area under the disc, drawing it towards the seat.
- At the same time the pressure of the flash steam builds up in the chamber above the disc forcing it down against the pressure of the incoming condensate until it seats on the inner ring and closes the inlet. The disc also seats on the outer ring and traps the pressure in the chamber.
- Pressure in the chamber decreases as the flash steam condenses and the disc is raised by the incoming pressure. The cycle is then repeated.

Thermostatic Traps

There are two basic designs for the thermostatic steam trap, a bimetallic and a balanced pressure design. Both designs use the difference in temperature between live steam and condensate or air to control the release of condensate and air from the steam line.

In a thermostatic bimetallic trap it is common that an oil filled element expands when heated to close a valve against a seat. It may be possible to adjust the discharge temperature of the trap - often between 60°C and 100°C.

This makes the thermostatic trap suited to get rid of large quantities of air and cold condensate at the start-up condition. On the other hand the thermostatic trap will have problems to adapt to the variations common in modulating heat exchangers.

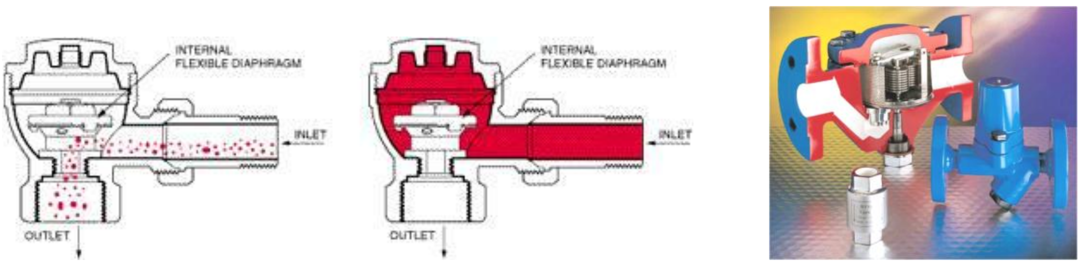

Figure 8-10: Thermostatic Trap
(Courtesy Spirax Sarco)

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8.3 STEAM TRAP SELECTION

Steam Trap Type	Float & Thermostatic	Inverted Bucket	Thermostatic	Thermodynamic
Reponses to load changes	Fast	Moderate	Moderate	Slow
Air venting	Medium/High	Low	High	Low
Main applications	Drip legs, Process equipment	Drip legs, Process equipment	Drip legs, Process equipment, tracing	Drip legs, tracing
Capacity	High	High	Low	Low
Maintenance	Moderate	Moderate	Easy	Easy
Relative cost	Medium/High	Medium/Low	Low	Low
Capacity	High	High	Medium	Low

Figure 8-11: Steam Trap Selection Chart

8.4 STEAM CONTROL SETS

Every low point in a steam line must be trapped and steam control sets are no exception, the drip leg must be located upstream of the upstream block valve so it is still functioning while the flow is going through the bypass.

