CONTROL VALVE SIZING

Introduction
This bulletin provides essential information and a practical guide to sizing control valves for hot water, chilled water and steam HVAC systems. If the control valves are properly sized and selected, the HVAC system should function as it was intended. Energy savings, greater occupant comfort and longer control life are additional advantages of properly sized valves.

Functions of Control Valve and Need for Proper Sizing
A pump creates a differential pressure across a hydronic system causing a flow of water. Boilers create differential pressure in steam systems. The friction and turbulence resulting from the flow of water (or steam) contacting the system components reduces the differential pressure. Coils, piping and valves are the sources of this system friction on resistance to flow. Friction in any section of the system will cause a pressure drop proportional to that section.

Flow Coefficient (Cv)
Sizing a valve requires determining the flow coefficient (capacity) Cv, which is defined as the flow rate in gallons of 60°F water that will pass through the valve in one minute at a one pound pressure drop. Valves with identical end fitting sizes may have different Cv’s depending on body style or valve trim. This Cv value is probably the most important piece of information needed to select a valve.

Information required to determine the Cv includes:

- The quantity of steam or water the valve must supply to the coil or heat exchanger when the valve is fully open.
- The pressure drop (∆P) across the valve in the full open position.
- For steam valves the inlet pressure must be known.
- The Cv can be determined by using a table, formula or nomograph (see Appendix A, B, C, or D).

Improper Sizing
Selecting too small a valve can result in not having sufficient heating or cooling available at design conditions. Damage to the valve body and trim may result from a cavitation caused by too great a pressure drop across the valve. Excessive noise may also be a result of too great a pressure drop. Oversized valves will provide needed flow only when operating near the closed position. Rapid wear of the seat and disc is caused by increased fluid velocity in the nearly closed valve. Oversizing may also cause excessive noise and rapidly fluctuating controlled media temperatures. In addition, the cost of the valve is greater than necessary for the system. Experience has shown that, by far, most improper valve selection results in oversizing.

Not all poor control problems are caused by incorrect valve sizing and selection. However, too many systems are operating at less than perfection because of valve misapplication.

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Control Valve Pressure Drop

The only variable normally available in sizing is the pressure drop ($\Delta P$) across the valve since the Cv's of the valves available are fixed and the coil usually has been selected. Selection of the proper pressure drop of the valves, relative to the total system $\Delta P$, depends on the system application. Some systems require large valve pressure drops. Other systems require small valve pressure drops. This pressure drop should be as large as practical for the application at maximum (design) flow.

Two-position applications require lower pressure drops for steam or water systems.

Flow proportioning two-way and three-way valves\(^1\) normally require high pressure drops relative to the total system pressure drop. Valves, in these applications, must provide the greatest resistance to flow in a circuit. A coil should not have a greater resistance to system flow than the control valve since control of flow is determined by the largest restriction in a system. No control will be achieved until the valve closes to the position that gives it a greater resistance to flow than the remainder of the system.

Additional considerations must be given in selecting pressure drops. Critical pressure with respect to steam, "wire drawing" and cavitation with respect to water are discussed later in this document.

Water Valve Sizing

The objective in sizing a water valve is to determine the required Cv factor. Once the Cv has been calculated, the proper valve can be selected for the application. See "Water Valve Selection" section for complete selection requirements for water valves.

Normally the simplest method is through the use of the formula:

$$Cv = \frac{\text{GPM}}{\Delta P}$$

Where:

- $Cv$ = Flow coefficient
- GPM = Flow in U.S. gallons per minute
- $\Delta P$ = Pressure drop in psi (full open valve)
  (Difference in pressure between inlet and outlet)

Cv's can also be determined by tables or a sizing chart. These methods are given at the end of this document (Appendices A and B). Skip to section entitled "Water Valve Selection" if the Cv has been calculated.

Consider both components of the Cv formula: GPM and $\Delta P$. As stated earlier, the $\Delta P$ is usually the variable of choice, so we will also discuss recommendations for choosing $\Delta P$ at length after examining the GPM requirements of the coil.

