

A GUIDE TO

STEAM TRAP INSTALLATION



FOR

FREEZE PREVENTION

A GUIDE TO STEAM TRAP INSTALLATION FOR FREEZE PREVENTION



INDEX

| <u>Section</u> | <u>Title</u> | <u>Page</u> |
|----------------|--|-------------|
| 1.0 | Introduction | 1 |
| 2.0 | Freeze Prevention Considerations | 1 |
| 2.1 | Low Points Ahead of Traps | 1 |
| 2.2 | Open Discharge Systems | 1 |
| 2.2.1 | Trap Discharge Lines | 2 |
| 2.2.2 | Steam Shut-Off | 3 |
| 2.3 | Freeze Prevention Drainage Devices | 3 |
| 2.4 | Closed Condensate Return Systems | 5 |
| 2.5 | Steam Trap Shutdown Characteristics. | 6 |
| 3.0 | Freeze Prevention Installations | 8 |
| 3.1 | Process and Heating Applications | 8 |
| 3.2 | Steam Main Drain and Steam Tracing | 9 |
| 3.2.1 | Single Trap Installation | 10 |
| 3.2.2 | Multiple Trap Installations (Manifolding)..... | 10 |

Drawings of Installations

- Sheet 1 Constant Steam Pressure Process Heat Exchanger
- Sheet 2 Modulated Steam Pressure Process Heat Exchanger
- Sheet 3 Steam Main Drain and Steam Tracing Single Trap
- Sheet 4 Vertical Manifold
- Sheet 5 Horizontal Manifold



1.0 Introduction

No steam trap is free draining and freeze proof. In attempting to simplify the selection of the proper trap and to minimize the cost of the installation, claims of inherent freeze prevention are made without in-depth analysis of what happens with each type of trap when steam is shut off. All traps have operating characteristics with the potential to set up conditions which will promote freezing if steam flow to the system is interrupted for an appreciable period of time and if ambient temperature is below freezing during that period.

A discussion of freeze prevention in the application of steam traps must take into consideration all parts of the system and the reaction of the trap when steam flow ceases. In this booklet, we present an analysis of freezing by the type of application being drained, the design of the drainage system, and the operating characteristics of each type of steam trap as well as means for preventing freezing using all types of traps.

2.0 FREEZE PREVENTION CONSIDERATIONS

Drainage line configuration, the existence of a condensate return system, and the characteristic response of the steam trap when steam flow is interrupted must be considered in determining the freeze prevention requirements of a condensate drainage system

2.1 LOW POINTS AHEAD OF TRAP

Heat exchangers and tracer lines must permit condensate to flow by gravity to the trap. Installation of the trap above heat exchanger outlets, low points in coils, and low points in tracer lines prevent gravity flow when steam is interrupted. All should be avoided.

Usually it is no problem to install steam main drain lines with no low points. However, in many cases such as instruments, valves, pumps, and other vertical projection applications; tracer condensate must flow upward for a short distance. With steam flowing in the tracer line, condensate can be transported vertically over these short distances, but when steam is shut off, condensate will lie behind these natural dams. This condensate can freeze.

These points must be drained, but often the tracer lengths involved are too short to justify a steam trap or the constant dribbling of condensate from a trap onto the floor or ground cannot be tolerated. Some form of auxiliary safety drain should be used to remove the condensate when steam is interrupted so that freezing can be prevented in these cases.

2.2 OPEN DISCHARGE SYSTEMS

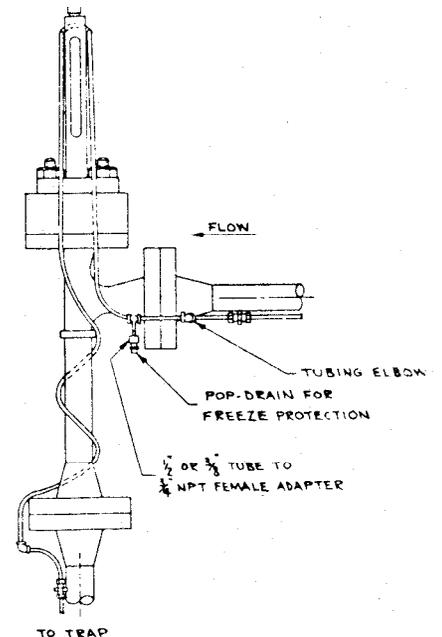
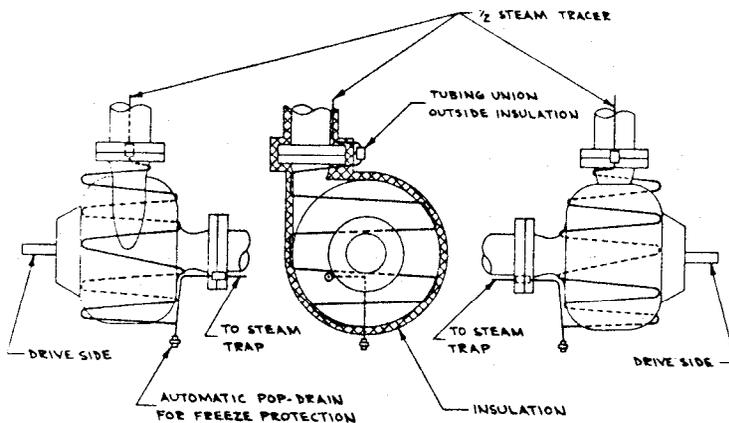
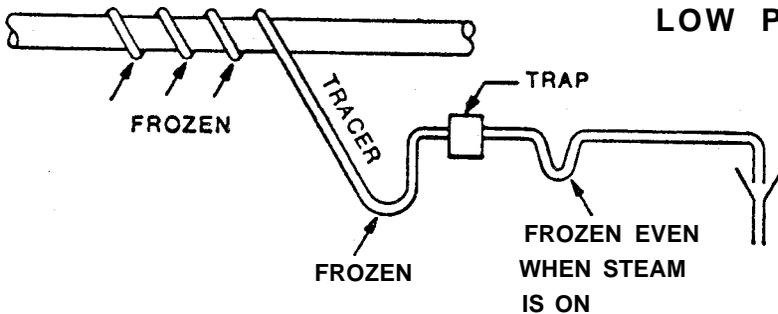
Trap discharge line configuration and the reaction of the trap when steam is shut off can promote freezing even when discharge is to drain at atmosphere pressure.

