Modeling a Supercritical Fluid

A supercritical fluid is a fluid at a temperature and pressure above the fluid’s critical pressure and temperature. Supercritical fluids do not have a distinguishable gas or liquid phase and their physical properties, such as density and viscosity, fall in between those of a typical gas or liquid.

Many common gases have relatively low critical temperatures and pressures. For example, carbon dioxide, air, and hydrogen have critical temperatures and pressures of \((88 \, ^\circ F, 1070 \, \text{psi a})\), \((-221 \, ^\circ F, 547 \, \text{psi a})\) and \((-400 \, ^\circ F, 190 \, \text{psi a})\), respectively. Considering these critical points, it is easy to see the possibility of encountering supercritical fluids in gas piping systems.

There are couple things to consider when modeling a system with supercritical fluids. First, the fluid table formulas that are used to calculate the fluid properties are only valid up to a maximum pressure. This maximum pressure value in the case of our gas tables is equal to the critical pressure of the fluid. Therefore the fluid property calculations may not be accurate for pressures above the critical pressure of the fluid. We recommend using an alternate resource for the supercritical fluid properties and inputting them as a custom fluid for your model. If you are using one of our fluid tables the program will return a warning for any system pressure above the fluids critical pressure.

The other thing to consider is where the system is operating in relation to the fluids critical point. Near the critical point, a supercritical fluid deviates considerably from ideal gas behavior and small changes in pressure yield large changes in density. At temperatures much higher than the critical temperature fluids tend to be more gas like and may be close to ideal gas behavior. A supercritical fluid should only be modeled in PIPE-FLO® Professional, Compressible or Flow of Fluids if the fluid can be approximated as an ideal gas. When modeling a supercritical fluid in PIPE-FLO® Professional or Flow of Fluids one must also ensure that the correct fluid densities are used for the system operating conditions.

You can determine how close your fluid is to ideal gas behavior at the system operating conditions by calculating the compressibility factor. Ideal gases have a compressibility factor of 1. Compressibility factors can be determined from generalized compressibility charts or an appropriate equation of state. Additionally, calculators can be found on the web that will determine the compressibility factor based on the critical and operating temperatures and pressures of the fluid.