

## Small Drip Legs Cause Big Problems

### Correct sizing eliminates water hammer, pipe erosion, and long startup times

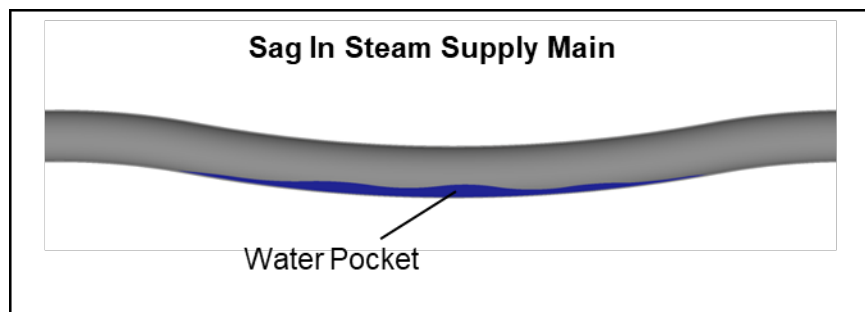
Drip Legs are vertical piping pockets located along the steam main pipe where condensate is collected for the purpose of draining from the system. The design, construction, and location of Drip Legs are all important aspects to consider for achieving reliable operation of the steam utility system, and efficient operation of the heat transfer processes and equipment. ANSI/FCI Standard 13-1: Determining Condensate Loads to Size Steam Traps refers to a Drip Leg as a Drip Point. ANSI/FCI 13-1 includes the formulas for calculating condensate loads for steam main start up and running conditions to help in sizing steam traps for draining Drip Leg/Drip Point locations.

At first glance it would seem that creating a Drip Leg is simply a matter of connecting piping or equipment to a correctly sized steam trap. But, an analysis of the varying conditions inside a steam system reveals that the location and sizing of Drip Legs are much more complex than first meets the eye.

Condensate moves in a combination of ways, depending on the type of system under consideration. At startup, low pressure and relatively high condensing loads create a gravity flow condition. High condensate loads, combined with moderate steam velocities, cause condensate to flow along the perimeter of piping. Under high-velocity, low-load conditions, condensate actually becomes entrained in steam. Drip Legs must be located and designed to remove condensate from steam lines throughout the operation cycle, regardless of condensate flow conditions. Refer to Section 4.2 of ANSI/FCI Standard 13-1 for determining the condensate loads associated with steam mains throughout their operating cycle.

Many problems mistakenly thought of as inevitable in the operation of a “typical” steam system are avoidable. Occurrences such as water hammer, steam leaks resulting from pipe erosion, short equipment life, reduced heat transfer, and long startup times are often reduced or eliminated by the proper placement and sizing of Drip Legs.

Fig. 1 Condensate collects in low areas that are created by the sagging of poorly supported piping.



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### Drip Leg Location

According to Section I, Paragraph 118 (a) of the American Standard Code for Pressure Piping, "Suitable drains or drips shall be provided wherever necessary to drain the condensate from all sections of the piping and equipment where it may collect..." Taking a few simple precautions when laying out steam lines minimizes the number of collection points.

- Ensure that steam mains are well supported. This is one of the most important, but often overlooked, precautions. A pocket of condensate can collect or pool in a section of main that is sagging due to insufficient mechanical support (Fig. 1).
- Use eccentric fittings to provide a continuous path along the bottom of steam distribution piping (Fig. 2).
- Pitch steam mains down, in the direction of flow, not less than 1 in. for every 20 ft. of run.
- Always trap each Drip Leg with a separate steam trap. Even the slight pressure drop found between two adjacent Drip Legs is enough to short circuit the system.
- Properly insulate piping to minimize the amount of condensate generated in a steam main or distribution line.

(Note: Some steam trap designs should not be insulated. Consult with the manufacturer).

Along with these general precautions, there are several specific recommendations that should be followed for the proper placement of Drip Legs. Drip Legs should be located at about 300-ft intervals along steam mains, and never at intervals greater than 500 ft. In addition, Drip Legs should be placed at risers, at points where there is a change in line/piping direction (preferably beyond the point of change in direction), at the end of steam mains, ahead of expansion joints or bends, and ahead of valves or regulators.

After choosing the proper location, Drip Legs must be designed so condensate freely enters throughout the operating cycle of the system. During normal operation, any steam system is subject to one or more conditions that must be taken into account in the sizing of Drip Legs to avoid problems.

### Startup Conditions

During startup, high condensate loads are created when steam condenses after encountering cool piping and equipment. At the same time, the high condensing rate leaves little steam pressure in the piping. If the system is well designed, gravity pulls condensate into the Drip Leg. On supervised startups, a valve is manually opened to drain and gravity alone is adequate to drain condensate.