2.2.1 TRAP DISCHARGE LINES

Discharge lines must be kept short. The operating mode of most traps is intermittent discharge. In low capacity applications, the condensate lying in long discharge lines between cycles can freeze. This freezing can build up to close the lines, thus even properly operating traps can have their outlet lines freeze completely.

The continuous light flow of the other types of traps can freeze in long discharge lines.

Low points in trap discharge lines add to the possibility of freezing.



VERTICAL TRACING PROJECTIONS

2.2.2 STEAM SHUT-OFF

When steam is shut off, the remaining steam in a trap inlet line will condense, collapse in volume, and form a vacuum in the inlet line. This vacuum can be as great as 20 to 25 inches of mercury. The vacuum will cause the valve in thermodynamic and thermostatic types of traps to close preventing the drainage of the system. Condensate not drained will freeze damaging inlet lines, traps and return lines.

Mechanical types of traps open in the presence of condensate regardless of the inlet pressure, so all condensate will drain down to the trap, but condensate will remain in the body of the trap. This condensate can freeze and damage the trap.

Some form of auxiliary safety drain should be used to drain trap inlet lines and trap bodies when steam is shut off.

2.3 FREEZE PREVENTION DRAINAGE DEVICES

Two types of devices are available to drain lines and systems under shut down conditions. There are pressure and temperature actuated valves.

2.3.1 TEMPERATURE ACTUATED DEVICES

These valves contain elements which sense the temperature of condensate in their bodies. When this temperature has fallen to a preset low limit somewhere above the freezing point, the temperature sensor will open the valve to drain the system before freezing can set in. When temperature rises again, the valves close.

These valves are relatively expensive.

Process heat exchangers are fewer in number than drip and tracer, they have larger drainage requirements, they have large lines, and often they have modulating steam pressure control which requires low pressure operation. A temperature actuated safety drain is required, and the higher cost can be justified.

2.3.2 PRESSURE ACTUATED DEVICES

When steam is shut off and the lines are not drained before pressure has dropped totally, the collapsing residual steam in the system will form a vacuum. A thermally operated device will not open to attempt to drain until pressure is lost completely and the water temperature has decreased well below saturation temperature. Vacuum will have formed, and when the valve does open, only gravity is available to drain the lines. In small lines such as tracers the vacuum may be sufficient

2.3.3 INSTALLATION OF DRAINAGE DEVICES

Freeze prevention drainage devices are installed closely coupled to the system and are well insulated.

The condensate in thermal drains should be kept as close to system temperature as possible. If condensate cools below the drain set point, the valve will open and discharge condensate. As soon as hot condensate arrives, the valves will close again, but this intermittent drainage will form pools of water or mounds of ice beneath the drain.

If the condensate in pressure type drains drops below 32⁰F, it will freeze preventing operation of the valve.

2.3.3.1 DIRT PROBLEMS

Any drainage device, thermal or pressure, is intended to act as a freeze proofing safety drain. By nature of its service, it is installed in low points where dirt will settle. Dirt will be flushed through the valve when it opens, however, if large particles of dirt are present to lodge between the ball and the seat whenever the valve recloses, leakage can occur.

The drain has performed its function by draining the system and preventing extensive damage saving much maintenance time and money, so the relatively small cost of removing the device, disassembling and cleaning it, or completely replacing it with a new drain is justified. This is especially true of the low cost Pop Drain.

Excessively dirty conditions may promote an accumulation of matter in the drain which could impair the opening of the valve. If these conditions are anticipated, the drain should be installed as shown in Sheet 1, and a strainer should be installed ahead of the drain.

The operation of the pressure type drain can be checked each time the steam trap is tested. The inlet valve to the trap can be closed to allow pressure to decay and to permit the drainage device to operate.

2.4 CLOSED CONDENSATE RETURN SYSTEMS

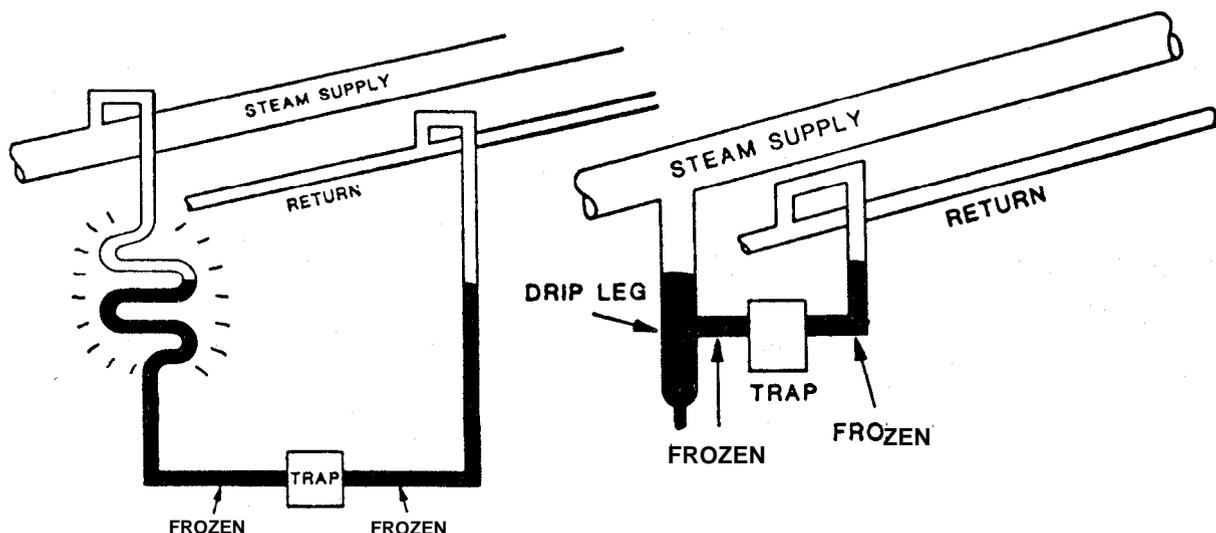
Because condensate is now a valuable commodity, virtually all installations are being designed with closed return systems, and many older plants are installing condensate returns. Attempts to save flash steam energy wasted in atmospherically vented closed condensate returns usually result in pressurized return systems. Closed return systems of any sort create a problem in freeze prevention with all types of traps.

