Armstrong
Machine Works

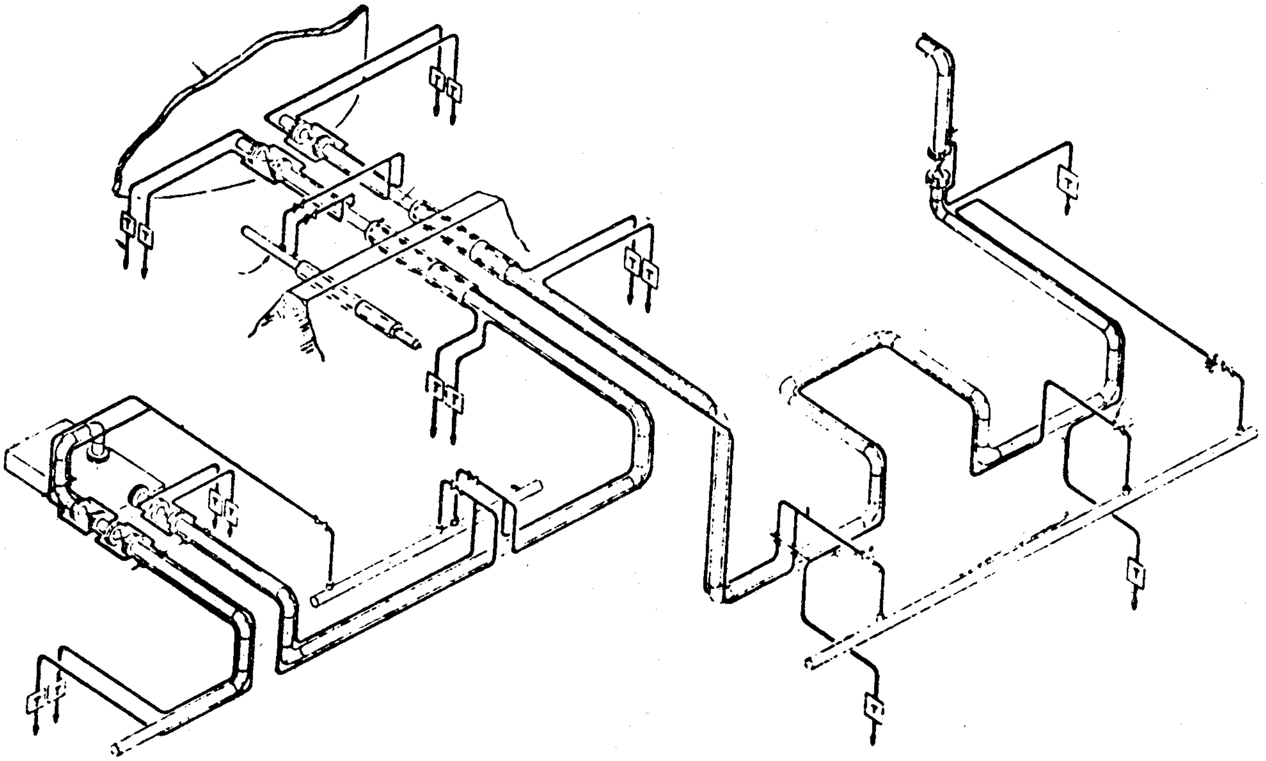
STEAM TRACER LINE APPLICATIONS

By R. L. Hitz

Steam is a common medium for maintaining the temperature of a primary process fluid line. This steam application is called a steam tracer line. The objective of steam tracer line systems is to maintain the fluid in the primary pipe at a given and uniform temperature. Steam tracer lines are utilized in both petrochemical and chemical industries. We would like to take this opportunity to review steam tracer line designs and discuss various aspects regarding the problems incurred as we try to maintain the temperature of the primary fluid.

Although the temperature of a primary fluid system must be maintained indoors, the outdoor applications are of particular interest. We will-be concentrating on steam tracer line applications for exterior primary fluid lines.

For most applications, steam tracer lines are economical and efficient. This diagram illustrates the use of steam tracer lines as commonly applied in the petrochemical industry.



