Control Valve Sizing
Application Information

Table of Contents

Appendices

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.

A valve is a controlled device that regulates the flow of hot water, chilled water or steam in a HVAC system. The regulation takes place by throttling the valve, varying its resistance to flow. System flow will vary as increasing valve resistance causes total system pressure drop to shift to the valve. The valve is in control when the pressure drop across it exceeds the pressure drop across the remainder of the system.

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.

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 (ΔP)** 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).

Control Valve Pressure Drop

The only variable normally available in sizing is the pressure drop (ΔP) 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 ΔP, 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:

$$C_V = \frac{GPM}{\sqrt{\Delta P}}$$

Where:

Cv = Flow coefficient
GPM = Flow in U.S. gallons per minute
ΔP = 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 ΔP. As stated earlier, the ΔP is usually the variable of choice, so we will also discuss recommendations for choosing ΔP at length after examining the GPM requirements of the coil.

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 (Δ(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 ΔP 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 ΔP 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% ΔP 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.

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.

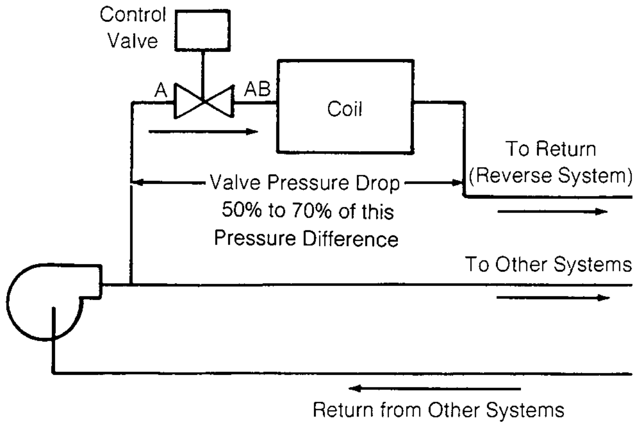


Figure-1

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.

Design Temperature Drop of Coil	Multiplier on Coil Pressure Drop
20°F	3
40°F	2
60°F or more	1

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).

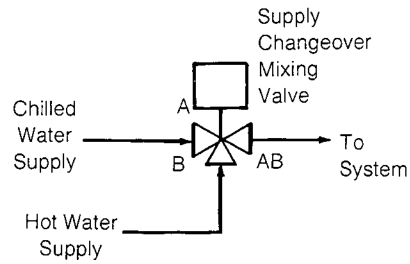


Figure-2

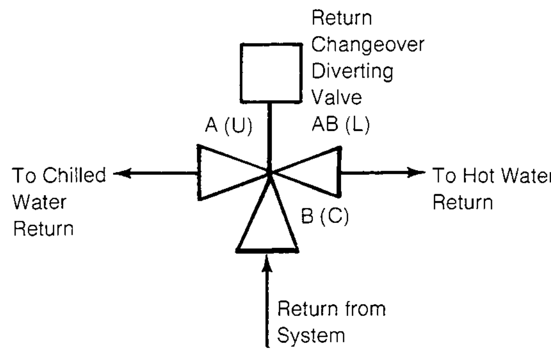


Figure-3

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).

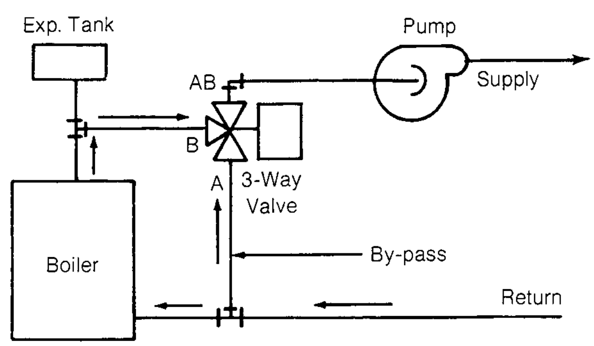


Figure-4

Proportional Temperature — Constant

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.

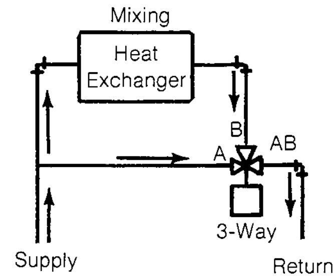


Figure-5 Three-Way Mixing Valve on "By-Pass" Application.