Traps discharging to headers below the trap still induce some back pressure at the traps even if the end of the system is atmospherically

vented. Purposely pressurized systems induce much higher back pressures. Closed traps or back flow result when steam flow is interrupted.

Traps discharging to overhead systems have additional back pressure induced by the trap outlet line rise to the condensate header. When steam is shut off, a leg of water will form in both the trap inlet and outlet lines which can freeze.

No trap free drains in a closed condensate return system



2.5 STEAM TRAP SHUTDOWN CHARACTERISTICS

All steam traps have a characteristic reaction or operating trait when steam flow is interrupted which will prevent full drainage of all condensate from the trap bodies and lines even when traps discharge to atmospheric conditions.

2.5.1 THERMSTATIC BI-METAL TRAPS

Bi-metallic traps are designed to close against normal operating pressure differential across the trap. A reversal of pressure differential will cause the trap to act as a check valve. The vacuum formed

in the trap inlet line when steam is shut off will cause a reversed pressure differential, and the valve will close.

Condensate will lie in the inlet line of a trap discharging to drain.

Condensate will lie in both the inlet and outlet lines of a trap discharging to a closed return system

2.5.2 THERMSTATIC BELLOWS TRAPS

These traps close at a preset temperature below saturation for the steam pressure imposed on the bellows. They open at a temperature slightly below the closing temperature.

Vacuum forms in the trap when steam is shut off, and the temperature at which the valve opens drops to 150° F or less. The valve will stay closed until the condensate in the trap body cools to this temperature. When the valve finally opens, vacuum in the small diameter inlet line will not permit drainage even though the discharge may be to atmosphere.

In closed return systems, back flow through the open valve will flood both inlet and outlet lines.

2.5.3 THERMODYNAMIC (DISC) TRAPS

Inlet pressure below 5 to 10 psi is not sufficient to open a disc trap once it is closed, and a negative pressure differential will cause the trap valve to close.

When steam is shut off, the collapsing of the remaining vapor in the system ahead of the trap creates a vacuum which pulls the disc down on the seat so that the remaining condensate cannot flow through the trap even to an open drain regardless how the trap is mounted.

In a pressurized closed return the collapsing pressure and vacuum formation of the trap combine with the back pressure to reverse the pressure differential across the valve. This condition causes the disc to act as a check valve preventing condensate flow in either direction.

2.5.4 MECHANICAL TRAPS

All mechanical traps including Inverted Bucket types will open in the presence of condensate regardless of the pressure.

Gravity will permit drainage of condensate from lines ahead of the trap, but water will remain in the trap body.

Backflow can fill the trap and inlet and outlet lines when discharge is to closed return systems.

3.0 FREEZE PREVENTION INSTALLATIONS

There is no self draining freeze proof type of steam trap in any installation regardless how the trap is installed. The operating characteristics of all traps discussed above will permit water to lie in the lines and the traps long enough to freeze. If freeze prevention is critical to operation, some means must be provided to insure complete drainage when steam flow is interrupted for any reason.

The application conditions, the type of trap, and the presence of a condensate return dictate what auxiliaries and piping configurations are required. The remainder of the booklet will present our concepts.

3.1 PROCESS AND HEATING APPLICATIONS

Since the vast majority of process traps do discharge into pressurized closed return systems of some type, we will limit our discussions to those installations.

Process loads in general can be divided into two types, constant steam pressure operation and modulating steam pressure operation.

3.1.1. CONSTANT STEAM PRESSURE OPERATION

Steam is supplied to the heat exchanger at a constant pressure. Heat load may vary with product flow or may be constant. In any case, the differential pressure across the steam trap is constant so that flow is assured as long as the heat exchanger is operating.

Shutdowns present potential problems because of water lying in the trap, inlet and outlet lines, and in heat exchangers. Metal surfaces can corrode, water hammer can damage heat exchangers, lines, and traps. To prevent this some means must be provided to drain the system when steam is shut off.

Differences in the operating characteristics of the various types of traps dictate different numbers of drains and placements.

3.1.1 THERMSTATIC AND THERMODYNAMIC TRAPS

These types of traps will close when steam is shut off as discussed in Section 2.5. For this reason both inlet and outlet lines cannot be drained from a single low point, therefore, a freeze prevention safety drain must be installed in the low points of trap inlet and outlet lines.

Flashing action of hot condensate in trap discharge lines to overhead returns causes very low pressures at the trap outlet, consequently pressure actuated drains cannot be used. Thermal type drains must be used with these traps.

A check valve is installed in the trap discharge line at the high point of the line to prevent back flow through the open drains.

This installation is shown in Sheet 1.

3. 1. 1. 2 MECHANICAL TRAPS

All mechanical traps open to condensate when steam is shut off, so both inlet and outlet lines can be drained by a single freeze prevention safety drain in the trap body. The trap body is at line pressure, therefore, a pressure actuated drain can be used.

The drain can be mounted in a low point of the trap inlet with bottom in - top out configuration Inverted Bucket traps. It can be mounted in the body bottom drain of all side in - side out traps.

Sheet 1 shows this installation.

3. 1. 2 MODULATED STEAM PRESSURE OPERATION

In this mode of operation, steam pressure in the heat exchanger is varied in response to changing load conditions. Usually the temperature of the product being heated is held constant by varying steam pressure. Wide variations in steam requirements can result in very low pressure or vacuum in the exchanger and the steam trap in normal operation.

Armstrong's Bulletin M-101 discusses the drainage problems and the special trap installations necessary.

Normal operation at low steam pressures rules out the use of pressure operated freeze prevention safety drain devices. Thermal drains must be used with all types of traps.

Freeze prevention safety drain installations will be the same as for constant pressure operation except that thermal type drains will be used for all types of traps and that a drain must be installed in the body drain of the Float and Thermostatic safety drain trap. These installations are shown in Sheet 2.

3. 2 STEAM MAIN DRAIN AND STEAM TRACING

These are the most numerous applications for steam traps. Most are installed outdoors and they have a vital freeze prevention function

in cold weather. Accidental steam interruption or failed, closed traps will present a serious and costly freeze problem with damage to tracing lines, traps, and return lines.

Attention to freeze proof installations will provide insurance against costly and time consuming maintenance.