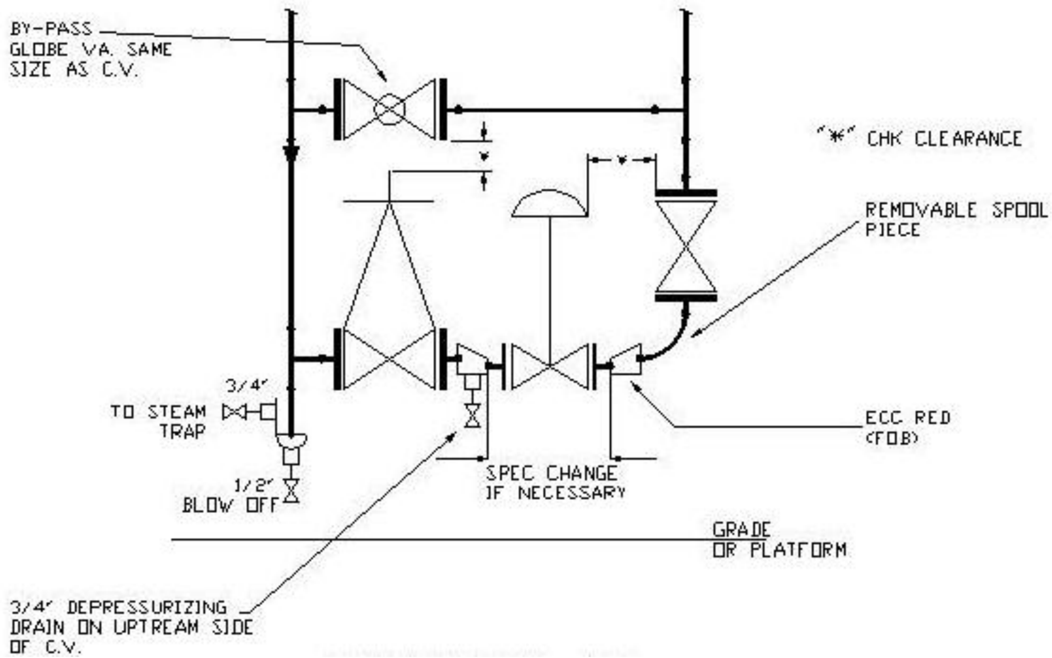


Figure 8-11: Typical Steam Control Set

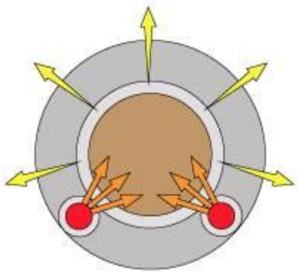
8.5 STEAM TRACING

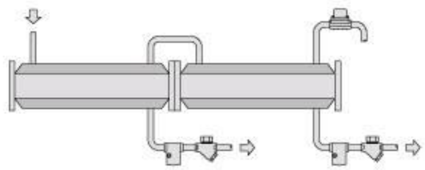
Pipelines carrying viscous fluids are frequently maintained at an elevated (or operating) temperature by means of steam tracers. These usually consist of one or more small bore steam lines running alongside the product line, the whole being covered in insulation. Steam tracing is also used as an alternate to electrical tracing in freeze protection of lines.

In theory, the exact calculation of steam consumption is difficult, as it depends on:

- The degree of contact between the two lines, and whether heat conducting pastes are used.
- The temperature of the product.
- The length, temperature and pressure drop along the tracer lines.
- The ambient temperature. Wind speed. The emissivity of the cladding.
- Fig. 8-12 A steam tracer
- Fig. 8-13 Jacketed pipeline
- Fig. 8-14 Heated sampling point

In practice, it is usually safe to assume that the tracer line simply replaces radiation losses from the product line itself. On this basis, the steam consumption of the tracer line may be taken as a running load being equal to the radiation loss from the product lines.





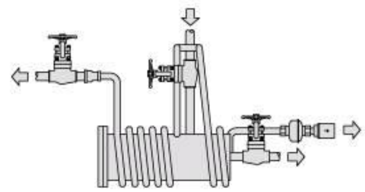


Figure 8-12: Figure 8-13: Figure 8-14:

- A steam tracing system consists of tracer lines separately fed from a steam supply header, each tracer terminating with a separate trap.
- The best way to size a steam tracing header is to calculate the total x section of all the tracers and to calculate the header size allowing the same flow area.
- The rate at which condensate forms and fills the tracer determines the length of the tracer in contact with the line.
- Expansion of the tracers must be considered and may be accommodated in horizontal piping by looping the tracer at elbows. Care must be taken that the expansion of the tracer does not cause damage to the insulation.
- Sch 80 carbon steel pipe, or copper or stainless steel tubing is used for tracers. Selection is based on steam pressure and required tracer size. Tracers are either 3/8" or 1/2" size with copper tubing being the most economical installation.