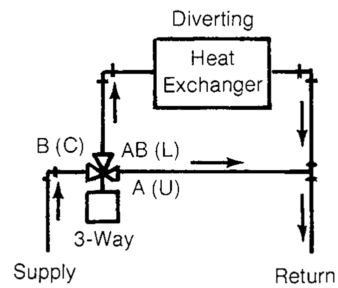


Figure-6 Three-Way Diverting Valve on "By-Pass" Application.

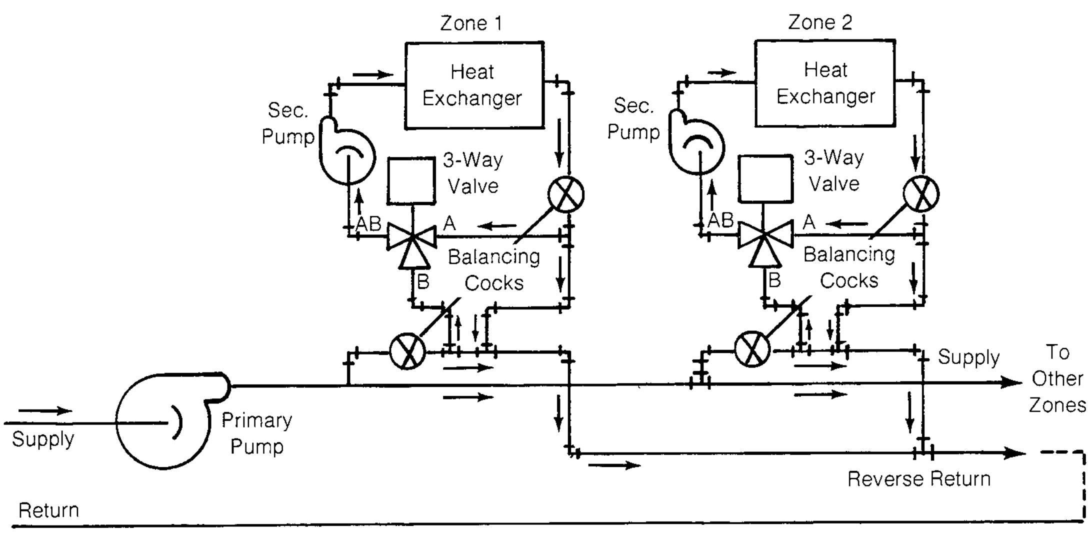


Figure-7 Primary-Secondary Systems.

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:

$Pm = 0.5 (P_1 - Pv)$

Pm = Maximum allowable pressure drop

P_1 = Absolute inlet pressure (psia)

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

Pv = Absolute vapor pressure (see Vapor Pressure or Water Table in Appendix E or Steam Table)

For example, if a valve is controlling 200°F water at an inlet pressure of 18 psig, the maximum pressure drop allowable would be:

$$Pm = 0.5 [(18 + 14.7) - 11.53] = 10.6 \text{ psi}$$

(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 ∆P 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

$$C_V = \frac{QK}{3\sqrt{\Delta P \times P2}}$$

$$Q_V = \frac{3\ Cv\ \sqrt{\Delta P \times P2}}{K}$$

Where:

Q = Lbs. per hour steam

∆P = Pressure drop psi

P_2 = Outlet pressure in psia (absolute)

K = 1 + (.0007 x °F 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 ∆P 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.

PSIG (Gauge Pressure)
+ 14.7
PSIA (Absolute Pressure)