The applications are similar to low capacity heat exchangers with constant steam pressure operation.

3.2.1. SINGLE TRAP INSTALLATIONS

Where traps are too widely spaced for economical grouping by installation at a common point and discharging to a common manifold, they are installed individually with separate return lines. Each trap must be installed and freeze proofed as a separate system

3.2.1.1. TRAP DISCHARGE TO OPEN DRAIN

Thermostatic and Thermodynamic traps close when steam is shut off, so a Pop Drain must be installed in the low point of the trap inlet line. Sheet 3 shows this installation.

The valve will remain open in Inverted Bucket traps when steam is shut off. The system will drain through the trap, but condensate will remain in the body of the trap, and this must be drained.

Sheet 3 shows this installation.

3.2.1.2. CLOSED RETURN SYSTEMS

All new plant designs include closed and cascaded pressurized return systems for low load traps as well as process except for applications located too remote to justify piping costs. Any closed return system presents the drainage and freezing problems described earlier in Section 3 for constant pressure process systems. Similar drainage precautions are advised.

Thermostatic and Thermodynamic type traps will require drains in the low point of both the trap inlet and outlet lines. These must be thermally actuated drains. Sheet 3 shows this installation.

A single pressure actuated device (Pop Drain) will drain both the inlet and outlet lines and the trap body in mechanical traps.

3.2.2. MULTIPLE TRAP INSTALLATIONS (MANIFOLDING)

Ease of maintenance and trouble shooting can be achieved through piping the tracer lines to multiple trap manifolds. When large numbers of steam tracing traps are located in a compact area, usually this simplifies installation and reduces costs since these manifolds can be

prefabricated in shops and shipped intact to the installation site requiring only setting of manifolds and attachment of the tracer drop lines.

It also more probably assures that space has been allotted for trap installation.

Means for freeze proofing can be built into the manifolds more easily and less expensively than with large numbers of single trap installations.

3. 2. 2. 1 FREEZING IN MANIFOLDS

In conventionally constructed manifolds, freezing of individual traps and lines is a possibility regardless of the type of trap used.

The conventional manifold with the condensate discharge piped from the top of the manifold up to the return header will be full of water at all times. If steam is lost to any one or more traps, the outlet of the trap is exposed to water at the pressure in the manifold while the inlet pressure degenerates to atmospheric and possibly to vacuum. A reverse pressure differential across the trap causes problems and presents the probability of freezing in that trap and its inlet and outlet lines.

3. 2. 2. 2 HEAT SYMPHON MANIFOLD

A special manifold can be used to prevent freezing of individual traps and lines. This manifold uses the available heat from flash steam derived from the hot condensate from the discharge of an operating trap. If one of the traps in the manifold is from a steam main drain on a main which would not be expected to be out of service at any time, this heat would be supplied to the manifold constantly.

The condensate discharge pipe is extended into the manifold below the center line to within $1/2$ " of the bottom. In operation, the water level in the manifold would not rise above the inlet to the manifold condensate discharge pipe. A large chamber above the water level fills with flash steam. This flash steam rises into any trap to which the steam had been shut off, and the heat from the flash steam is given off to the condensate in the trap. Excess condensate formed flows back to the manifold to be replaced by more flash steam. In this way, trap and outlet line are kept hot and freezing conditions are prevented.

The entire system, all lines, all mechanical traps, all valves, all fittings, and the manifold must be insulated to retain the small amount of available heat. Other types of traps require radiation to operate, and insulation will promote backing up and sub-cooling of condensate ahead of the trap.

The construction and principle of the manifold are shown in Bulletin 128-A. A paper entitled, "Freezing Problems Associated with Steam Systems in the Petrochemical and Refining Industries" describes the testing of this manifold concept with inverted bucket traps.

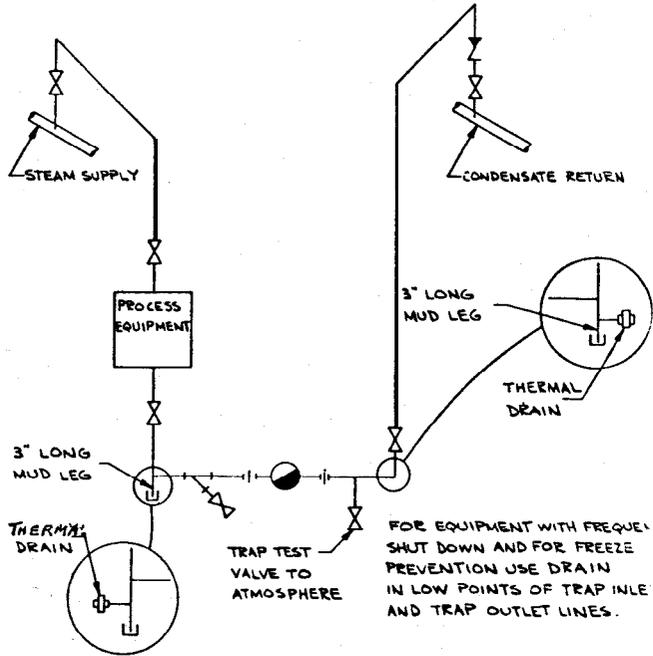
3. 2. 2. 3 THERMSTATIC AND THERMODYNAMIC TRAPS

Because of the tendency of these traps to close when inlet pressure drops and vacuum form or when reverse differential exists across the trap as described in Section 4, condensate will remain in the trap inlet. An Armstrong Pop Drain will remove this condensate as shown in Sheets 4 and 5.

3. 2. 2. 4 MECHANICAL TRAPS

All condensate from the inlet lines will have drained into the trap body, and the heat from the flash steam will prevent freezing conditions. No auxiliary drains are required. See Sheets 4 and 5.