Steam Tracing – Design Points

- Run tracers parallel to and against the underside of the pipe to be heated.
- Run a steam tracing sub-header to operating level and individual tracers should take off from the top of the header with an isolating valve provided.
- Feed steam to the highest point of the system of lines to be traced, so that gravity will assist the flow of condensate to the traps and condensate header.
- Provide unions at loops around flanges.
- Do not provide a trap at every low point of a tracer (as in steam lines) but provide one at the end of the tracer.

- Do not run more than one tracer to a trap.
- If possible group supply sub-headers and condensate return headers and locate them at grade or on a platform.

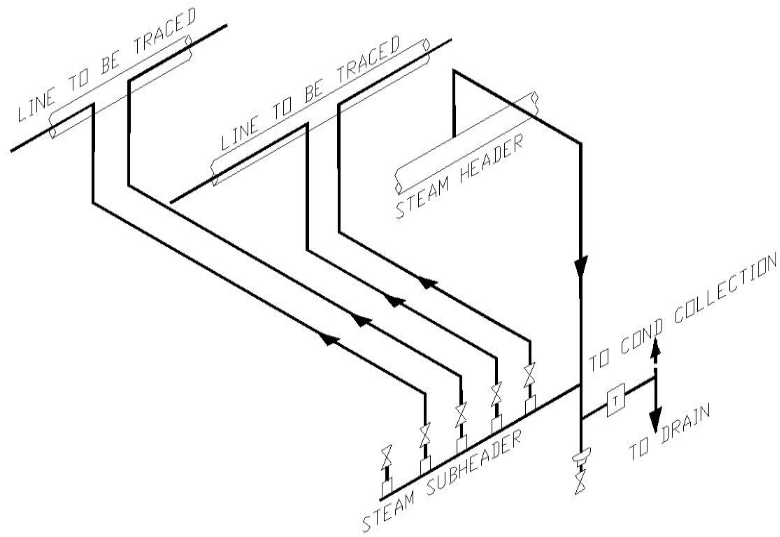


Figure 8-15: Steam Tracing Sub Header

Steam Tracing Sub Header Manifolds

Manifolds are generally located at piperack columns and are laid out as shown in Figure 8-15.

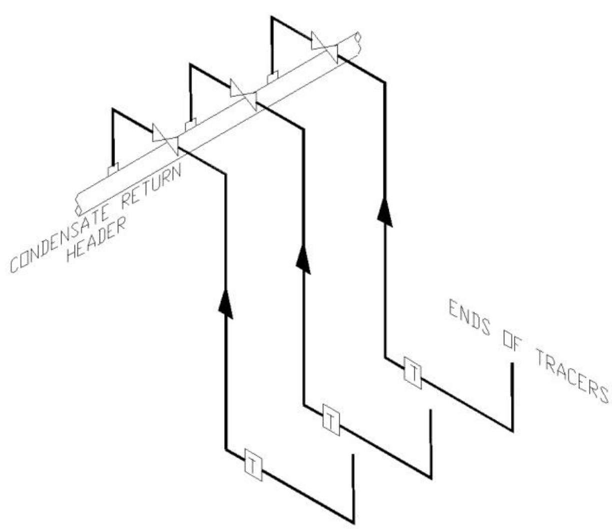


Figure 8-16: Condensate Collection Sub Header

Condensate Collection Manifold

Again these manifolds are generally located at piperack columns and are laid out as shown in Figure 8-20.

Pre-Manufactured Steam and Condensate Manifolds

As can be seen below on Figures 8-17 and 8-18, pre-manufactured manifolds are available and normally are located at piperack columns.