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

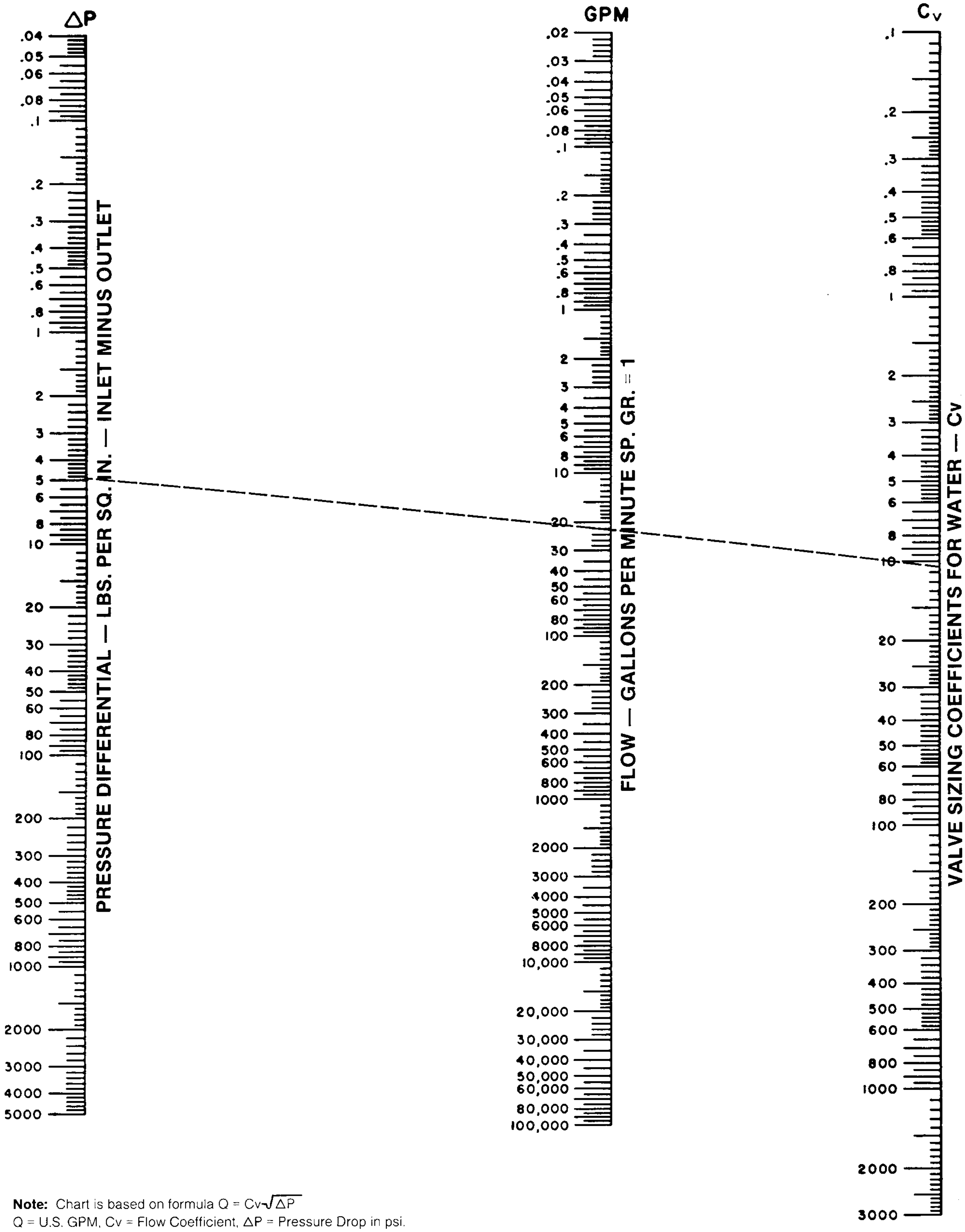
1. Place a straight edge from pressure drop scale at known pressure point to flow rate in gpm on gpm scale.
2. Read Cv at intersection of Cv scale and straight edge.
3. Select valve size having the closest Cv rating. If valve size is smaller than the chosen Cv, check to see what actual ΔP will result. 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 $Q = Cv\sqrt{\Delta P}$
Q = U.S. GPM, Cv = Flow Coefficient, ΔP = Pressure Drop in psi.