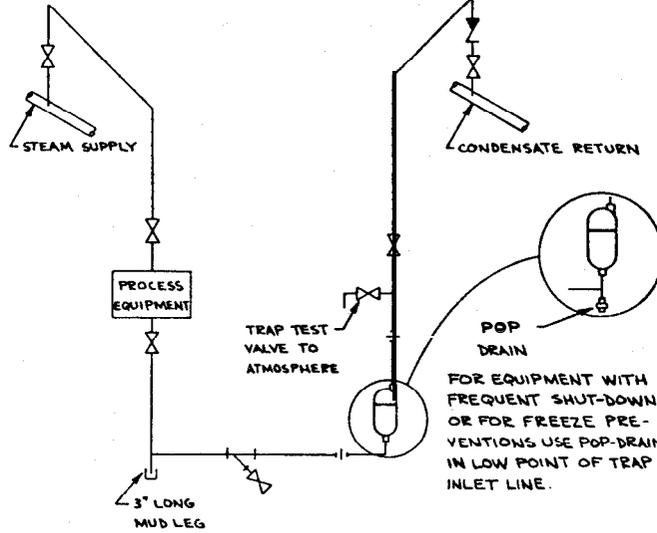
Thermodynamic and Thermostatic



FOR EQUIPMENT WITH FREQUENT SHUT-DOWN AND FOR FREEZE PREVENTION USE DRAIN IN LOW POINTS OF TRAP INLET AND TRAP OUTLET LINES.

NOTE: Strainer should be installed on side for drainage for freeze prevention.

Inverted Bucket
Bottom In - Top Out Models

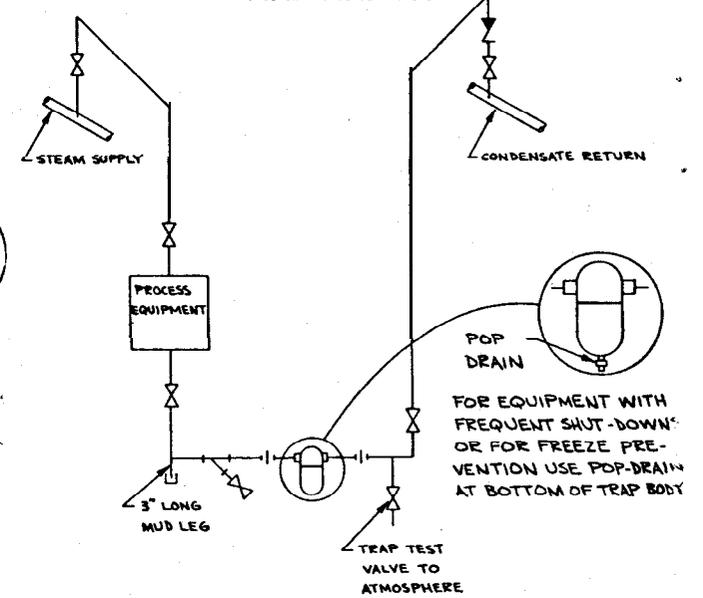


FOR EQUIPMENT WITH FREQUENT SHUT-DOWN OR FOR FREEZE PREVENTIONS USE POP-DRAIN IN LOW POINT OF TRAP INLET LINE.

Orifice: Determined by Condensate Load
Consult Factory and Representative

NOTE: Strainer should be installed on side for drainage for freeze prevention. Inverted Bucket traps can be insulated.

Inverted Bucket
Side In - Side Out Models

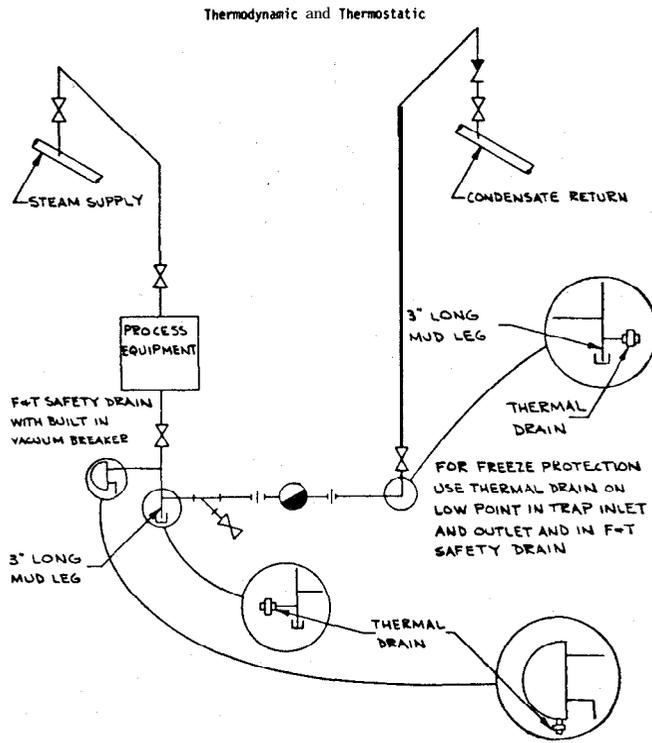


FOR EQUIPMENT WITH FREQUENT SHUT-DOWN OR FOR FREEZE PREVENTION USE POP-DRAIN AT BOTTOM OF TRAP BODY

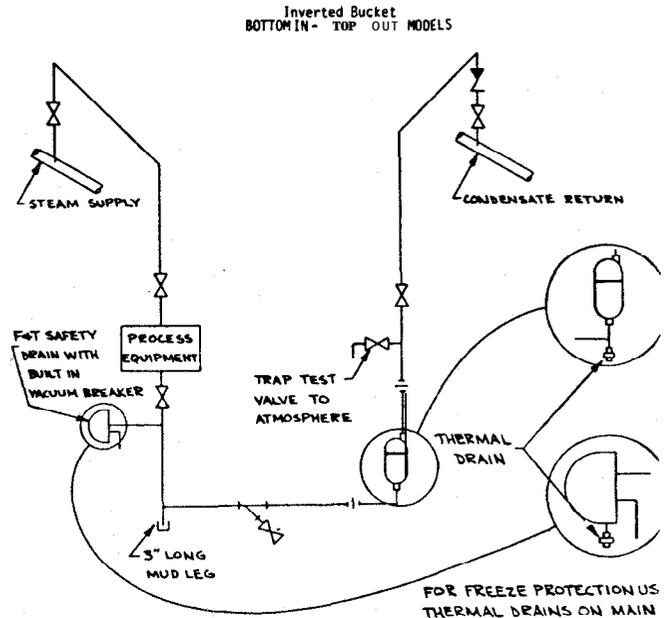
Orifice: Determined by Condensate Load
Consult Factory and Representative

NOTE: Strainer should be installed on side for drainage for freeze prevention. Inverted Bucket traps can be insulated.