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\(^1\) Some 3-way valve arrangements proportion temperature rather than varying the supply flow in the system. These applications require lower pressure drops than two-way valves.

GPM Flow Requirements

As previously mentioned, the coil has usually been selected and its flow requirements should be known. It may be necessary to calculate the flow requirements if the specifications are not available. See Heating and Cooling Formulas at the end of this document (Appendix F).

Pressure Drop Recommendations

Pressure drop ($\Delta(P)$) across the valve is measured with the valve in the fully open position. A choice of a pressure drop depends on the application and normally it is the only variable in sizing a valve.

A low $\Delta P$ is used in:

- A proportional system (using three-way valves) that delivers a constant volume of water at the proper temperature.
- A system requiring two position control.

A high $\Delta P$ is used in:

- A flow proportional application that varies the GPM in the system under control.

The pressure drop across the valve changes, as the valve closes, in flow proportioning. To provide good heat transfer control, keep the change in pressure drop across the valve, relative to the pressure drop in the circuit under control, as low as possible. (i.e., The valve should have a 50% to 70% $\Delta P$ in that part of the system controlled when full open.)

The following guides to selecting the proper pressure drop are:

Two-Position, Two-Way Valves

These types of valves are selected line size or they use 10% of the available pressure as a drop. Valve bodies with line sized end fittings are usually used to reduce installation costs. A valve one size smaller than the line can be selected without affecting performance.

Applications: Zone control of a building or a portion of a building using radiators, convectors, unit heaters or similar equipment.

Proportional Two-Way Applications

Ideally, the pressure drop for two-way valves for proportioning systems should be 50% to 70% of the difference between the supply and return main pressure at the valve location with rated coil flow (Figure 1). Practically, the actual pressure difference in most systems cannot be accurately determined from the normal information available.
One practical method is to select a pressure drop at least equal to the pressure drop in the coil (or other load) or a minimum of 5 psi. A more precise method is to take a pressure drop for the valve as shown in the following table.

<table>
<thead>
<tr>
<th>Design Temperature Drop of Coil</th>
<th>Multiplier on Coil Pressure Drop</th>
</tr>
</thead>
<tbody>
<tr>
<td>20°F</td>
<td>3</td>
</tr>
<tr>
<td>40°F</td>
<td>2</td>
</tr>
<tr>
<td>60°F or more</td>
<td>1</td>
</tr>
</tbody>
</table>

Note: Minimum 5 psi pressure drop across the valve.

For example, systems having a low design temperature drop, say 20°F, the pressure drop across the valve should be three times the pressure drop in the coil (minimum 5 psi).

Secondary circuits with small booster pumps — use 50% of available pressure difference (equal to drop through the secondary load, or 50% of booster pump head).

When control valves are applied to jobs using Monoflo type fittings to cause flow through the load, particular care must be taken not to undersize the valve because of the extremely low pressure differences available. Recommended procedure here is to size the valve using a pressure drop about equal to the drop through the load at full flow, or 50% of available pressure developed by the Monoflo fittings on the loop in question.

Applications: Room control of radiator, unit ventilator, unit heater, air handling unit with constant air circulation and room control, etc.

Three-Way Valves

Three-way valve size recommendations are a little more difficult because the systems and piping arrangement of the valve must be carefully studied. Three-way valve applications are more fully discussed in CA-27 (F-12348).

Two-Position

Two-position, three-way valves used for summer/winter changeover generally have a low pressure drop and are generally the same size as the line (Figures 2 and 3).

Proportional Temperature - Constant Volume Applications

Proportioning, three-way mixing valves on mixing applications will need a low pressure drop. A mixing valve for these applications is designed to deliver a constant volume of water at the proper temperature. Use 20% of “available pressure”, or equal to 25% of the pressure drop through the load at full flow.

Applications: Zone control mixing service (Figure 4), air handling unit and fresh air unit (each system should have its own pump so that mixed water can be circulated through the controlled coil).
Volume Control of Hot Water Supply

Proportioning/"By-Pass"

"By-pass" applications can use mixing or diverting three-way valves. Valves of this type should be sized on the same basis as proportional two-way valves since they vary the volume of water through the coil. **Whenever volume must be proportionally changed, a higher pressure drop is needed.**

Applications: Individual coil with valve return or supply (Figures 5 and 6), primary-secondary systems (Figure 7) and cooling tower applications (Figure 8).

