EngineeredSoftware, Inc.

Determine the Characteristic Curve of an Installed Control Valve

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Generalized Form of the Control Valve C_V Equation

$$C_V = \frac{Q}{\sqrt{\frac{P_1 - P_2}{SG}}}$$

The performance of a control valve is defined by its inherent and installed characteristic curves. The inherent characteristic curve is a plot of the percent of valve opening vs. the percent of maximum flow coefficient (C_V). The inherent characteristic curve is determined by measuring the flow rate at various positions of valve travel with a fixed differential pressure across the valve (typically 1 psid) and calculating the C_V at each position using a form of the generalized Control Valve C_V equation.

The most common characteristic curves are the quick opening, linear, and equal percentage curves. Valve manufactures can also design valves with modified linear, modified equal percentage, parabolic, and square root characteristics, as shown in the graph in Figure 1.

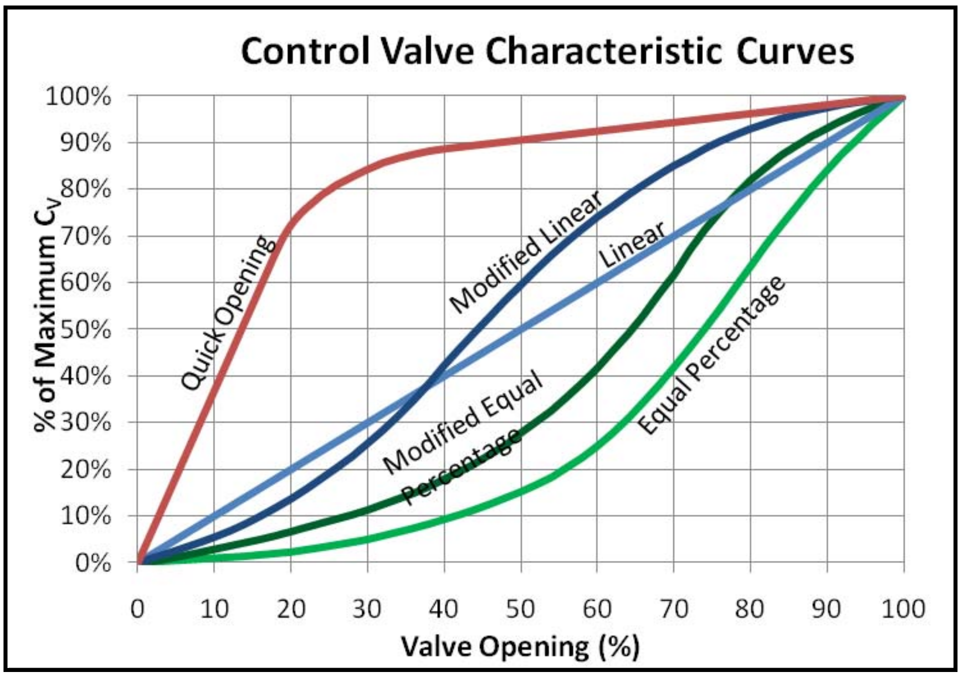

Figure 1: Typical Control Valve Inherent Characteristic Curves

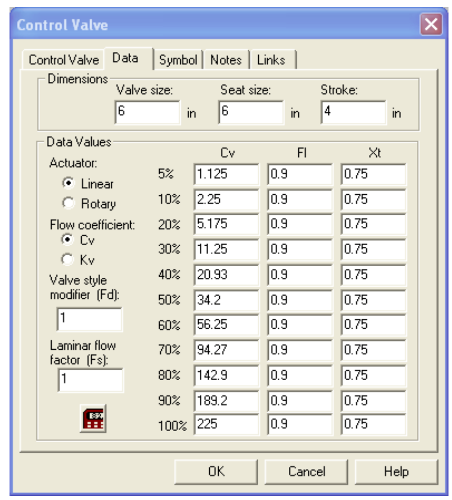

Figure 2: Control Valve Data

When modeling a control valve in PIPE-FLO, the inherent valve C_V data from the manufacturer can be entered into the Control Valve dialog box, or a set of data can be generated using the Control Valve C_V Calculator by entering a single C_V value at any valve position and selecting the type of valve and characteristic curve, as shown in Figure 2.

The C_V of the valve at each position will not change when installed in an actual system. However, the ***installed*** characteristic curve of valve position vs. percent of maximum flow rate will be different than the inherent characteristic curve because the differential pressure across the valve will change with a change in valve position. How the curve shifts is determined by the shape of the pump curve and the amount of static head in the system.