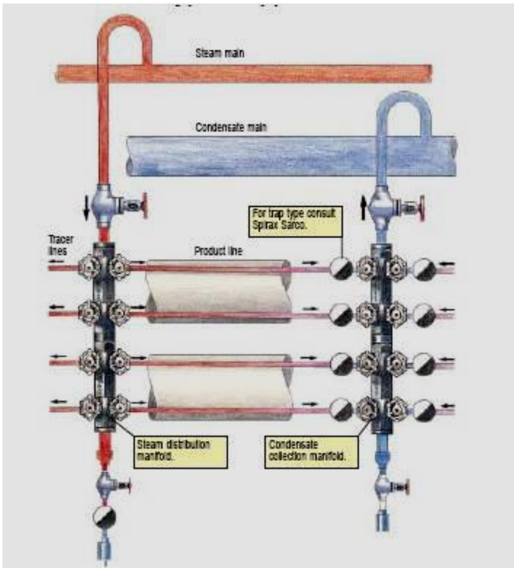


Figure 8-17: Steam Tracing Manifold (Courtesy Spirax Sarco)

Figure 8-18: (Courtesy Spirax Sarco)

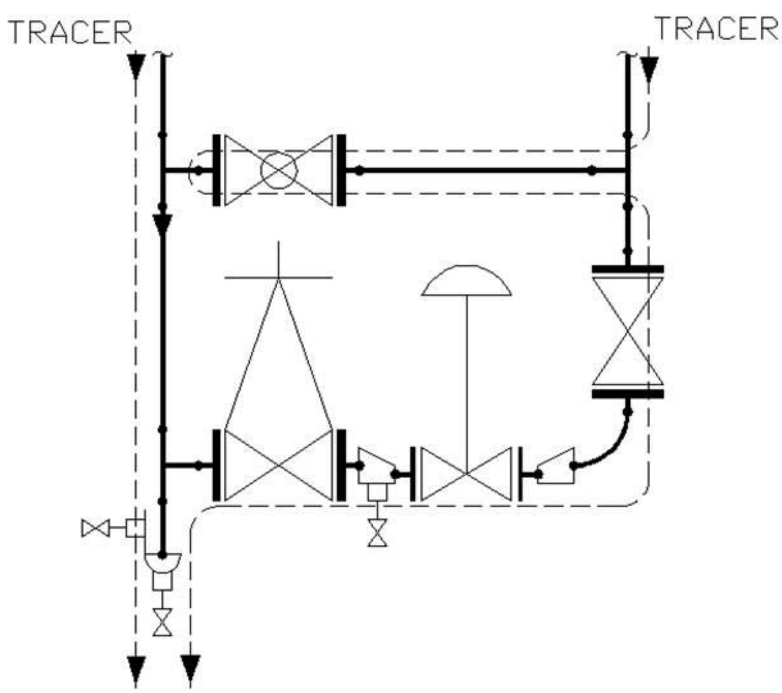


Figure 8-19: Steam Tracing at a Steam Control Set

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Steam Tracing and Manifolds

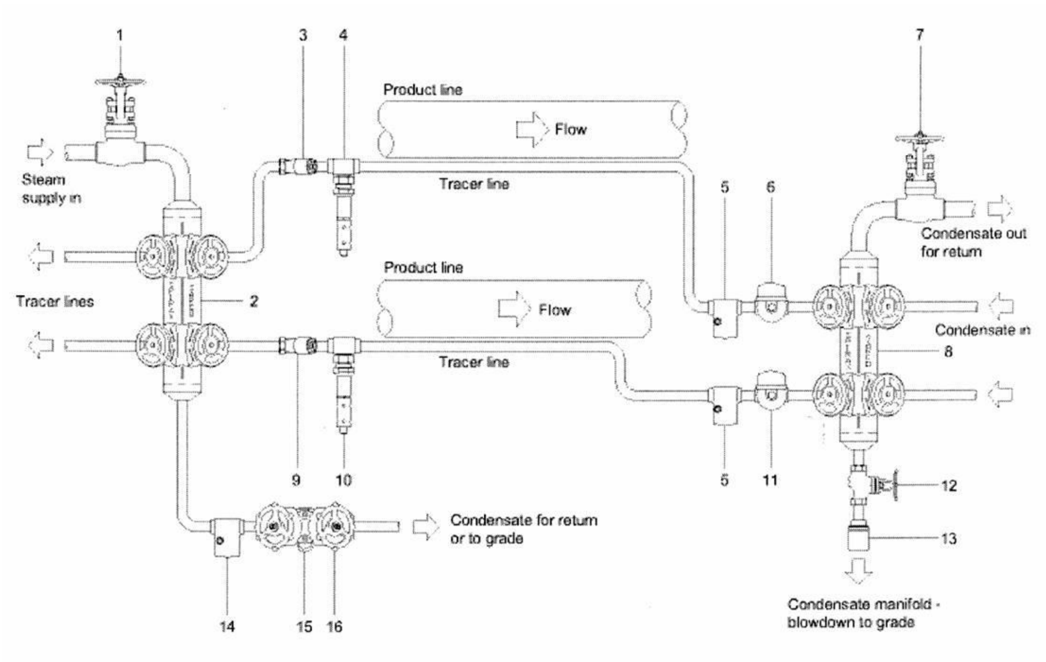

Figure 8-20: Steam Tracing Manifold (Courtesy Spirax Sarco)

Manifolds on Non-Critical Tracing (Courtesy Spirax Sarco)

The required components of non-critical tracing control with manifolds.

1. Isolation Valve to isolate the drain trap from the supply steam
2. Steam Condensate Manifold to distribute steam to tracing lines
3. Strainer to protect the control valve from detritus
4. Temperature Control Valve to regulate the flow of steam through the tracer
5. Spiratec Sensor Chamber to monitor the trap condition
6. Steam Tracing Steam Trap to discharge condensate correctly