**Note:** Pressure drop for the cooling tower should be at least as great as the pressure drop between the valve outlet and the top of tower plus spray nozzle drop, if spray nozzles are used. Use care when selecting butterfly valves because they have greater capacity than conventional three-way valves size for size. Close off requirements for this application normally require that the valve be located at (or near) the same level as the cooling tower.

**Limitations on Valve Pressure Drop**

A valve selected with too high a pressure drop can cause erosion of discs and/or wire drawing of the seat. In addition, cavitation can cause noise, damage to the valve trim (and possibly the body) and choke the flow through the valve. Do not exceed the maximum differential pressure (pressure drop) for the valve selected. This information will be found in the Schneider Electric valve data information (see Controls Catalog F-16650).

The following formula can be used on higher temperature water systems, where cavitation could be a problem, to estimate the maximum allowable pressure drop across the valve:

\[
P_m = 0.5 (P_1 - P_v)
\]

Where:
- \(P_m\) = Maximum allowable pressure drop
- \(P_1\) = Absolute inlet pressure (psia)
- \(P_v\) = Absolute vapor pressure (see Vapor Pressure or Water Table in Appendix E or Steam Table)

**Note:** Add 14.7 psi to gauge supply pressure to obtain absolute pressure value.

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Figure-5 Three-Way Mixing Valve on “By-Pass” Application.

Figure-6 Three-Way Diverting Valve on “By-Pass” Application.

Figure-7 Primary-Secondary Systems.
For example, if a valve is controlling 200°F water at an inlet pressure of 18 psig, the maximum pressure drop allowable would be:

\[ P_m = 0.5 \left[ (18 + 14.7) - 11.53 \right] = 10.6 \text{ psi} \]

(Vapor pressure of 200°F water is 11.53 psi)

If the pressure drop for this valve is less than 10.6 psi, cavitation should not be a problem.

Systems where cavitation is shown to be a problem can sometimes be redesigned to provide lower inlet velocities. Valves having harder seat materials should be furnished if inlet velocities cannot be lowered.

Water Valve Selection

Selection of the specific valve and actuator comes after the proper sizing of the control valve - determining the pressure drop and calculating the Cv. The following questions need to be answered so as to complete the selection process:

- Is tight shut-off required?
- Fluid pressure and temperature limitations?
- Flow characteristic needed?
- Body pattern required?
- Selection of actuator?
- Close-off Rating?

Note: Actuators with sufficient force available must be used to meet close-off requirements for valve. Specific close-off rating tables for actuator/body combinations are located in the Controls Catalog F-16650.

- Ambient temperature at actuator?
- Valve size?
- Positive positioner requirement?

The above information for specific Schneider Electric valves is found in the data information Controls Catalog F-16650.

Steam Valve Sizing

The procedure for sizing steam valves is similar to that for sizing water valves in that we need to determine a Cv factor. Again, as in the sizing of a water valve, the only variable of choice is the pressure drop across the valve. The inlet pressure should be known and quantity of steam (lbs. per hour) needed by the system has been fixed by the coil selection.

All valves recommended by Schneider Electric for use in HVAC steam applications are of the two-way type. Pressure drop recommendations will depend on low or high pressure steam applications.

After choosing the appropriate pressure drop, use one of the three methods (sizing table, formula or chart) to determine the Cv for the application. See below.

Pressure Drop Recommendations For Steam Valves

Low Pressure Steam - 15 psig or less

Two-Position Control

A valve chosen for this type of control can be line size (this will be the usual method of selection) or sized using 10% of inlet gauge pressure.

Note: Two-position valves will, at most, be a size smaller than the line unless the line is grossly oversized.

Applications: Control of a zone or an entire building using radiators, convectors, unit heaters and similar equipment.

Room control of radiators, convectors, fan coil units, etc.