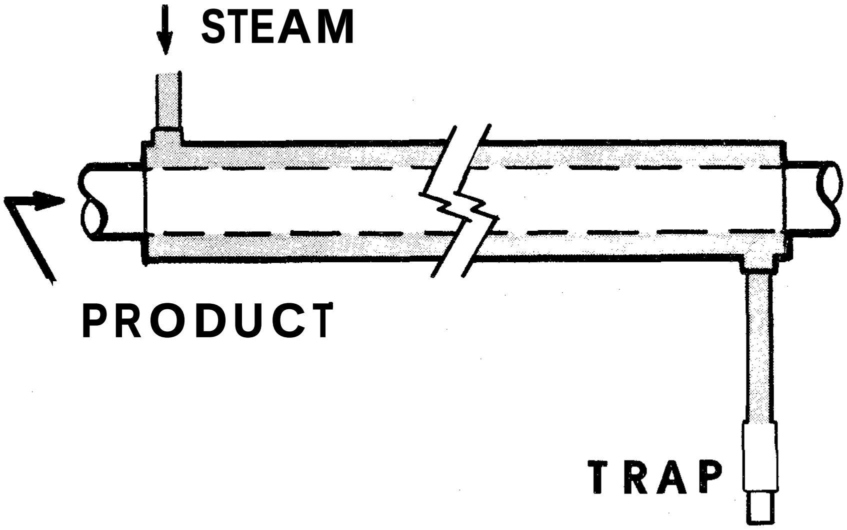
The temperature must be maintained not only in the primary fluid pipe, but through pumps, valves and joints. In short, anywhere the primary fluid is exposed to weather conditions.

You will note in this diagram the tracer lines are following the primary pipe from the storage tank across the valve.

We pick up the fluid line underground, through the dike, completely tracing to the pump. The fluid end of the pump is also protected.

Steam is a common medium for maintaining the temperature of a process fluid line. If the fluid line or process pipe temperature is required to approach closely that of the available steam, a jacketed pipe arrangement may be essential.

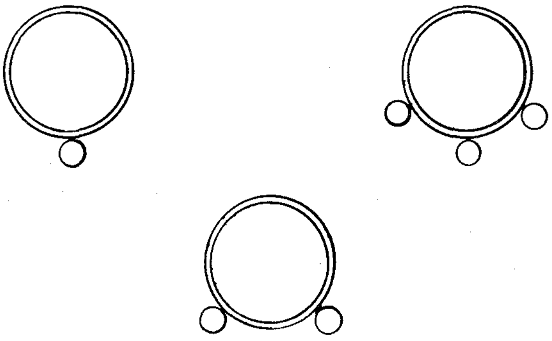
Jacketed Steam Tracing



As is true with any piping system, proper installation procedures are essential to insure tracer line efficiency. On horizontal fluid lines, tracing steam generally flows in the opposite direction of the fluid in the pipe, but it must be installed to allow the condensate to drain by gravity. Low points which can cause stagnation and the resulting cold spots should be avoided.

Generally when a single tracer line is used, the line is placed under the fluid pipe.

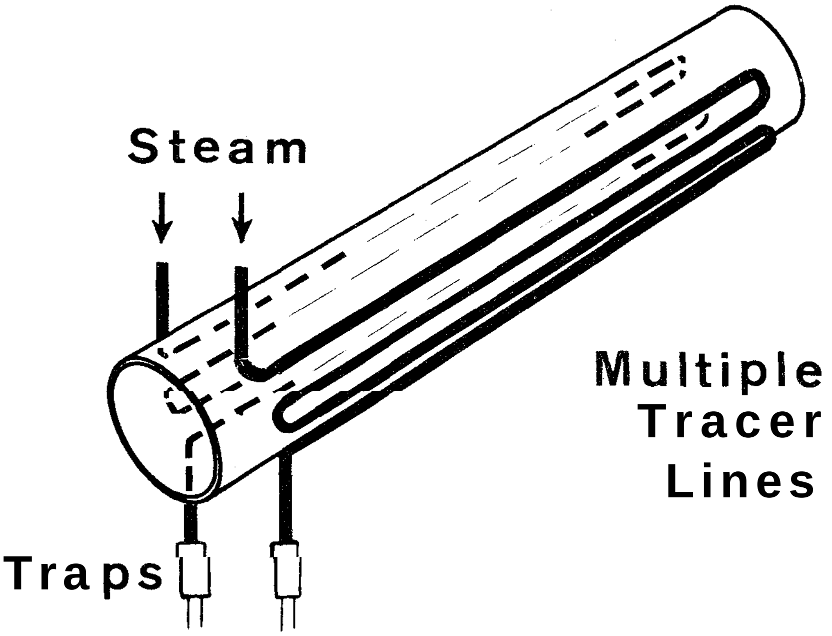
When there are two tracers, these are normally placed under the fluid pipe about 30° apart.



