Technical Note
Regarding Usage of Manual Input of PRV Area

AFFTAC 4.00 Beta 07 Patch 01

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If you choose to input the area of a PRV manually, it will override the area computed internally by AFFTAC and, in so doing, override part of the Vapor Flow Test Data that you specify for the PRV. Below is an explanation for why that is the case.

There are two key flow models in AFFTAC for the PRV, the choked vapor flow model and the two-phase liquid flow model. Since PRVs have historically been tested and specified for vapor flow, it is that test data that has historically provided the inputs for AFFTAC to describe the PRV. Specifically, if a PRV is tested for vapor flow at a given pressure, AFFTAC uses the following to describe the flow characteristics of the PRV. It is referred to here as the "Vapor Flow Test Data":

Vapor Flow Test Data

1. The pressure at which the test was performed (standard temperature is assumed)
2. The volumetric flow rate of air at that pressure
3. The coefficient of vapor discharge, which is used to scale the choked flow model so that it matches the experimental data

The equation below is the choked vapor flow model that AFFTAC uses during the simulation of the fire event:

$$w = 144 C_{DV} A_v P \sqrt{\frac{g\gamma}{ZRT}\left[\frac{2}{\gamma+1}\right]^{\frac{\gamma+1}{\gamma-1}}}$$

where

w	=	mass flow rate (lbs/sec)	
A_v	=	minimum cross-sectional area of the valve (ft^2)	
P	=	upstream gas pressure (psia)	
T	=	upstream gas temperature (absolute, deg-R)	
g	=	gravitational constant (ft/sec^2)	**(constant)**
R	=	gas constant, equal to 1,545/(molecular weight) (ft/deg –R)	**(constant)**
C_{DV}	=	valve discharge coefficient	**(user input)**
Z	=	gas compressibility factor	**(user input)**
γ	=	ratio of specific heats	**(user input)**

During the simulation, pressure and temperature are known and mass flow rate is sought. The one value that is not typically known by the user is the area and so AFFTAC computes it using the same equation above but while inserting the Vapor Flow Test Data to provide values for some of the variables. Specifically, the equation above is rearranged to solve for area:

$$A_v = \frac{w_{\text{Vapor Flow Test Data}}}{144 C_{DV} P_{\text{Vapor Flow Test Data}} \sqrt{\frac{g\gamma}{ZRT_{\text{Vapor Flow Test Data}}} \left[\frac{2}{\gamma+1}\right]^{\frac{\gamma+1}{\gamma-1}}}}$$

Once the value for area is known, it can be used in the two-phase liquid flow model as well.

The key point is: In all flow calculations, the *same value of area is used*. Therefore, overriding AFFTAC's area estimator (above) with manual input also affects the vapor flow model. In fact, it overrides the role of the Vapor Flow Test Data in the equation above.

That stated, if exactly the same value for area as would be computed above is specified manually, the computations will work out the same. So, if you want to specify the area manually and also ensure the PRV model honors the Vapor Flow Test Data, you must calculate the area by hand using the equation above and enter that value. If you choose to do that, please refer to the User's Manual, which provides a detailed discussion of the units.

There is one minor, rather obscure heuristic in AFFTAC that is based on the volumetric flow rate data. Because of that, the GUI does not disable the PRV volumetric flow rate data when you choose to enter the area manually. However, for reasons described here, it is essentially ignored when the area is entered manually.