Discharge control of convectors can be used where there is considerable storage of hot water. A two-position valve can be used in this application.

Proportional Control

The pressure drop should be based on 80% of the inlet gauge pressure.

For example, a 5 psig system inlet pressure should have a valve sized on a 4 psi drop.

Note: The proportional valve will be at least a size smaller than line size and may be two (or more) sizes smaller if selected for a proper pressure drop.

Applications: Room control of a radiator, fan coil unit, unit ventilator, or air handling unit with constant air circulation.

System Examples

Air handling units with 100% outside air passed over coil:

For these applications, care must be taken to insure that the condensate will not freeze. Coils should be selected to minimize stratification and must be of some type of “non-freeze” construction. Preheat and reheat coils with face and by-pass dampers are almost always used with this type of system, with the valves fully open at 40°F. Another practice is to use two valves, splitting the total flow in terms of 1/3 and 2/3 capacity. This combination reduces valve wear and costs less than one larger valve. The valve combination should have the capacity to bring the air up to between 38° and 40°F when supplied with outside air at design temperature. When outside air is below freezing, this valve combination should move towards the full open position.

Alarm thermostats, low limit thermostats, aquastats placed on the condensate returns, connected to close off the outside air dampers and shut off the fan, should be utilized to insure against coil freeze-up. In no case should a system of this type be controlled from a room thermostat without a low limit discharge thermostat. A discharge controller will normally be used to control the valve.

Steam to water convertors have a valve on the steam line to the convertor controlled by a discharge immersion thermostat on the leaving water line. For domestic water application such as shower rooms, dishwashing, etc., use only discharge control. When water is used for space heating, the leaving water temperature can be reset by an outdoor controller.
Instantaneous or low storage convertor controls require care in application. A high pressure drop should be used to select the valve. Steam convertor capacity is usually sensitive to the pressure within the convertor, so be certain that the valve pressure drop is not too large to prevent the convertor from developing full capacity. The initial steam supply pressure must allow for the pressure drop used in selecting the valve and still leave enough for full convertor capacity. For example, if the convertor requires 15 psig steam to develop full capacity, the valve should be fed with 37 psig steam to allow the convertor full capacity. See High Pressure Steam Applications in the next section, “Outlet Pressure Limitation - Convertors”.

High Pressure Steam - Greater Than 15 psig

Two-Position Control

A valve chosen for this type of control can be line size or sized using 10% of inlet gauge pressure.

Note: This is the same as sizing a valve for two-position low pressure steam.

For high inlet pressure steam greater than 35 psig, use stainless or other hard trim. The pressure drops chosen will be the same as in other two-position high pressure steam applications.

Proportional Control

These valves should be sized using a ΔP of 42% of the inlet absolute pressure. For example, for 40 psig steam, the valve should be sized for a 23 psi drop.

Sizing Table Method

Use Steam Valve Sizing Table shown in Appendix D. Note that the numbers in the body of the table are lbs. of steam per hour of saturated steam. The pressure drops for listed inlet gauge pressure are 10% and 80% for low pressure steam (through 15 psig). Pressure drops for higher pressure steam are given as 10% of gauge and 42% (of absolute inlet) pressure.

Formula Method

\[ Cv = \frac{QK}{3 \sqrt{\Delta P \times P_2}} \]

\[ Q_v = \frac{3 \cdot Cv \sqrt{\Delta P \times P_2}}{K} \]

Where:

- \( Q \) = Lbs. per hour steam
- \( \Delta P \) = Pressure drop psi
- \( P_2 \) = Outlet pressure in psia (absolute)
- \( K = 1 + (.0007 \times ^\circ F \text{ super heat}) \)

Note: K normally is 1 (saturated steam)

Valve Sizing Chart

Using the chart (Appendix C) may not be as rapid as using a valve sizing table or the formula shown above. However, it offers a method of choosing between two valve sizes if none of the valve sizes available have the Cv found. It also allows an easy method for determining actual ΔP once a Cv is selected.