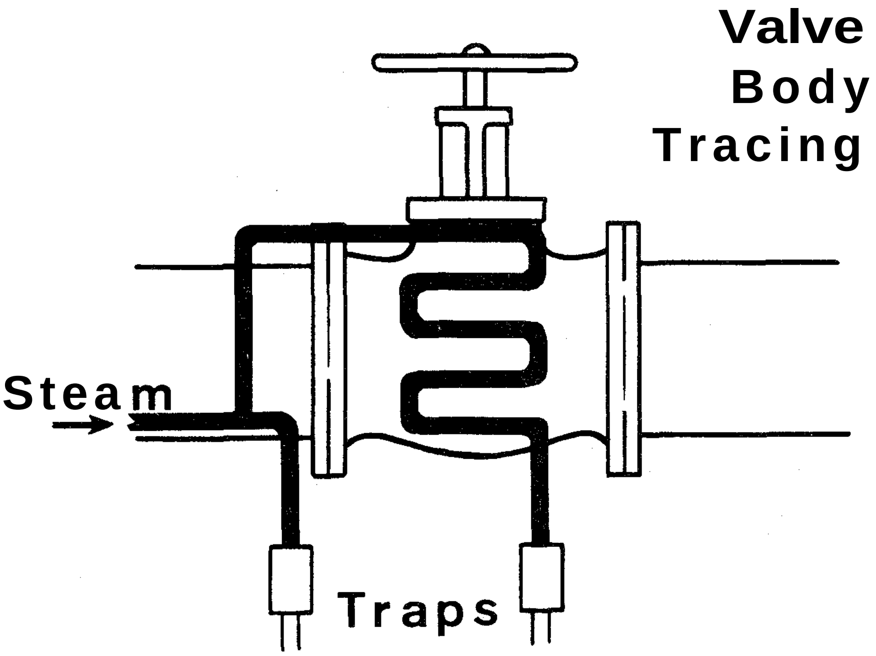
External Parallel Tracing

When three tracer lines are installed, they should be distributed about 45" apart.

When multiple tracer lines are required, loops which uniformly reheat can be installed. On vertical piping it's logical to uniformly distribute the multiple tracers, such as in this diagram.

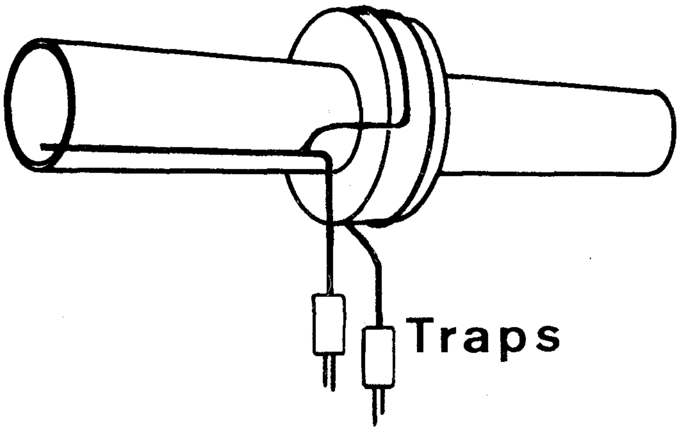


If the tracer lines are required to wrap such items as controls, valves or pumps, low points in the tracer lines can be avoided by proper installation.

