The National Institutes of Health | Division of Technical Resources | Office of Research Facilities

Design Requirements Manual News to Use

September 2024

Vol. 02, No. 84

The formulae $\frac{\partial \rho U_i}{\partial t}+\frac{\partial}{\partial x_j}(\rho U_i U_j)=-\frac{\partial P}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu\frac{\partial U_i}{\partial x_j}\right)+g_i(\rho-\rho_0)$ for building $\frac{\partial}{\partial x_j}(\rho \bar{U}_i \bar{U}_j)=-\frac{\partial P}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu\frac{\partial \bar{U}_i}{\partial x_j}-\rho\overline{u_i'u_j'}\right)+g_i(\rho-\rho_0)$ state of the art $\frac{\partial}{\partial x_i}(\rho \bar{U}_i \bar{H})=\frac{\partial}{\partial x_i}\left(\lambda\frac{\partial \bar{T}}{\partial x_i}-\rho\overline{u_i'h'}\right)$ biomedical research facilities.

Design Considerations for Modulating Hydronic Control Valves

Variable flow applications for heat transfer - used in all terminal coils and equipment on variable frequency drive (VFD)-operated systems - require two-way modulating control valves to regulate water and glycol flow and meet the design conditions of the spaces served. Designers must consider multiple factors when selecting a valve for an application, including desired valve flow and coil characteristics, water temperature drop across the coil, and (when driven by modulating controls) control loop parameters fine-tuned to provide fast, stable, and accurate valve response to meet room setpoints. Even with fine-tuning, pressure fluctuations in a hydronic system may cause valves to overshoot or undershoot setpoints, leading to unsatisfactory temperature control and, with it, inefficient and expensive operation. This article discusses the basic function of and design considerations for control valves.

Control valves at NIH can be globe, ball, or butterfly type. Designers must select the valve's flow characteristic so that the hydronic coil served provides stable and predictable heat transfer as the valve position changes from fully closed to fully open. This characteristic describes how much flow passes through a valve as it opens. Hydronic coils at NIH utilize control valves with an equal percentage characteristic that guarantees flow through the valve increases an equal percentage for each equal increment the valve modulates open, providing stable output from the coil. Valves that control flow through building chilled water loops, which are not paired with a coil, utilize a linear characteristic to provide a more stable water flow over the entire range as the valve modulates.

Designers must ensure the valve experiences a pressure drop across its internal components sufficient to maintain control over flow regardless of valve position but limits pressure losses in the system the valve and coil serve. The ratio between the pressure drop across the valve to the pressure drop across all components on the branch piping serving the coil is called authority. The NIH *Design Requirements Manual* (*DRM*) requires an authority greater than 50% for modulating water control valves. Refer to *DRM* 6.3.4 and 7.6 for control valve requirements.

For pressure-dependent control valves, the pressure drop across the valve at the maximum design flowrate is expressed as a flow coefficient (Cv), published by the valve manufacturer, that provides the desired authority over the branch piping circuit. This Cv (see Figure 1) is only an estimate; designers typically assume a valve pressure drop of 5 psi, and fluctuations in other parts of the hydronic system result in changes to pressure drop, and thus flow, across the valve. These fluctuations alter flow and anticipated heat transfer through the coil. Control valve actuators governed by direct digital controls (DDC) must then apply Proportional, Integrated and Derivative (PID) control parameters to quickly restore and stabilize the design flow rate and temperature setpoints. Pressure-dependent control valves are paired with a balancing valve calibrated to maintain the system design flow through the branch piping.

$$C_v = Q\sqrt{\frac{S_g}{\Delta P}}$$

C_v = required flow coefficient for the valve
Q = flow rate (in gal/min)
S_g= specific gravity of the fluid
ΔP= pressure drop (psi)

Figure 1: Flow Coefficient Equation (Fluid Controls Institute, Inc.)

Pressure-independent control valves maintain design flow across the valve by employing an internal mechanism to decrease flow across the valve when system pressure changes would otherwise increase valve pressure drop and flow, and increase flow across the valve when system pressure changes would otherwise decrease valve pressure drop and flow. This allows designers to select the valve's design flowrate independent of system pressure changes that alter flow so long as pressure drop across the valve remains within a manufacturer-prescribed range (typically 5-50 psi).

Facility personnel can adjust the maximum flowrate through connections with the Building Automation System (BAS) or by field-replacing a cartridge governing the valve flow. Per *DRM* 7.6, NIH prohibits replaceable cartridges due to maintenance concerns. Mixing pressure-independent valves and regular control valves in the same system is not preferred for renovation projects.

Building chilled water return control valves shall be selected for high turn-down ratios and proper control across significant plant-pressure differentials. Valves shall be of high quality and industrial grade, and actuators sized to close against anticipated system pressure so that valve seats are not forced open.

Conclusion

Control valve selection must consider the application served, type and magnitude of the control required over connected equipment, and adjustability and serviceability in the field. Designers should consult *DRM* design and control requirements in concert with manufacturer recommendations and industry best practices.

Additional Information

1. ASHRAE. (2020). ASHRAE Handbook—HVAC Systems and Equipment.
2. Fratelli Pettinaroli. The Definitive Guide to Pressure Independent Control Valves. Click Here for Link
3. NIH *DRM* (Rev 1.5) 3-5-2020
4. Schneider Electric. (2010). Control Valve Sizing Application Information

---

'*Design Requirements Manual (DRM)* News to Use' is a monthly ORF publication featuring salient technical information that should be applied to the design of NIH biomedical research laboratories and animal facilities. NIH Project Officers, A/Es and other consultants to the NIH, who develop intramural, extramural and American Recovery and Reinvestment Act (ARRA) projects will benefit from 'News to Use'. **Please address questions or comments to:** megan.teague@nih.gov