Re: June 2023 issue, "Steam System Pipe Sizing for Industrial Facilities" by Kevin R. LaPlante, P.E.

I congratulate Mr. LaPlante on his article on the lost art of steam pipe sizing, an important part of the overall steam system design. I understand how difficult it is to convey all the nuances of steam system design in a short article. I wish to point out to the readers some additional issues to consider, which may differ from this article.

Figure 1 may be oversimplified. Readers need to be aware that high pressure condensate to the plant from high pressure steam drip traps may be limited by the length depending on the available vertical space for pipe pitch and/or the backpressure imposed by the boiler plant, which may include boiler plant receiver elevation. One or more intermediate condensate pump stations may be required depending on these conditions.

The trap discharge from low pressure steam loads may sometimes be subatmospheric depending on the pressure drop of the steam pressure reducing valve and the associated heat exchanger. The discharge of these types of low pressure loads should have connections to the dedicated low pressure pump receiver or be as close as possible to the receiver inlet.

I agree that the equations in *Table 1* are very useful and could replace the cumbersome charts in the *2021 ASHRAE Handbook—Fundamentals,* provided that one has viscosity data for steam. Dynamic viscosity data for saturated steam is listed in the *2021 ASHRAE Handbook—Fundamentals*, Chapter 30, R-718 table, or values can be searched online. Online data will most likely be dynamic viscosity units of centipoise.

The designer needs to convert dynamic viscosity units to kinematic viscosity units of ft^2/s

(m^2/s) by applying the appropriate conversion factors to get lbm/ft·s (kg/m·s) and then multiplying by the specific volume in units of ft^3/lbm (m^3/kg). The equations can also adjust for superheated steam properties, which are different than saturated steam properties used for ASHRAE's tables.

I agree with *Table 2* values for maximum velocity, which are more conservative than the 8,000 fpm to 12,000 fpm, with a maximum of 15,000 fpm values in the *2021 ASHRAE Handbook—Fundamentals,* Chapter 22. I would only recommend a 10,000 fpm to 15,000 fpm maximum for industrial applications where noise is not an issue and where first costs are important.

The pressure drop per 100 ft and the total system pressure drops values appear to be from Table 29 in the *2021 ASHRAE Handbook—Fundamentals,* Chapter 22. The designer needs to be aware that the maximum pressure drop per 100 ft will usually apply for smaller piping, resulting in velocities much lower than the maximum values listed. For larger pipe, the maximum velocities will apply to pipe sizing.

The total system pressure drop of 20% to 30% will usually only apply to systems with an equivalent length longer than 600 ft (180 m). For longer systems consider using the average system pressure for each major pipe section in lieu of pressure at the boiler header or at the pressure reducing valve outlet when determining steam properties.

The description of pipe sizing between the equipment outlet (or the steam drip leg) and trap inlet may be incomplete. The slope and velocity limits are important but not as important as the total head of liquid condensate upstream of the trap. The article's suggestion is of a pressure loss of 1.0 ft of water. This may result in flash steam and potential damage of the trap due to water hammer. Hydraulic pressures at the trap inlet should be above the flash point.

The pipe sizing between the trap outlet and the common drain line may be designed differently than described in this article. Flash steam is expanding in this section due to the high pressure drop of the steam trap, thus transitioning from bubble to slug flow to eventually stratified flow. A designer may want to keep flow in the slug flow regime, especially when lifting condensate. Keeping the pipe size the same as the trap outlet for a short distance will assist in maintaining slug flow in a vertical riser.

In sizing the common dry-closed steam condensate return lines, I agree that applying the pressure drop limit of 0.125 psi/100 ft listed in *Table 3* is appropriate when using slopes between 0.36 in. and 0.5 in. per 10 ft. I do not agree the maximum flash steam velocities should apply to dry-closed steam condensate pipe sizing. This is a departure from Table 37 in the *2021 ASHRAE Handbook—Fundamentals,* Chapter 22 and from my discussion in my February 2023 *ASHRAE Journal* article.

I disagree that dry-closed steam condensate lines can be characterized by the upstream pressure. I contend that they should be characterized by the backpressure of the receiver. I contend that this is a better method based on the fact that average pressures in the common drain line are closer to the receiver pressure than to the upstream supply steam pressure.

Regarding steam condensate return pipe design, I encourage the reader to review my February 2023 article along with my response to Mr. LaPlante's letter to editor in the April 2023 issue of *ASHRAE Journal*.

Gene Nelson, P.E.
Life Member ASHRAE
Madison, Wis.

LAPLANTE RESPONDS

I thank Mr. Nelson for his interest in the article and the opportunity to respond. We agree on the main points of steam supply pipe sizing. As the article describes, proper sizing will ensure both pressure drop and velocity limitations are not exceeded; one of these factors will govern for a given mass flow rate and supply pressure. The article also acknowledges that average specific volume (and consequently, pressure) should be used in calculations for pressure drops ranging from 10% to 40% of upstream absolute pressure to achieve accurate results.

High pressure condensate (HPC) piping is pressurized by flash steam at drip trap outlets. A positive pressure is maintained due to lack of vents to the atmosphere at condensate entry points in the piping. This pressure allows condensate to be lifted above the steam trap discharge elevation without the aid of a condensate return pump. If it is not practical to directly return HPC to the plant, it would be prudent to consider routing this valuable condensate to a flash steam recovery vessel to generate low pressure steam for other needs, rather than discharging it directly to vented pump receiver sets. This approach offers several benefits, including lower makeup water use, reduced boiler input energy and decreased chemical treatment requirements.

Mr. Nelson accurately explains the process of obtaining kinematic viscosity from dynamic viscosity and specific volume. Alternatively, kinematic viscosity values can be obtained from a variety of online sources. One may elect to calculate this value or retrieve the desired data points for use with computational software that can leverage lookup tables to automate this part of the sizing process.

A minimum elevation difference from equipment condensate outlets to steam trap inlets, known as a "liquid leg," is indeed necessary for proper system operation. Slope, velocity and pressure drop per unit length guidelines provided in the article are applicable to pipe sizing practices; they do not preclude the need for a liquid leg at steam trap inlets or other necessary provisions.

Mr. Nelson's comment on dry-closed condensate return pipe sizing reveals a disagreement concerning the definition of these piping networks. The article supports the *2021 ASHRAE Handbook—Fundamentals* description, which includes:

- Piping is not completely filled with liquid ("dry");
- Piping is non-vented ("closed");
- Piping is motivated by steam pressure;
- Sizing is based on condensate capacity without slope, although it is "…common practice to slope the line in the direction of flow to a collection point to clear the lines of sediment or solids."

Based on this information, it would be inadvisable to use pipe slope as a sizing basis for dry-closed condensate return piping in lieu of the flash steam velocity and pressure drop guidelines outlined.

The article also notes that normal operating pressures of high, medium and low-pressure condensate returns are much lower than their associated steam supply piping. It is neither expressed nor implied that the operating pressure of dry-closed condensate piping can be solely characterized by upstream pressure.

Kevin R. LaPlante, P.E.,
Member ASHRAE
Concord, N.H. ■