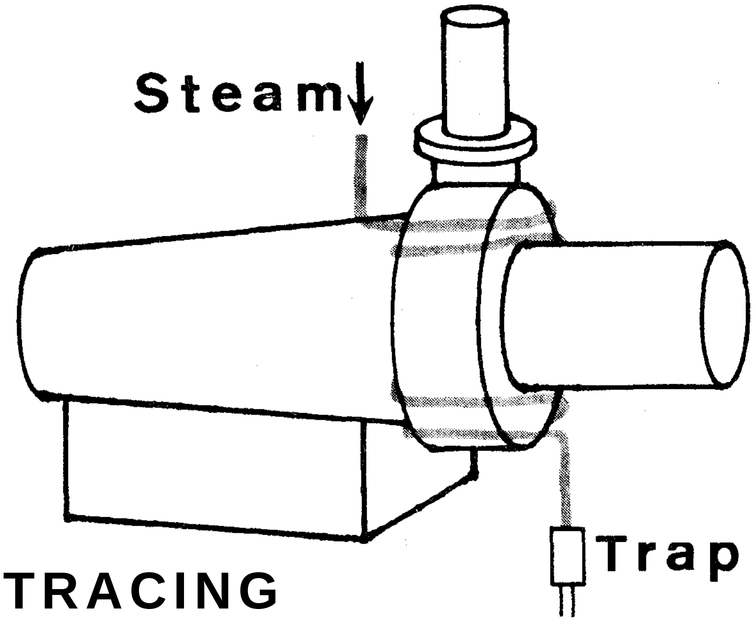


Note that a separate trap is used to drain the condensate formed in the horizontal line. The tracer for the valve can be tapped off the horizontal tracer line.

Tracing for REHEATING STOPS

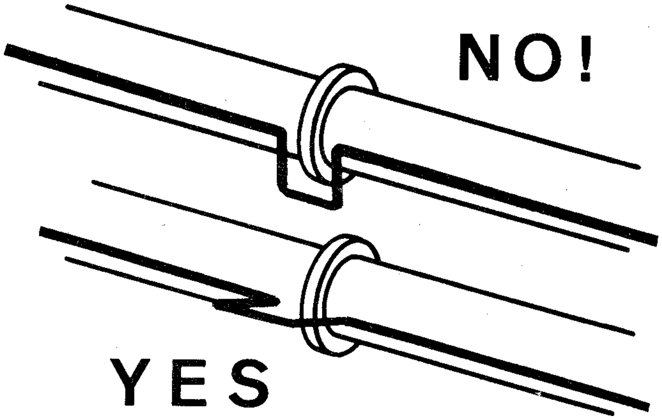


This same piping system can be used for reheating stops, elbows, expansion joints or flanges.



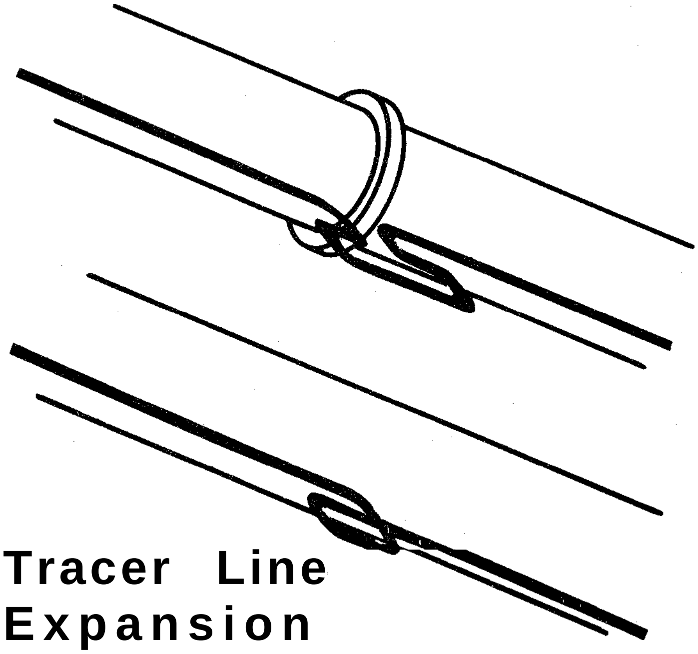
TRACING PUMP BODIES

You will note from this diagram that when tracing a pump body, we are avoiding low points or pockets in the tracer line to insure efficient gravity drainage.