CONSTANT STEAM PRESSURE PROCESS HEAT EXCHANGER



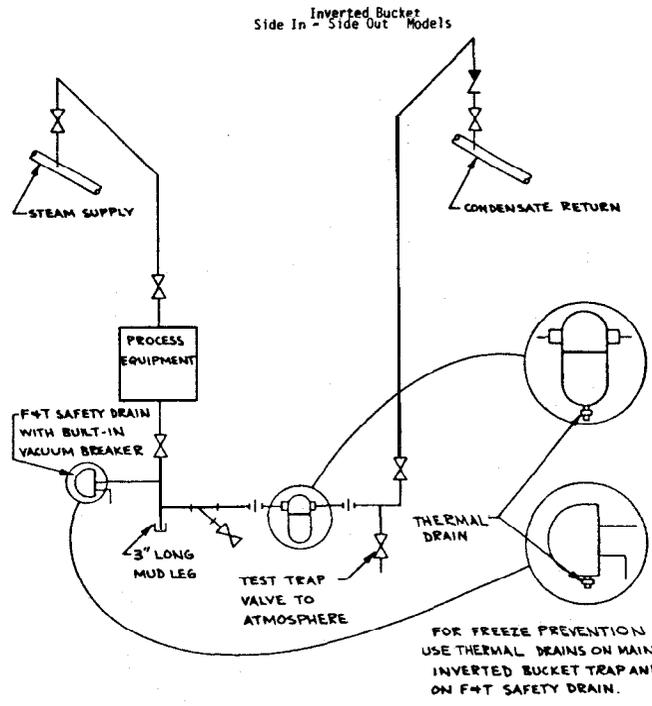
NOTE: Strainer should be installed on side for drainage for freeze prevention.



Orifice: Determined by Condensate Load
Consult Factory and Representative

Note: For low pressure (30 psig maximum)
steam operation use Float and Thermostatic Traps.

Strainer should be installed on side for drainage for freeze prevention. Inverted Bucket and F & T traps can be insulated.



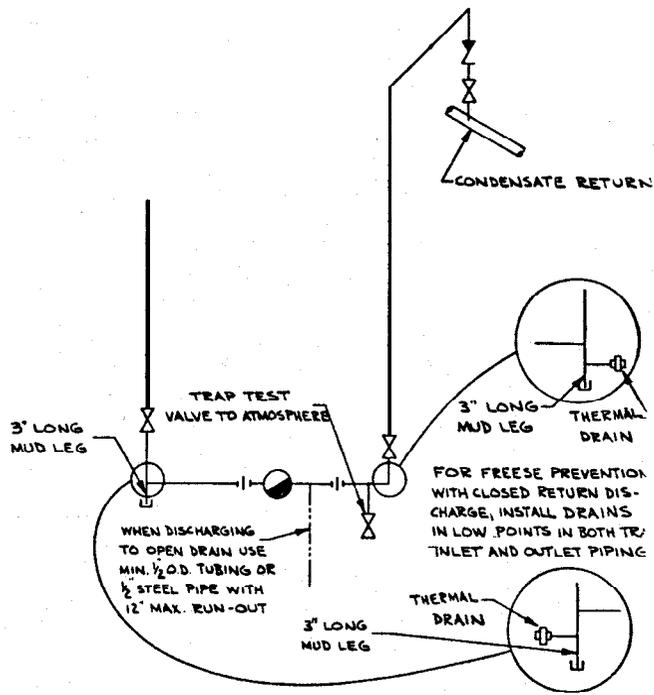
Orifice: Determined by Condensate Load
Consult Factory and Representative

Note: For low pressure (30 psig maximum)
steam operation use Float and Thermostatic traps.

Strainer should be installed on side for drainage for freeze prevention. Inverted Bucket and F & T traps can be insulated.