7. Isolation Valve to isolate the drain trap from the condensate system
8. Steam Condensate Manifold to collect condensate from tracing lines
9. Strainer to protect the control valve from detritus
10. Temperature Control Valve to regulate the flow of steam through the tracer
11. Steam Tracing Steam Trap to discharge condensate correctly
12. Isolation Valve to drain the condensate manifold
13. Diffuser to diffuse the condensate when draining to grade
14. Spiratec Sensor Chamber to monitor the trap condition
15. Steam Tracing Steam Trap to discharge condensate correctly
16. Pipeline Connector to allow quick trap change during maintenance

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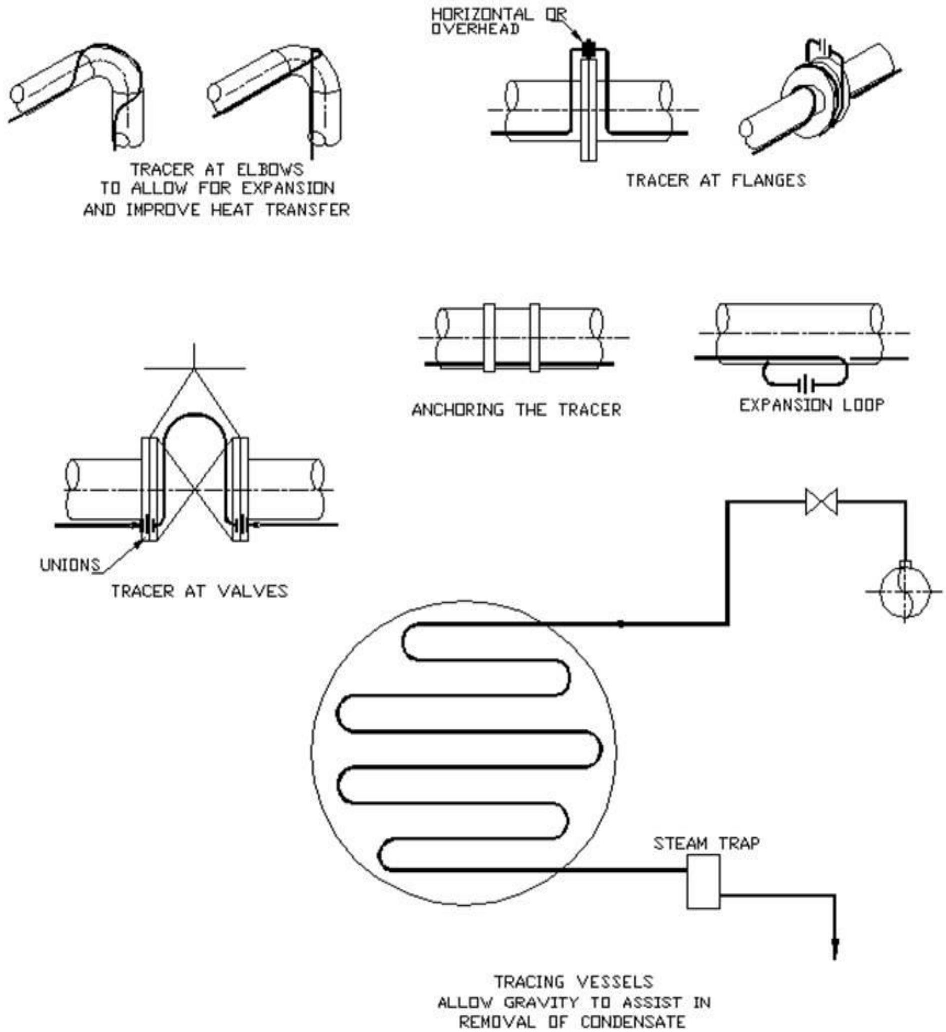
HORIZONTAL OR
OVERHEAD
TRACER AT ELBOWS
TO ALLOW FOR EXPANSION
AND IMPROVE HEAT TRANSFER
TRACER AT FLANGES
ANCHORING THE TRACER
EXPANSION LOOP
UNIONS
TRACER AT VALVES
STEAM TRAP
TRACING VESSELS
ALLOW GRAVITY TO ASSIST IN
REMOVAL OF CONDENSATE