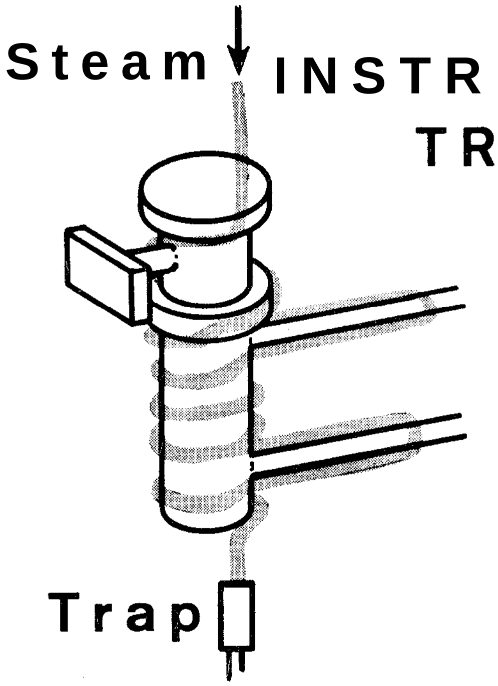
The same thing is true when installing a tracer line around a flange. It's always better to keep the tracer line horizontal avoiding vertical loops.

Occasionally the problem of tracer line expansion is overlooked in design and construction. A horizontal tracer line tends to expand more than the primary fluid pipe. An ideal point at which to allow for this expansion is at a flange, Form a small expansion absorbing loop (see figure) around the flange. If the tracer line is long and horizontal (see figure), it may be necessary to absorb the expansion by looping the tracer line in this method.



Instrument tracing can't be overlooked. It's important to maintain the temperature of the primary fluid to various system instruments.