PIPE-FLO can be used to show how the inherent curve is changed by installing the valve in an actual system and to create an installed characteristic curve for a control valve.

Consider the typical piping system in Figure 3 consisting of a Supply Tank, Pump, Flow Control Valve (FCV), Heat Exchanger (HX), and a Product Tank. The pump curve has been specified for the pump and C_V data has been entered for the FCV with an equal percentage characteristic and a maximum C_V of 225.

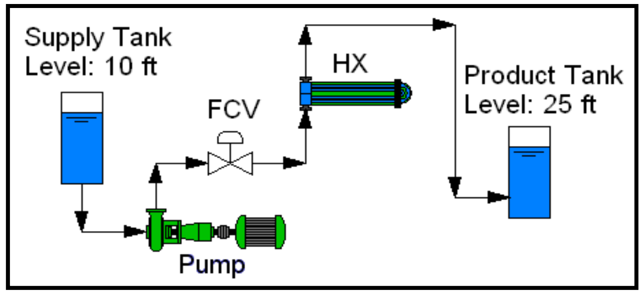

Figure 3: Typical piping system.

The installed characteristic curve for the FCV is obtained by giving the FCV a manual position from 5% to 100% and entering the resulting flow rates into an Excel spreadsheet, calculating the percentage of maximum flow rate and graphing the result.

The graph in Figure 4 shows how the equal percentage inherent curve is shifted up and to the left to obtain the installed curve. Figure 4 also shows how much the curve is shifted when the static head is increased to 130 ft by pressurizing the Product Tank to 50 psig.

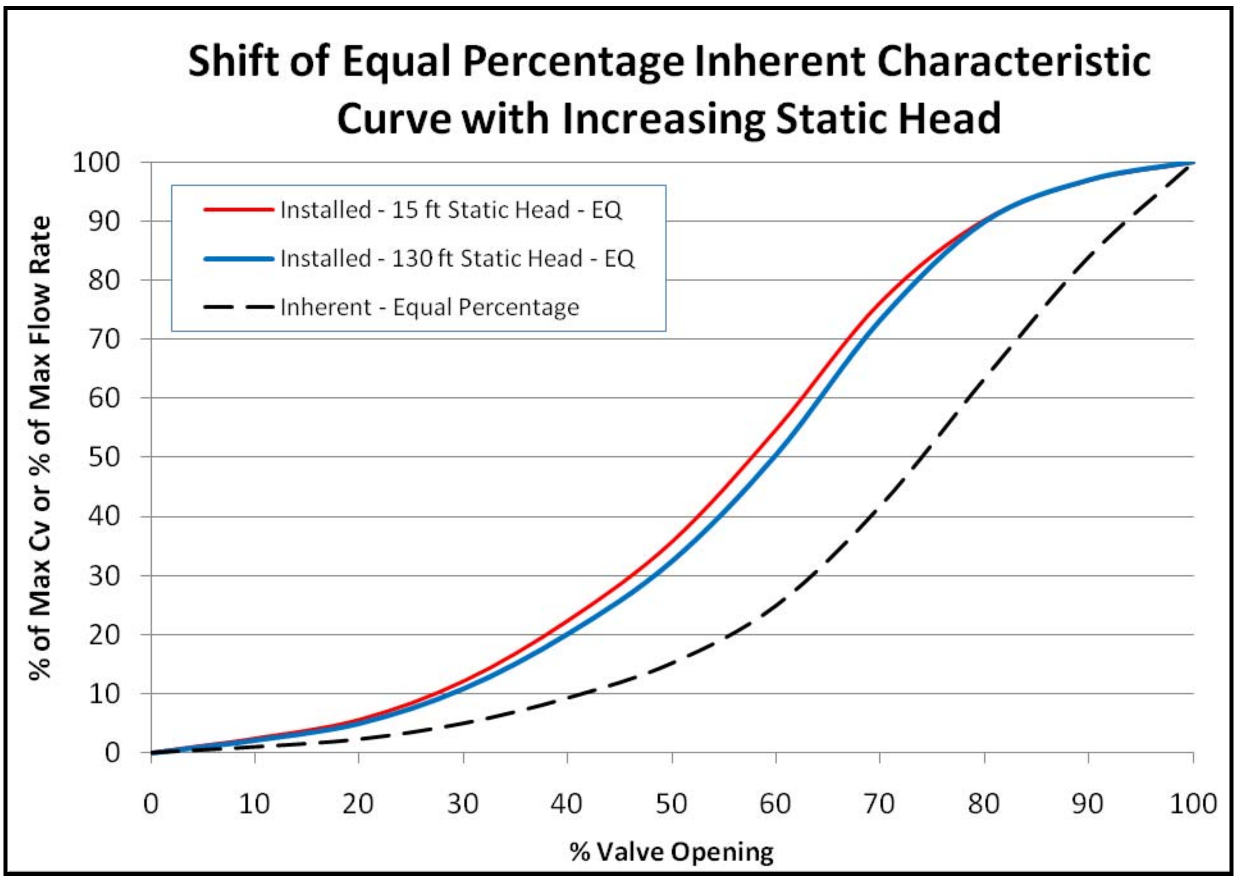

Figure 4: Shift of an equal percentage characteristic curve for FCV installed in a typical piping system.