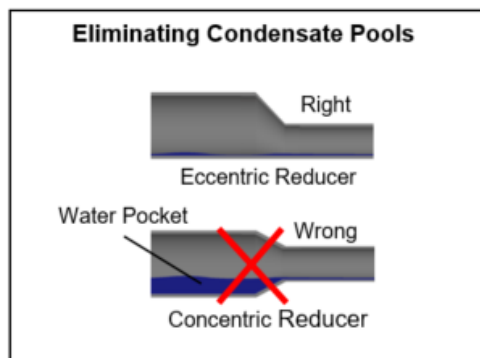


Fig. 2 An eccentric reducer precludes the forming of a condensate pool that can form behind a concentric reducer.

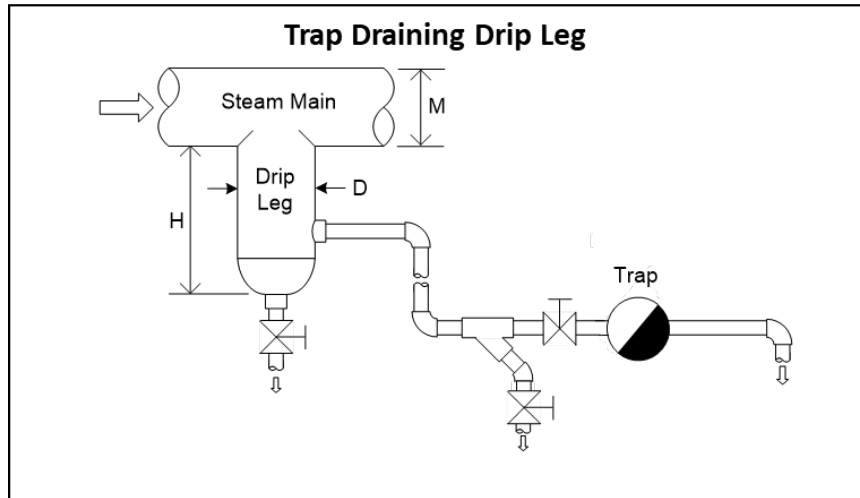
On automatic startups, however, there may not be sufficient differential pressure to provide flow through a steam trap orifice. In these cases, the Drip Leg must be sufficiently long to provide the necessary static head (dimension H, Fig. 3) to push condensate through the steam trap.

In many cases, the condensate collected at the Drip Leg and drained through a steam trap is recovered to and through a condensate return line located at high elevation in a pipe rack or building ceiling. The condensate must be lifted from the steam trap (typically at ground level) to the condensate return line. The Drip Leg must provide ample volume for water to accumulate

until there is sufficient pressure to elevate condensate to the level of the return line (must overcome about 1 psi of static head pressure for every 2 ft. of lift). (Note: if lifting condensate, a check valve should be fitted on the outlet side of the steam trap).

If the system is not properly drained, it takes an excessive amount of time to reach operating temperature, increasing operating costs. Insufficient drainage during startup can result in live steam being injected into pockets of cool condensate, creating thermal shock, a form of water hammer, causing premature damage to the piping system.

Fig. 3 Typical steam trap-draining Drip Leg is installed on steam main. Values for M, D, and H are provided in the table on the next page.



**Perimeter Flow Conditions**

With relatively large condensate loads and lower velocities, commonly found in low pressure, modulated heating systems or upstream of any control valves, condensate flow usually takes place on inside pipe walls. Steam constantly condenses on the wall of the pipe and condensate flows by gravity to the bottom of the pipe where it forms a stream that is pushed along by the forces of gravity and friction with gas flowing over its surface. The Drip Leg diameter must be sized so that the entire condensate stream is collected and drained away as it flows over the top of the opening. Partial drainage is likely when the common practice of “hot

tapping” a small pipe into the steam main is used to provide a Drip Leg (Fig. 4).

If the Drip Leg is undersized, the condensate stream flows over and past each collecting leg. As condensate accumulates, it reduces the pipe’s steam space (volume) and absorbs some of the steam’s heat, increasing operating cost. If the condensate stream is allowed to build to sufficient levels in the pipe, waves are formed by relatively high gases passing over the surface of the condensate.

These waves can rise and block the entire pipe creating a slug. With system pressure upstream of this slug, and collapsing steam downstream, the slug is accelerated in the pipe and can reach velocities as high as 90 mph. A great deal of damage can be done to piping and equipment when a slug is forced to stop or change direction.