INSTRUMENT TRACING

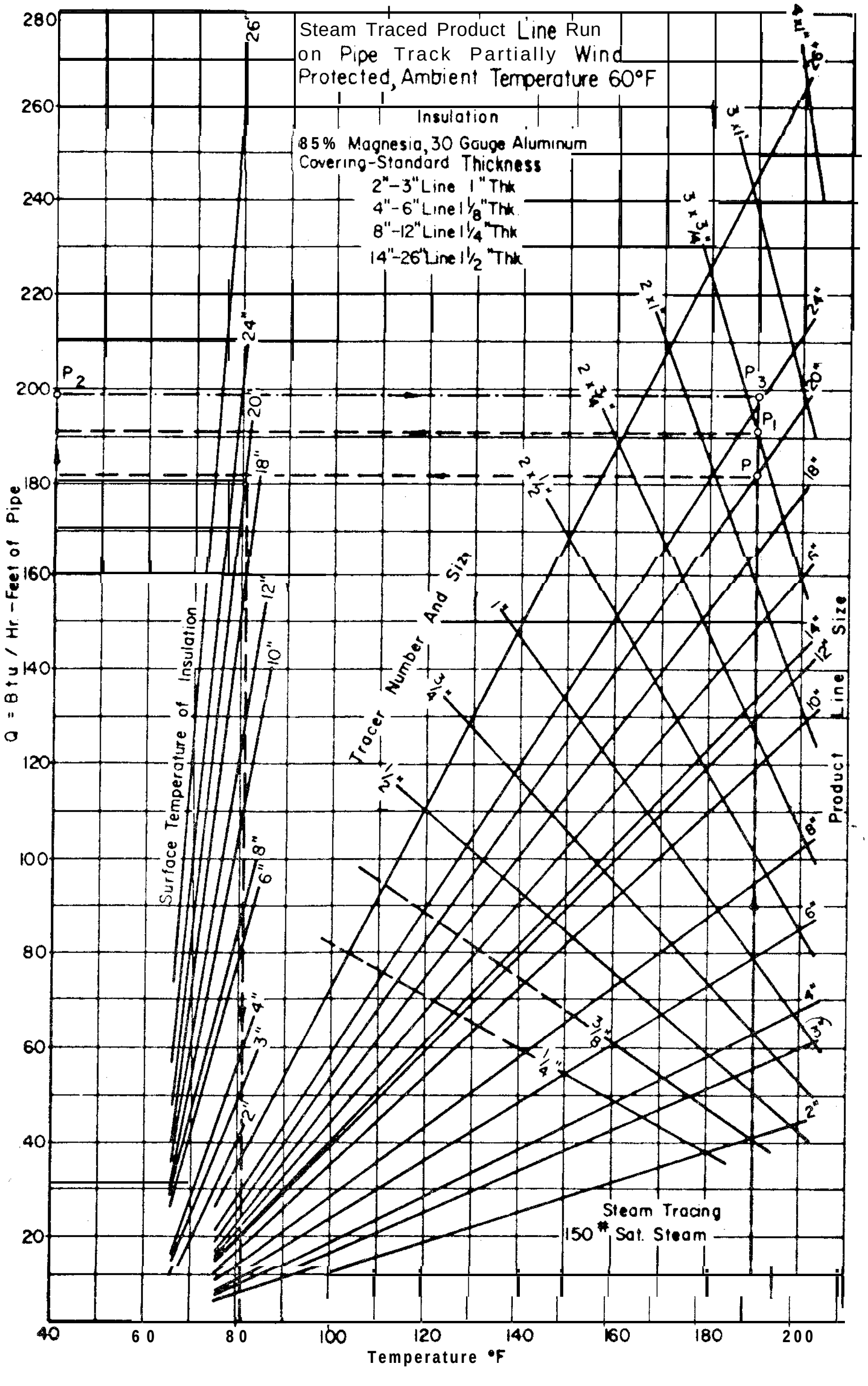


In this diagram you will note that we are looping the complete instrument as well as the hookup lines feeding it. Again note that there are no low spots and that the tracer line is gravity draining to the steam trap.

How many tracer lines and of what size are questions that need to be answered. The heat loss of the fluid product line, the size of the product line and the temperature of the primary fluid are used in selecting the size and number of tracer lines. Several methods are used to size these lines. Let's look at one of them.

By the use of a pre-calculated table known as a nomograph, the number and size of steam tracer lines can be determined. Here we have a simplified nomograph which we'll be using for discussion purposes.

On the bottom quadrant is the temperature of the product that we wish to maintain in degrees Fahrenheit. On this scale we determine the heat loss from the traced product line in BTU/hr/ft of pipe. These lines represent product line size while these intersecting lines represent the number of tracer lines and their size. For example, this is one l/Z" tracer line; this is one 1" tracer line and this represents two 3/4" tracer lines. These lines again represent the product line sizes, only adjusted to give us the surface temperature of insulation wrapping the product line.



Let's try an example. Suppose the product line size is 20" and the product temperature to be maintained is 190°F. Using our nomograph we find the 190" along the temperature scale. We trace the temperature up to our product line size of 20". Following across the graph, we find that the heat loss is 182 BTU/hr/ft. To determine the size and number of tracer lines, we first return to our temperature and pipe diameter intersection point. To allow a margin of safety, we then follow our temperature line up until it intersects with the nearest above line indicating the number of tracer lines and their size. In this case we should be using three 3/4" tracer lines to meet the requirements of our conditions. If we now follow the nomograph across, we find that the actual heat transfer from the tracer lines is 191 BTU/hr/ft. If we want the surface temperature of the insulation, we find the point where the 191 BTU line intersects with the 20" pipe line size on the surface temperature of insulation scale. Dropping down to our temperature scale, we see that the surface temperature is going to be 81" under our conditions. From these nomographs, normally 10% is added to the heat loss if the tracer lines are exposed to wind conditions. Nomographs are often used to double-check other more exact methods of sizing tracer lines. However, field experience shows that nomograph results come very close to actual results.

As with any heat transfer application, each tracer line application has its own characteristics, so common sense must be used.

For example, in a super-critical high temperature distillation system, it may be safer to rely on pipe jacketing to maintain the process temperature of the fluid,

Another possibility might be a process in which there is an unusual possibility of the process fluid solidifying in the pipe. The steam tracing must have the capability of remelting the solidified fluid. The time required to melt the material can be established by using available data. The "melting out time" can be determined from charts utilizing a range of values of the latent heat of fusion, density of the product and the heat required per foot run of the various sizes of pipe.

Each steam tracer line is equipped with a steam trap. Its sole purpose is to retain the steam until its latent heat is fully used and to discharge the condensate and noncondensable gases. As is true with any piece of heat transfer equipment, tracer line should have its own trap even though multiple tracer lines are installed on the same primary fluid pipe. When a deviation is made from a tracer line, for example the reheating of slurries, each pipe must be trapped separately in order to maintain a uniform and efficient heat.