MODULATED STEAM PRESSURE PROCESS HEAT EXCHANGER

Thermostatic and Thermodynamic

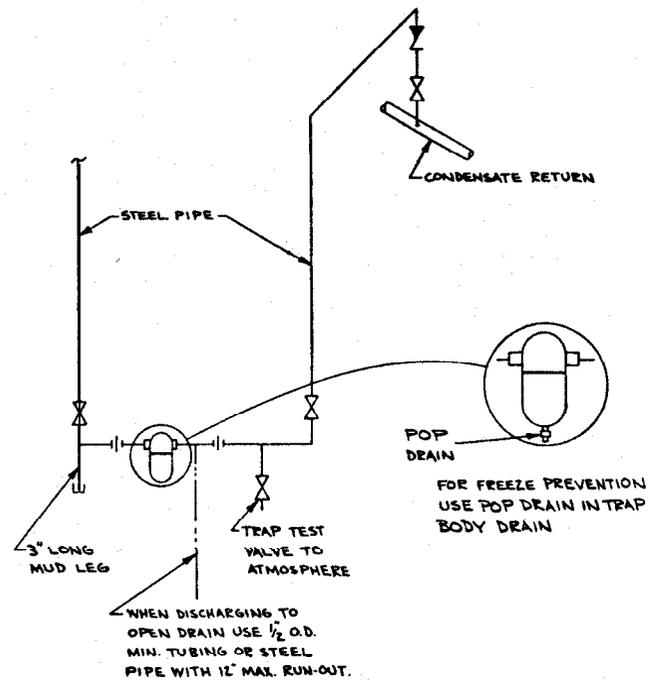


FOR FREEZE PREVENTION WITH CLOSED RETURN DISCHARGE, INSTALL DRAINS IN LOW POINTS IN BOTH TRAP INLET AND OUTLET PIPING

FOR FREEZE PREVENTION WITH OPEN DISCHARGE INSTALL DRAIN IN LOW POINT IN TRAP INLET PIPING

WHEN DISCHARGING TO OPEN DRAIN USE MIN. 1/2" O.D. TUBING OR 1/2" STEEL PIPE WITH 12" MAX. RUN-OUT

Inverted Bucket Side In - Side Out Models



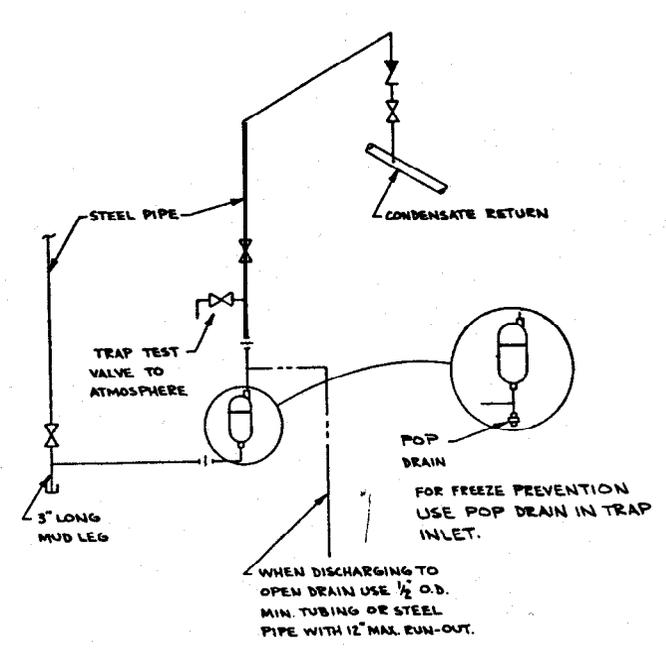
FOR FREEZE PREVENTION USE POP DRAIN IN TRAP BODY DRAIN

WHEN DISCHARGING TO OPEN DRAIN USE 1/2" O.D. MIN. TUBING OR STEEL PIPE WITH 12" MAX. RUN-OUT.

Orifice: Tracer - 5/64" R60
Drin - 5/64"

Note: Strainer not normally required with Inverted Bucket traps.
Inverted Bucket traps can be insulated.

Inverted Bucket Bottom In - Top Out Models



FOR FREEZE PREVENTION USE POP DRAIN IN TRAP INLET.

WHEN DISCHARGING TO OPEN DRAIN USE 1/2" O.D. MIN. TUBING OR STEEL PIPE WITH 12" MAX. RUN-OUT.

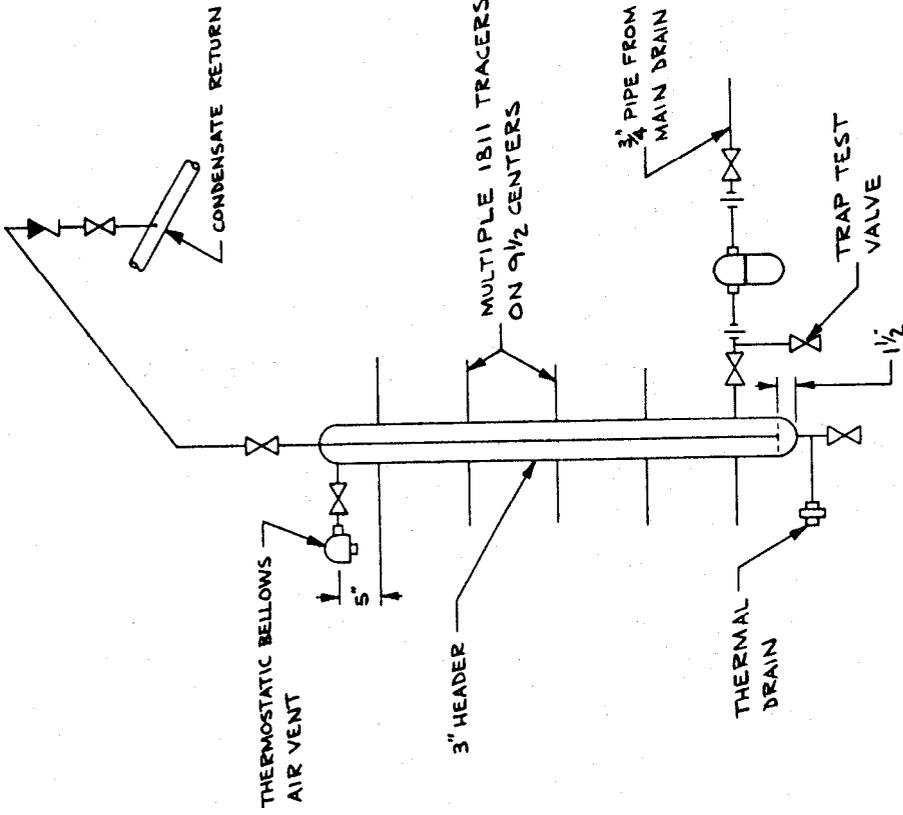
Orifice:

Note: Strainer not normally required with Inverted Bucket trap.
Inverted Bucket traps can be insulated.

STEAM MAIN DRAIN AND STEAM TRACING

SINGLE TRAP

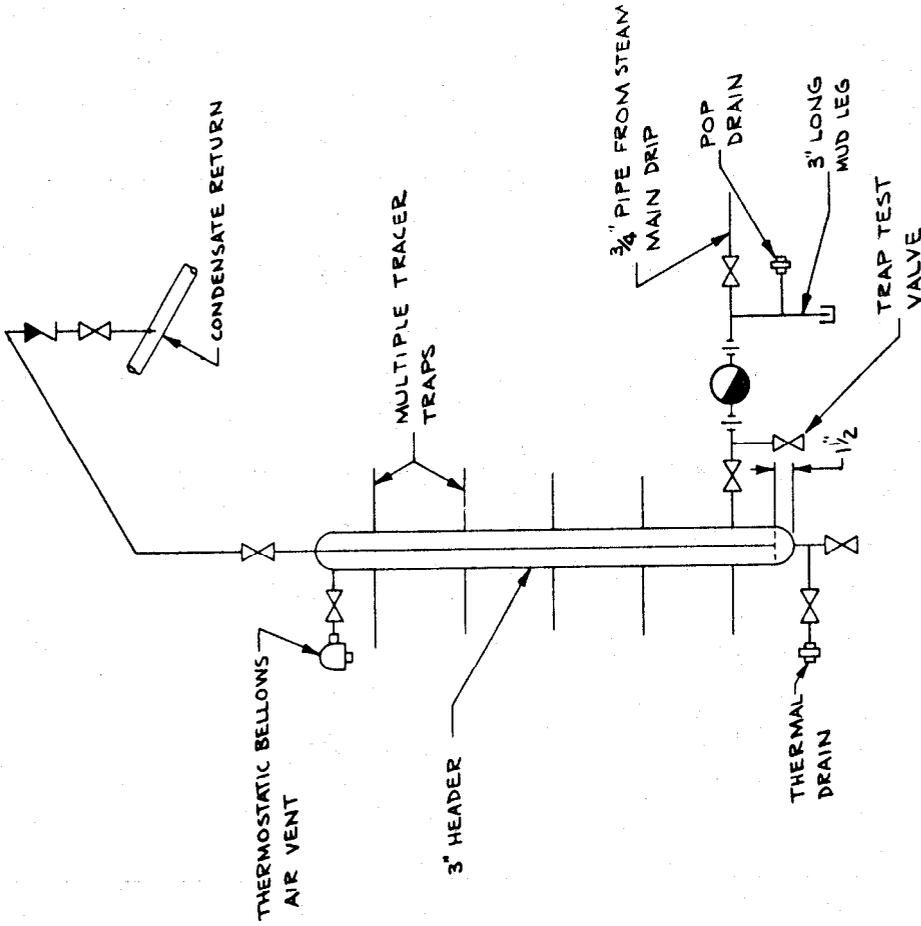
Inverted Bucket
1810/1811 Vertical Manifold