Critical Pressure for Inlet Steam Pressure Greater Than 15 psig

Do not size steam valves using a pressure drop greater than 42% of the absolute inlet pressure. This is called the critical pressure drop.

\[ \begin{align*}
\text{PSIG (Gauge Pressure)} & + 14.7 \\
\text{PSIA (Absolute Pressure)} & \\
\end{align*} \]

Pressure drops larger than the critical pressure drop will cause a significant decrease in steam capacity through the valve since steam flow characteristics will then become the flow limiting factor. Do not exceed the pressure drop recommended for the valve selected (see valve data, Controls Catalog F-16650).

Outlet Pressure Limitation - Convertors

When sizing valves for convertors, some care must be taken to make sure that the outlet pressure at the valve, when full open, is great enough to provide a sufficient pressure to the convertor so that it can provide enough heat to do the job. If the valve is sized too small, the convertor cannot provide its full output. The best solution is to subtract the convertor pressure from the inlet pressure. The difference is the maximum pressure drop across the valve.

Steam Valve Selection

Selection of the specific valve and actuator comes after the proper sizing of the control valve - determining the pressure drop and calculating the Cv. The following questions need to be answered so as to complete the selection process:

- Is tight shut-off required?
- Fluid pressure and temperature limitations?
- Flow characteristics needed?
- Body pattern required?
- Selection of actuator?
- Close-off rating?

Note: Actuators with sufficient force available must be used to meet close-off requirements for valve. Specific close-off rating tables for actuator/body combinations are located in the Controls Catalog F-16650.

- Ambient temperature at actuator?
- Valve size?
- Positive positioner requirement?

The above information for specific Schneider Electric valves is found in the valve data information (see Controls Catalog F-16650).

Summary

There are many more types of control systems than shown in this document. Most of these are variations on the systems already described. Using the basic information on when to use
high or low pressure drops and valve characteristics described, the controls engineer can make the correct selection of the control valve on those applications not shown.

APPENDIX

Appendix A

Instructions For Using Water Valve Sizing Chart
(See following page)

This chart is based on water at 60°F and for sizing Schneider Electric valves for water flow. Flow coefficients (Cv’s) for valve bodies are given in the valve data (Controls Catalog F-16650).

To Determine Water Valve Size When Pressure Drop and Flow Rate are Known

1. Place a straight edge from pressure drop scale at known pressure point to flow rate in gpm on gpm scale.
2. Read Cv at intersection of Cv scale and straight edge.
3. Select valve size having the closest Cv rating. If valve size is smaller than the chosen Cv, check to see what actual ΔP will result. Use the smaller valve size if actual ΔP is acceptable.

EXAMPLE: To select a three-way mixing valve for proportioning service to pass 23 gpm with 5 psi drop.

1. Set straight edge at 5 psi on ΔP scale and 23 gpm on gpm scale.
2. Read Cv of 10.3 at intersection of straight edge and Cv scale.
3. Refer to valve data: 1" valve has Cv of 12 which has adequate capacity.

In some cases the required Cv falls midway between two valve sizes. Set Cv of smaller valve with gpm required on chart to solve actual pressure drop. With knowledge of actual drop, decision can be made on using valve if system pressures will allow the greater pressure drop. See limitations on valve pressure drop in Controls Catalog F-16650. Whenever possible, select smaller valve since greater pressure drops result in more satisfactory control.
Water Capacity Chart

Note: Chart is based on formula $Q = C_v \sqrt{\Delta P}$
$Q =$ U.S. GPM, $C_v =$ Flow Coefficient, $\Delta P =$ Pressure Drop in psi.
Instructions for Using Water Valve Sizing Table

The differential pressure (pressure drop) is expressed at the top row of the table. The Cv's (flow coefficients) are listed in the left column. Enter the table at the top using the pressure drop selected and move down into the body of the table to the gpm water flow rate. Then, move to the far left column marked Cv and read the Cv required for the application. See limitations on valve pressure drop in Controls Catalog F-16650.

Example: To select a two-way valve for proportioning service to pass 37 gpm with a 5 psi pressure drop.