Figure 8-21:

Typical Steam Tracing Application in an Oil Refinery

- There are pipes running all round a typical oil refinery or chemical plant. These pipes carry crude oil, intermediate products and final products.
- The largest pipes carry crude oil and are a metre in diameter. The heavier fractions of crude oil are either solid (bitumen and fuel oil) or thick viscous liquids (lube basestock and heavy gas oil). However, we have to move around the refinery through pipes and pumps. The only way to do this is to keep them hot.
- Hot oil is less viscous than cold oil - i.e. it is thinner and flows more easily. When the fractions come out of the distillation column, they are already hot. However, they would soon cool down in normal pipes, clogging up pumps and the pipes themselves. So they have to be kept hot.
- We do this using special pipes with steam tracers. The tracer is a pipe that runs alongside the oil pipe. It carries pressurised steam at up to 270°C. The assembly is then wrapped in thick insulation to reduce losses by conduction. This is covered in a shiny, metallic jacket that reduces the radiation (shiny surfaces radiated less than dull, black surfaces).
- Different pipes have to be kept at different temperature. A pipe carrying bitumen is kept at 180°C using a steam tracer at 270°C. Sometimes, the tracer pipe runs down the middle of the pipe to keep it at such a high temperature. Other products are kept at more like 80°C using a steam tracer at 180°C.
- The steam tracer keeps the product hot rather than heating it. It has already been heated in the furnace before distillation.
- Even with all the insulation, the oil and the steam cool down as they run through the pipe. So most steam tracers are only about 150 metres long. One end is connected to the steam main that runs around the site and the other end passes out into the atmosphere where the cooled steam condenses. As one pipe passes out, a new pipe is fed into the lagging with fresh, hot steam.