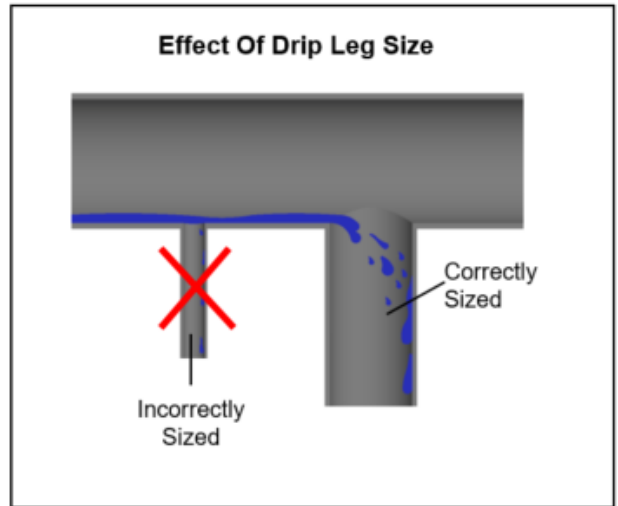
**Entrained Flow Conditions**

In low condensing load, high velocity service (typical running load condition steam mains), most of the condensate is picked up by the passing gas stream as it forms on pipe walls. These water droplets are carried along, mixed

with steam at velocities that can exceed 100 mph. To separate the condensate from high-velocity steam, the Drip Leg must be large enough to provide expansion in the flow area, reducing gas velocity and allowing condensate to drop out. If the Drip Leg is not large enough, the pressure drop created at the interface of the steam line and the Drip Leg can actually draw condensate out of the Drip Leg and back into the steam main line/pipe. In applications where dry steam is essential, it is preferable to use a steam separator to provide flow reduction and moisture removal, and drain with an adequately sized steam trap.

| <b>Recommended Steam Main and Branch Line Drip Leg Sizing</b> |                        |                            |                   |
|---|------------------------|----------------------------|-------------------|
| M   | D                      | H                          |                   |
| Steam Main Size, in.  | Drip Leg Diameter, in. | Drip Leg Length, Min., in. |                   |
|   |                        | Supervised Warm-Up         | Automatic Warm-Up |
| 1/2   | 1/2                    | 10                         | 28                |
| 3/4   | 3/4                    | 10                         | 28                |
| 1   | 1                      | 10                         | 28                |
| 2   | 2                      | 10                         | 28                |
| 3   | 3                      | 10                         | 28                |
| 4   | 4                      | 10                         | 28                |
| 6   | 4                      | 10                         | 28                |
| 8   | 4                      | 12                         | 28                |
| 10  | 6                      | 15                         | 28                |
| 12  | 6                      | 18                         | 28                |
| 14  | 8                      | 21                         | 28                |
| 16  | 8                      | 24                         | 28                |
| 18  | 10                     | 27                         | 28                |
| 20  | 10                     | 30                         | 30                |
| 24  | 12                     | 36                         | 36                |

Fig. 4 Drip Legs must be large enough to allow condensate to drop out of the stream at the pipe bottom



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If condensate accumulates in the flowing steam, it reduces steam quality. This “wet steam” reduces the amount of heat delivered and transferred downstream and increases operating costs. The erosive force of condensate droplets in “wet steam”, being whipped along at 70 to 100 mph, is roughly analogous to wind driven rain in a major hurricane. As pipe walls and heat exchanger surfaces are eroded by the water blast, they begin to leak or fail. Control valves, ends of mains, and expansion loops also become eroded and eventually fail when subjected to these forces.

### Drip Leg Design

Given these three flow dynamics, it is obvious that, to be effective, a Drip Leg must be as carefully designed as the rest of the steam system. Following a few simple sizing guidelines enables the steam trap to drain condensate from the main throughout the operating cycle of any steam system.

In general, for steam mains up to 4 in. in diameter, the Drip Leg should be constructed from the same size pipe as the main. For steam mains larger than 4 in., the Drip Leg

should be half of the diameter of the main but never less than 4 in. The distance from the bottom of the main to the top of the steam trap, in inches, divided by 28 yields the amount of static head, in psi, available to push condensate through the trap on startup. The accompanying table gives recommendations for sizing of steam mains and branch Drip Legs when the steam trap discharges to a gravity return.

On automatic startup, when return lines are elevated or pressurized, special precautions should be taken to prevent flooding. The best method is to collect the steam trap discharge in an atmospheric receiver and use a pump to raise condensate or overcome back pressure.

Please visit the Fluid Controls Institute website at [www.fluidcontrolsinstitute.org](http://www.fluidcontrolsinstitute.org) for a list of Steam Trap member companies. The FCI Steam Trap members are the industry leaders in manufacturing and technical expertise and they can assist you in selecting the best type of steam trap for your application.

*This article written by Thomas J. Grubka (Application Engineer, Armstrong International, Inc.) appeared in the September 9, 1993 issue of Plant Engineering and has been updated and modified by the Steam Trap Section of the FCI. To view the current list of FCI members, visit the FCI website: [fluidcontrolsinstitute.org](http://fluidcontrolsinstitute.org).*