1. Select a pressure drop of 5 psi.
2. Move down the column until a valve as close as possible to 37 gpm is located - in this case 36. Move to the far left column and read the Cv of 16. Refer to the valve data in the Controls Catalog F-16650 to select the properly sized valve. Note the limitations on valve pressure drop in the data.

Whenever possible, select the smaller of two possible valves since greater pressure drops result in more satisfactory control.

### WATER VALVE SIZING TABLE

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<thead>
<tr>
<th>Water Capacity in Gallons per Minute</th>
<th>Water Capacity in Gallons per Minute</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delta P (psi)</td>
<td>Cv</td>
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<tr>
<td>----------------</td>
<td>----</td>
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<tr>
<td>0.4</td>
<td>.75</td>
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<table>
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<tr>
<th>Delta P (psi)</th>
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</tbody>
</table>

Note: This table is based on water at 60°F.

*Cv corresponds to Schneider Electric valve offering.
Appendix C

Valve Sizing Chart - Saturated Steam
(see following page)

To size valves when steam is saturated and quantity, inlet pressure, and pressure drop are known:

1. Set straight edge on inlet pressure scale ($P_1$) and pressure drop scale ($\Delta P$) and mark intersection of straight edge on base line.
2. Set straight edge on base line mark and steam quantity on (#/hr) scale.
3. Read flow coefficient at intersection of straight edge and flow coefficient scale ($C_v$).
4. Select flow having same or greater coefficient. Valve $C_v$'s are shown on valve data sheets.

*Exception:* When $C_v$ required is between two valve sizes and closer to smaller valve size, re-calculate $C_v$ using 42% of absolute inlet pressure as a drop. If this re-calculated $C_v$ is smaller than the small valve $C_v$, use the small valve size. If re-calculated $C_v$ is larger than the small valve $C_v$, use the larger valve size.

Finding Proportional Steam Control Valve Size

Example: Given inlet saturated steam pressure of 5 psig and a load requiring 214 #/hr, find $C_v$ for proportional control valve using 80% of 5 psig as a pressure drop.

1. Set straight edge on inlet pressure scale (5 psig) and pressure drop scale (4 psi). Mark intersection of straight edge with base line (see dotted lines).
2. Set straight edge on base line mark and steam quantity on #/hr scale (214 #/hr).
3. Read valve $C_v$ on intersection of straight edge and $C_v$ scale $C_v = 9$.
4. Locate specific valve body in valve data in Controls Catalog F-16650.
### STEAM CAPACITY IN POUNDS PER HOUR

**NOTE:** Table is based on saturated steam.

<table>
<thead>
<tr>
<th>Inlet Pressure PSIG</th>
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Appendix D

Instructions for Using Steam Valve Sizing Table

Enter the table at the inlet pressure row at the top and move down under the pressure drop selected into the body of the table to locate the steam quantity. Move right to the Cv column for the required Cv. The final step is to check the valve data sheet for a valve having a Cv close to the required Cv. If the required Cv falls between two valve sizes, a choice must be made based on the application.
Appendix E

Table-1 Vapor Pressure of Water

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Appendix F

Heating and Cooling Formulas

Steam Coil

Condensing Capacity of a Steam Coil:

Steam in lb per hr = \(\frac{\text{Coil heat load, air (Btu per hr)}}{\text{Latent heat of steam in Btu per lb}}\)

= \(\frac{\text{cfm x 60 x weight per cu ft x sp ht x (T - T_0)}}{970}\)

= \(\frac{\text{cfm x 1.08 x (T - T_0)}}{970}\)

= \(\frac{\text{cfm x (T - T_0)}}{890}\)

= \(\frac{\text{cfm x } \Delta T}{890}\)

Equivalent Direct Radiation (EDR):

EDR = Btu/240

lb per hr = EDR/4

Hot Water Coil

Capacity of Hot Water Coil:

\(\text{gpm} = \frac{\text{Coil heat load, air (Btu per hr)}}{\text{Sensible heat, hot water (Btu per gal)}}\)

\(= \frac{\text{cfm x 1.08 x (T - T_0)}}{890}\)

= \(\frac{\text{cfm x 1.08 x (T - T_0)}}{890}\)