Orifice: #1810 - #38 R60 (standard)
#1811 - Tracer - 5/64" R60
Drip - 5/64"

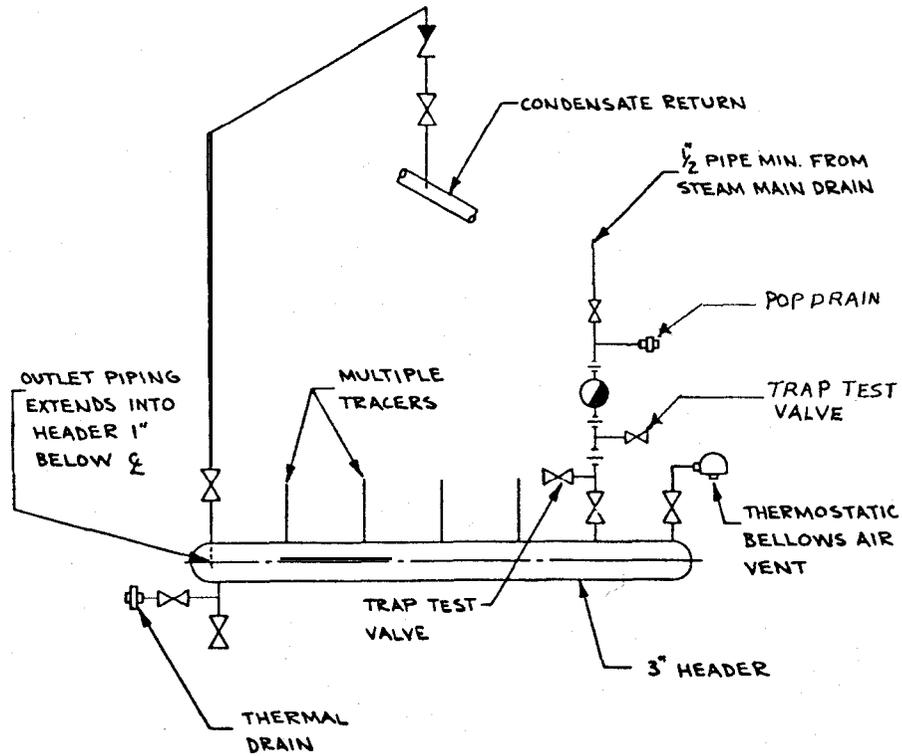
Note: Strainer not normally required with Inverted
Bucket traps.
Entire system except air vent
must be insulated.

Vertical Manifold



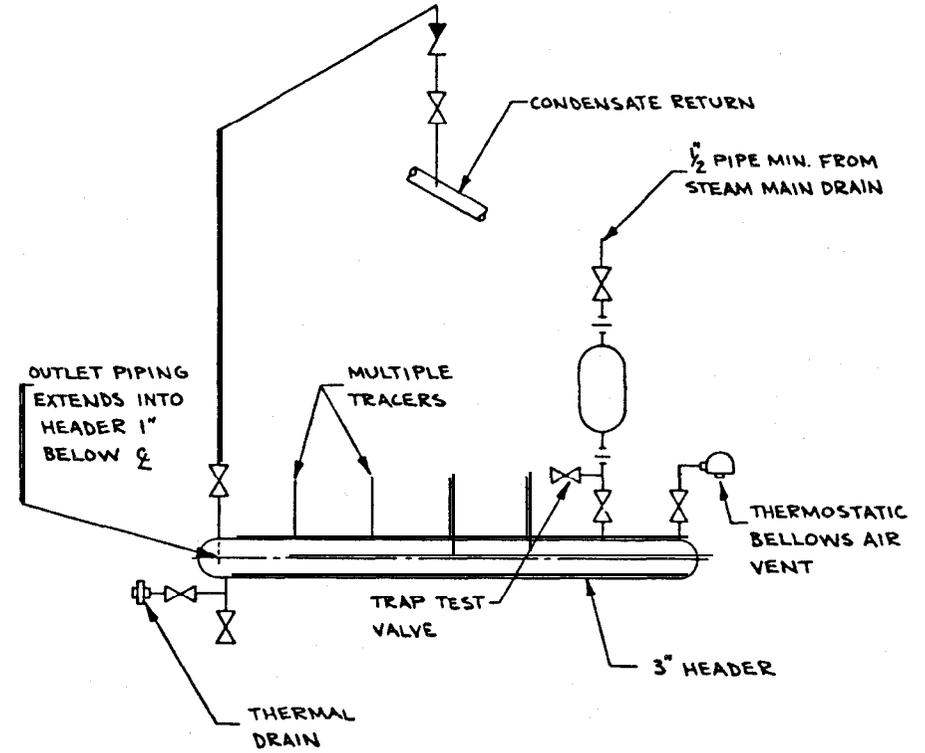
NOTE: Entire system except air vent
must be insulated.

THERMOSTATIC AND THERMODYNAMIC



Entire system except air vent must be insulated.

THERMOSTATIC AND THERMODYNAMIC



NOTE: Strainers not normally required with Inverted Bucket Traps.

ORIFICE: Drip 5/64" - Tracer 5/64" R 60

Entire system except air vent and thermal drain must be insulated.

INVERTED BUCKET MODEL 1911

HORIZONTAL MANIFOLD