Figure 8-22:

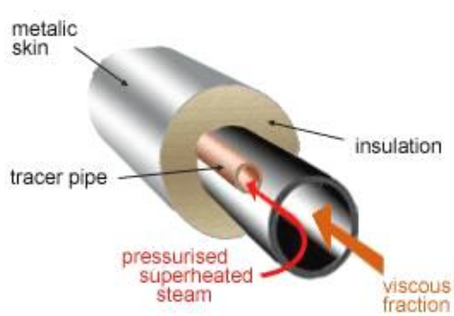

Figure 8-23:

Jacketed and Gut-Line Steam Tracing Systems

Jacketed and gut-line steam-tracing systems of this era were simply extended versions of the age-old double pipe heat exchanger. In this system, one of the process streams contains flowing steam and the other stream is the process fluid which requires temperature maintenance. The inner pipe contains the process fluid and the steam flows through the outer pipe. Steam enters at the top and condensate is drained through a nozzle at the bottom of the outer pipe. The distance between take offs depend on the rate of condensation. A slope of 1" every 10' – 20" is required to aid in condensate removal.

8.6 HOSE STATIONS

The purpose of hose stations is to provide the plant with facilities to clean equipment and hose floors. The lines are steam, air and possibly water and inert gas. The piping to the hose station is permanent and from the station to the local would be a flexible hose.

Hose Stations comprising of all services (water, steam, air possibly inert gas) are located at piperack columns so as to give coverage of whole unit at grade using 15000mm long hoses.

Air and steam connections are placed at tower platforms such that these services are available by hose at each manhole. Thus one station may serve more than one platform by dropping the hose down from a station above. Horizontal Drum platforms are served from the yard (piperack) hose stations. In general most companies will have their own configuration for hose stations. Figure 8-24 shows a couple of typical hose station installations.

Firewater is run separately from an independent water supply.

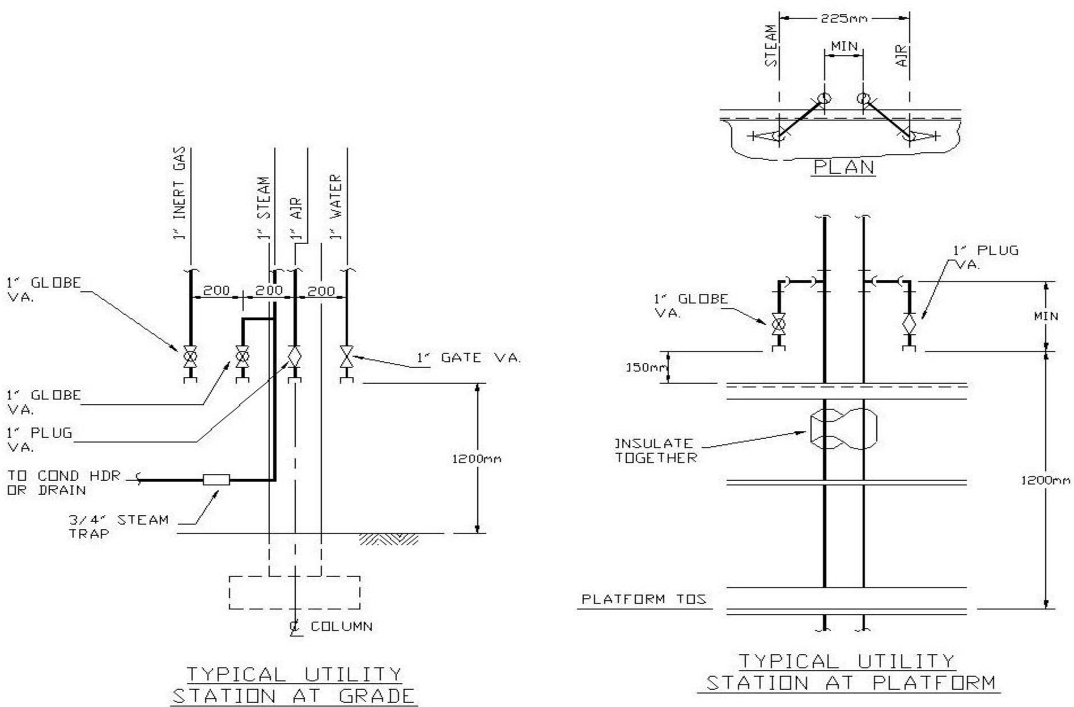

Figure 8-24: Hose Station Manifold