Equivalent Direct Radiation (EDR):

EDR = Btu/150

Chilled Water Coil

Capacity of Chilled Water Coil:

\(\text{gpm} = \frac{\text{Total cooling load, air (Btu per hr)}}{\text{Sensible heat, chilled water (Btu per gal)}}\)

= \(\frac{(H_1 - H_2) \times \text{cfm x .075} \times 60}{(T_1 - T_2) \times 500}\)

Properties of Air

Sensible Heat (Air): Btu per hr = \(\text{cfm x 1.08 x (T - T_0)}\)

Latent Heat (Air): Btu per hr = \(\text{cfm x 0.68 x gr per lb std air}\)

Number Air Changes (N) /Hour: \(\text{N} = \frac{60 \times \text{cfm}}{\text{cu ft of space}}\)

Heat Exchangers (Steam to Water)

Steam lb per hr = \(\frac{\text{Sensible heat of water (Btu per hr)}}{\text{Latent heat of steam (Btu per lb)}}\)

= \(\frac{\text{gpm x 60 x weight per gal x (T_1 - T_2)}}{970}\)

= \(\frac{\text{gpm x 408 x (T_1 - T_2)}}{970}\)

= 0.5 x gpm x (T_1 - T_2)

= 0.5 x gpm x \(\Delta T\)

Heat Exchangers (Water to Water)

Water Btu per hr = \(\frac{\text{Sensible heat of water (Btu per hr)}}{\text{Water to Water}}\)

= \(\frac{\text{gpm x 60 x weight per gal x (T_1 - T_2)}}{970}\)

= \(\frac{\text{gpm x 60 x 8.34 x (T_1 - T_2)}}{970}\)

= \(\frac{\text{gpm x 500 x (T_1 - T_2)}}{970}\)

Terms

\text{cfm} = \text{Cubic feet of air per minute passing through the coil.}

\text{Weight per cu ft sp ht} = \text{Weight of 1 pound (.075).}

\text{Btu required to raise the temperature of 1 lb of air 1°F (.24).}

\text{T_0} = \text{Temperature of air entering coil, in °F.}

\text{T} = \text{Temperature of air leaving coil, in °F.}

\text{1 EDR = 240 Btu per hour.}

\text{Enthalpy of entering air.}

\text{1 cu ft water = 62.4 lbs}

\text{1 M.B.H. = 1000 Btu/hr}

Conversion Factors

1 lb / sq. in. = 2.04 in. mercury

1 lb / sq. in. = 2.3 ft. water

1 lb / sq. in. = 27.7 in. water

1 U.S. gallon water = 8.33 lbs

1 cu ft water = 62.4 lbs

1 cu ft water = 7.5 U.S. gallons

1 U.S. gallon water = 0.83 Imperial gallon

1 M.B.H. = 1000 Btu/hr
Glossary

Absolute Pressure 14.7 psi + gauge pressure (psi).

Ambient Temperature Rating Temperature surrounding an actuator or valve body.

Angled Body A two-way valve body that has end fittings at right angles to each other.

Booster Pump Pump used in secondary loops of hydronic systems to raise pressure for that section of the system.

Capacity Index See Flow Coefficient, Cv.

Cavitation The forming and imploding of vapor bubbles in a liquid due to decreased, then increased, pressure as the liquid flows through a restriction.

Contoured Plug Shaped end of valve disc that controls the flow of the medium through the valve. Used for smaller sized equal percentage valves.

Controlled Medium Whatever fluid is being controlled - hot water, chilled water or steam.

Close-Off Rating Maximum allowable pressure drop (inlet to outlet) that the valve body will tolerate when fully closed. The power available from the actuator usually determines the close-off rating.

Critical Pressure Drop The pressure drop across a valve which causes the maximum possible velocity of steam though the valve.

Design Conditions Space temperature conditions that require the full heating or cooling requirements of a system.

Diverting Valve Three-way valve that has one inlet and two outlets. Water entering the inlet port is diverted to either of the two outlet ports in any proportion desired by moving the valve stem.