The objective of the tracer line steam system, is to maintain the fluid in a primary pipe at a constant temperature. The trap helps accomplish this with maximum efficiency. In the selecting and sizing of steam traps, it's important to consider the traps compatibility with the objectives of the system. Let's look at the objectives that a tracer line system requires of a steam trap.

TRACER LINE STEAM TRAPS MUST:

1. Resist damage from freezing
2. Operate under light load conditions
3. Provide abrupt periodic discharge to purge line

For our evaluation, let's look at three different types of steam traps which are used on tracer line service. First, there are controlled disc steam traps. These are Armstrong Model 41 and Armstrong Model 61 steam traps. Second, we have the inverted bucket steam trap. An example is the all stainless steel Model No. 1010 tracer line steam trap. A third trap we will consider is a thermostatic steam trap. This is an Armstrong all stainless steel Model No.' TT-1 Thermostatic Tracer Line Trap.

As we can see, all three of these traps are lightweight and easy to install. This controlled disc trap weighs 3/4 lb., this inverted bucket trap weighs l-1/4 lbs., and this thermostatic trap weighs 1 lb, The first requirement of a steam trap on a tracer line is to resist damage due to freezing.

These three traps are all designed with this characteristic. The controlled disc trap is constructed of steel and, if properly installed normally will drain itself and avoid freeze up blockage. While the inverted bucket trap will freeze, its stainless steel design resists damage. The thermostatic trap, installed properly also will drain itself and avoid freeze up blockage.

Since the amount of condensate being in a tracer line application is small, our second requirement calls for a trap that can operate on light loads. This controlled disc trap delivers optimum performance and life when the load exceeds 5% of the trap rated capacity. Since the inverted bucket steam trap is a mechanical trap, it drains the condensate as it comes to the trap even if the load is very slight. The thermostatic trap, sensing the temperature difference between condensate and steam, also discharges the condensate even if the condensing rate of the tracer line is minimal.

The tracer line often is a long small coil with many bends and loops. In order to efficiently transfer heat or energy from the steam, the condensate and noncondensable gases must be kept moving. Our third requirement calls for a trap with this purging action. A trap with an abrupt intermittent action produces periodic pressure drops that provide the velocity surges that help break up the insulating film of noncondensables and water. These velocity surges also help to move the condensate through pockets in the tracer line. Both the controlled disc trap, and the inverted bucket trap are intermittent traps and will produce the desired action. The thermostatic trap is also basically an intermittent trap, but its action is less abrupt.

Out here we have simulated a typical horizontal tracer line application. As you can see, we have a primary fluid pipe with a horizontal tracer line running the length of the pipe and doubling back to our steam trap. We've done this in order to simulate 100 ft. of tracer line. For display purposes, we are not using insulation, which would normally be recommended. We have steam from the main supply line coming in at 125 psi pressure. You'll notice that we're tracing an instrument at the end of the horizontal tracer line. We're coming off the top of the horizontal tracer line with a "T" tracing the instrument with horizontally wound loops discharging out through a separate trap.

Let's watch the steam traps in action. We'll operate the tracer line utilizing the controlled disc steam trap first -- please note the abrupt, intermittent action of this trap -- this trap opens or tests on a time cycle, whether or not there is condensate to the trap. This action helps to break up the water film and insulating air in the tracer line. During the "off" cycle of this trap, condensate builds up behind the trap. If the load is light, as is the case in most tracer line applications, the build up of condensate behind the trap is insignificant. Although this trap is draining to atmosphere, many industries find it economical to return their condensate. If the condensate is to be returned, we recommend that the back pressure be no more than 50% of the inlet steam pressure. This is a standard operating requirement of this type of controlled disc trap.