If the control valve in the system had a linear inherent characteristic, a similar graph can be obtained to show the shift in the inherent curve. Figure 5 shows how the installed curve is shifted up and to the left from the inherent linear curve, and the amount of shift is affected by the amount of static head in the system. The installed curve for a control valve with a linear inherent characteristic is closer to a quick opening characteristic.

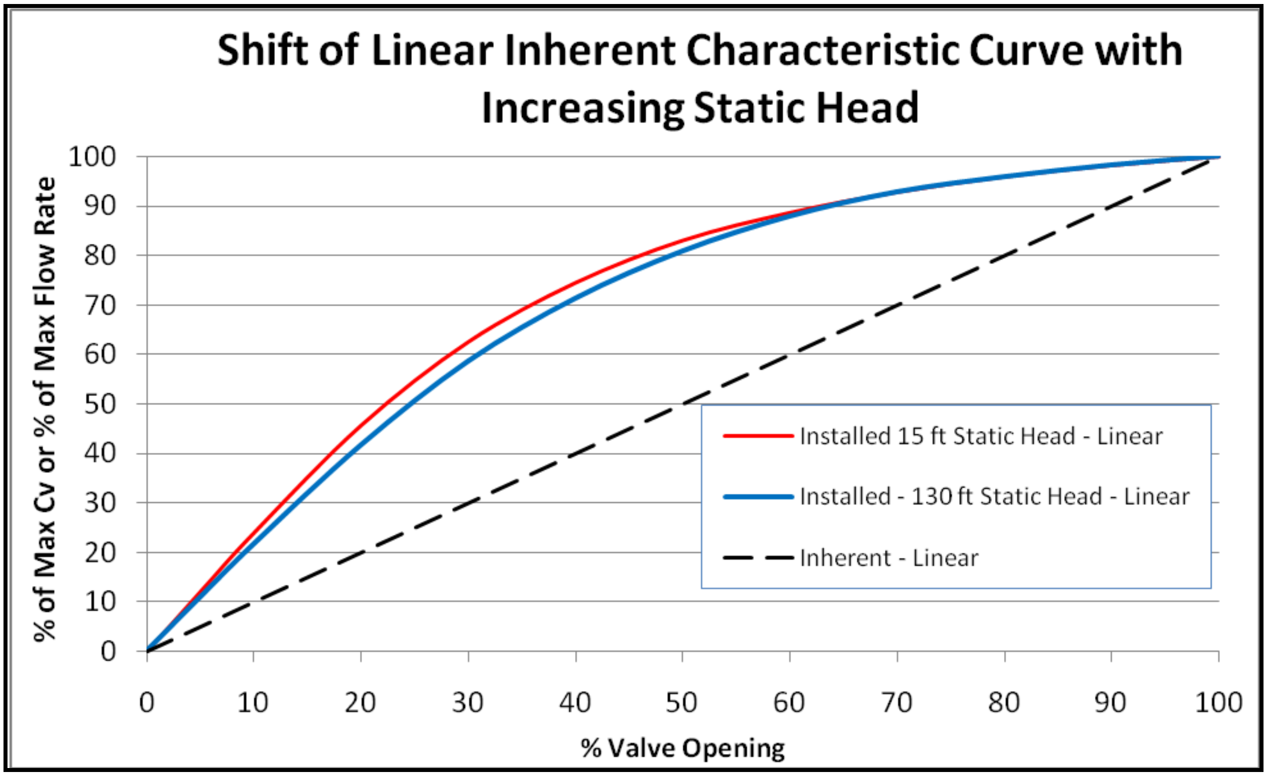

Figure 5: Shift of an linear inherent curve for FCV installed in a typical piping system.

Evaluating the two graphs above, it's easy to see why the vast majority of control valves installed in industrial applications have an equal percentage inherent characteristic curve. When installed in a system, the shift in the inherent curve results in a control valve with an installed characteristic that is closer to linear.