End Fitting Part of the valve body that connects to the piping. Union, screwed, flared, sweat, and flanged are typical examples of end fittings.

Equal Percentage Valve Equal changes in the valve stem changes the existing flow by an equal percentage.

Flow Characteristic Relation between flow through the valve as the stem travel is varied between 0 and 100%.

Flow Coefficient, Cv The quantity of water, in gallons per minute at 60°F, that will flow through a given valve with a pressure drop of 1 psig. (Also called capacity index.)

Flow Rate The amount of fluid passing a given point per unit of time. Units are gallons per minute (gpm) for water and pounds per hour for steam.

Full Port Maximum flow capacity possible for particular end fitting size.

Gauge Pressure Pounds per square inch (psi) as read on a gauge.

GPM Gallons per minute.

Load The demand on the mechanical equipment in a HVAC system.

Load Change A change in building heating or cooling requirements as a result of lights, machinery, people, outside air temperature variations, solar effect, wind, etc.

Mixing Valve Three-way valve, has two inlets and one outlet. The proportion of the fluid entering each of the two outlets can be varied by moving the valve stem. Not suitable for diverting applications.

Monoflo* Fittings Connect rises to main, diverts water to heating units for single pipe systems. (*Trademark of the Bell & Gossett Co.)

Normally Closed (N.C.) Condition of the valve upon a loss of power or control signal to the actuator.

Normally Open (N.O.) Condition of the valve upon a loss of power or control signal to the actuator.

Packaging Material used to seal the valve stem so that the controlled medium will not leak. Teflon “V” rings and graphite rings are typical materials used.

Port Flow controlling opening between the seat and disc when the valve is wide open.

Positive Positioner Device that eliminates the actuator shaft positioning error due to load on the valve or damper.

Pressure Drop (ΔP) The difference in pressure between inlet and outlet of a control valve.

PSI Pounds per square inch.

PSIG Pounds per square inch gauge.

Rangeability Ratio of maximum to minimum controllable flow.

Reduced Port Smaller flow capacity that is possible for particular end fitting. See Full Port.

Saturated Steam The maximum amount of vapor that can exist at a specific temperature and pressure.

Seat The stationary portion of the valve which, when in contact with the movable portion (valve disc, stem, etc.), stops flow completely.

Self-contained Valve Terminal control valves that derive all of the energy to open or close from the sensed ambient temperature.

Static Pressure Rating Maximum pressure (inside to outside the body) that valve will tolerate before leaking. Pressure varies with temperature.

Stem The cylindrical shaft which is moved manually or by an actuator and to which the throttling plug is attached.

Straightway Body A two-way valve body that has end fittings on opposite sides.

Stroke The total distance a valve stem travels or moves. Also known as lift.

Superheated Steam Steam at a temperature higher than saturation temperature at the given pressure.

System Pressure Drop (ΔP) The difference in pressure between supply and return mains in a hydronic system.

Three-Way Valve Valve with one inlet and two outlets or two inlets and one outlet. See Mixing or Diverting Valves.

Trim All parts of the valve which are in contact with the fluid agent but are not part of the valve shell or casting. Disc, stem, throttling range packing rings, etc., are all trim components.
**Turndown** Ratio between maximum usable flow and minimum controllable flow. The ratio is usually less than rangeability.

**Two-Way Valve** Valve with single flow path - one inlet and one outlet.

**Valve** A controlled device which will vary the rate of flow of a controlled agent such as water or steam.

**Valve Body** The portion of the valve through which the controlled agent flows.

**Valve Disc** A movable part of the valve which makes contact with the valve seat when the valve is closed. Typical disc materials used are teflon and composition.

**Valve Guide** The part of the valve throttling plug which keeps the disc aligned with the valve seat.

**Valve Size** See Flow Coefficient, Cv. Sometimes referred to as end fitting size - 1/2", 1", 1-1/4", etc.

**Wiring Drawing** A small eroded area or thin slit on a valve seat or plug. This is the result of a high velocity fluid acting on the surfaces when the valve is just above the seat.

**Zone Valve** Terminal control valve for a zone loop of radiation.