Now we have the same tracer line being drained by an Armstrong stainless steel inverted bucket tracer line trap. We can again see that this is also an intermittent trap producing the desirable purging action. This trap responds directly to the amount of condensate coming into it. There is no back up of condensate. Because of the vent hole in the bucket of this trap, air is continuously being vented and at steam temperature. This inverted bucket trap has its valve and orifice at the top avoiding the possibility of failure due to pipe scale, undissolved boiler compound or dirt. There are no close tolerances in this trap and strainers for trap protection are not necessary. Since this is a mechanical trap, it will operate against any back pressure providing the back pressure doesn't exceed the inlet pressure. Considering the long life and dependable service of an inverted bucket trap, maintenance costs and downtime are at an absolute minimum. Also remember that this trap is 100% stainless steel, practically eliminating failure due to corrosion.

The third trap we'll look at on this horizontal tracer line, is an Armstrong thermostatic steam trap. This trap is essentially intermittent in operation. This trap senses the temperature difference between steam and condensate. This takes a little time, so one can expect a small build up of condensate ahead of the trap. On tracer line applications this would normally be minimal. This trap is also 100% stainless steel, preventing corrosion, particularly corrosion caused by acetic acid or oxidizing conditions. This trap has a thermostatic bellows element charged with a fluid which enables the trap to operate close to steam temperature.

Let's take a closer look at the load or the amount of condensate a steam trap is required to handle on tracer line applications. Referring to our previous example, you'll remember that we're attempting to maintain 190°F in a 20" pipe. Let's assume that we're trapping this tracer line every 100 ft. of horizontal run. We'll also be using a U factor of 2.44 BTU/lb/hr/°F. We've pulled this from Chart A-27 in the Armstrong "L" Catalog. We're using 100 psi steam in our example.

Again from the Armstrong "L" Catalog, we note that a 20" pipe has 0.191 lineal ft. to equal 1 sq. ft. of heating surface. Calculating this out, we take $\frac{100 \text{ ft. x } 1 \text{ sq. ft.}}{0.191 \text{ Ft.}}$ which gives us a total of 524 sq. ft. of heat loss surface. Continuing on with the computation, we take the U factor of 2.44 times the sq. ft. of heating surface which is 524 times 200 which is the temperature difference of our example times .25 which represents a 75% insulation efficiency. This comes out to 63,900 BTU/hr. To convert this to lb/hr, we divide this figure by the amount of latent heat found in the 100 psi steam we have, which is 880 BTU/hr. This gives us approximately 72 lbs/hr. Now this 72 lbs/hr. is the amount of heat that we need to add to the 100 ft. of 20" pipe to maintain the product fluid temperature under our conditions.

Some heat loss from the tracer lines will occur to the surroundings. We'll need to add this loss to the amount of heat needed to maintain the temperature of our product fluid. If you'll remember from our nomograph, we picked three 3/4"' pipes to do our tracing with. In running through the calculations, we take 3 times 0.5, as we have assumed that l/2 the surface of the tracer line is radiating to the surroundings, times 100, the length of run, times the sq. ft. of heating surface for 3/4" pipe which we found in the "L" Catalog, giving us an answer of 41 sq. ft. of heating surface. This represents the amount of sq. ft. of heating surface that we're losing. Again returning to the calculations, we're using a U factor of 4 BTU times 41 sq. ft. of heating surface times 350°, which is the temperature differential divided by the latent heat in our steam, giving us a loss of 65 lb/hr. Remember our insulation is 75% efficient, so we multiply this times 0.25 giving us a total loss of 16 lbs./hr. We add this to the 72 lb/hr. needed to maintain the temperature divided by the number of tracer lines which is 3, and we come up with a capacity per each trap of 30 lbs/hr.

On most tracer line applications, the flow to the steam trap is surprisingly low. The smallest steam trap available is normally adequate. When sizing a controlled disc type steam trap, remember the best operating conditions exist when the actual load is from 5% to 50% of the trap rated capacity. Again, the smallest inverted bucket trap is normally large enough. If not, use a safety factor of 2 to 1. The orifice should be selected small enough to allow the trap to discharge often. This keeps the air and noncondensables moving. A 2 to 1 safety factor is normally adequate for a thermostatic trap, also.

As we have seen from this program, all three of these traps are ideally suited for tracer line applications. The objectives and criteria for selecting the best trap for each tracer installation would vary. Let's review what is required of a tracer line trap.

1. Resistance to damage due to freezing

2. Operation on light condensate loads

3. Intermittent abrupt discharge or cycling

Certainly one of these traps would fit any tracer line requirement.