Appendix B

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

Water Capacity in Gallons per Minute

Cv* \ ΔP	2	3	4	5	10	15	20	25	30	35
.4	.57	.69	.80	.89	1.26	1.55	1.79	2.0	2.2	2.4
.95	1.3	1.7	1.9	2.12	3.0	3.7	4.3	4.8	5.2	5.6
1.3	1.8	2.2	2.6	2.9	4.1	5.0	5.8	6.5	7.1	7.7
1.4	2.0	2.4	2.8	3.1	4.4	5.4	6.3	7.0	7.7	8.3
1.7	2.4	2.9	3.4	3.8	5.4	6.6	7.6	8.5	9.3	10.1
1.8	2.5	3.1	3.6	4.0	5.7	7.0	8.1	9.0	9.9	10.7
2	2.8	3.5	4.0	4.5	6.3	7.8	8.9	10	11	12
2.2	3.1	3.8	4.4	4.9	7.0	8.5	9.8	11	12	13
2.4	3.4	4.2	4.8	5.4	7.6	9.3	10.7	12	13	14
2.5	3.5	4.3	5.0	5.6	7.9	10	11	13	14	15
3.3	4.7	5.7	6.6	7.4	10.4	13	15	17	18	20
3.6	5.1	6.2	7.2	8.1	11.4	14	16	18	20	21
3.8	5.4	6.6	7.6	8.5	12.0	15	17	19	21	22
4	5.7	6.9	8.0	8.9	12.7	15	18	20	22	24
5	7.1	8.7	10	11	15	19	22	25	27	30
5.5	7.9	9.5	11	12	17	21	25	28	30	33
6	8.5	10.4	12	13	19	23	27	30	33	36
6.2	8.8	10.7	12	14	20	24	28	31	34	37
6.8	9.6	11.8	14	15	22	26	30	34	37	40
7.4	10.5	12.8	15	17	23	29	33	37	41	44
7.5	10.6	13.0	15	17	24	29	34	38	41	44
8	11.3	13.9	16	18	25	31	36	40	44	47
8.2	11.6	14.2	16	18	26	32	37	41	45	49
8.5	12.0	14.7	17	19	27	33	38	43	47	50
9	12.7	15.6	18	20	28	35	40	45	49	53
10.5	15	18	21	23	33	41	47	53	58	62
11	16	19	22	25	35	43	49	55	60	65
12	17	21	24	27	38	46	54	60	66	71
15	21	26	30	34	47	58	67	75	82	89
16	23	28	32	36	51	62	72	80	88	95
17.4	25	30.1	35	39	55	67	78	87	95	104
25	35	43	50	56	79	97	112	125	137	148
30	42	52	60	67	95	116	134	150	164	177
33	47	57	66	74	104	128	148	165	181	195
35.8	51	62	72	80	113	139	160	179	196	212
40	57	69	80	89	126	155	179	200	219	237

Water Capacity in Gallons per Minute

Cv* \ ΔP	2	3	4	5	10	15	20	25	30	35
42	59	73	84	94	133	163	188	210	230	248
45	64	78	90	101	142					
55	78	95	110	123	174	213	246	275	301	325
56	79	97	112	125	177					
68	96	118	136	152	215	263	250	340	372	402
70	99	121	140	157	221	271	313	350	383	414
74	105	128	148	165	234	287	331	370	405	438
75	106	130	150	168	237	290	335	375	411	444
85	120	147	170	190	269	329	380	425	466	503
100	141	173	200	224	316					
101	143	175	202	226	319	391	452	505	553	598
115	163	199								
145	205	251	290	324	459	562	648	725	794	858
160	226	277	320	358	506	620	716	800	876	947
170	240	294	340							
195	276	338	390	436	617	755	872	975	1068	1154
200	283	346	400	447						
235	332	407	470	525	743	910	1051	1175	1287	1390
250	354	433	500	559	791	968	1118	1250	1369	1479
275	389	476	550							
290	410	502	580	648	917	1123	1297	1450	1588	1716
350	495	606	700	783	1107	1356	1565	1750	1917	2071
390	552	676	780	872	1233	1510	1744	1950	2136	2307
425	601	736	850							
440	622	762	880	984	1391	1704	1968	2200	2410	2603
640	905	1108	1280							
680	962	1178								
1125	1591	1949	2250							
1150	1626	1992	2300							
1750	2475	3031	3500							
1850	2616	3204	3700							
2600	3677	4503	5200							
2650	3748	4590								
3400	4808	5889								
4500	6364									

Note: This table is based on water at 60F.
* 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 (ΔP) 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 (Cv).
4. Select flow having same or greater coefficient. Valve Cv's are shown on valve data sheets.

Exception: When Cv required is between two valve sizes and closer to smaller valve size, re-calculate Cv using 42% of absolute inlet pressure as a drop. If this re-calculated Cv is smaller than the small valve Cv, use the small valve size. If re-calculated Cv is larger than the small valve Cv, 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 Cv 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 Cv on intersection of straight edge and Cv scale Cv = 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

Inlet Pressure PSIG	2#		5#		10#		15#		20#		25#		40#		50#		75#		100#	
C_V \ ΔP	.2	1.6	.5	4	1	8	1.5	12	2	14	2.5	16	4	23	5	27	7.5	37	10	48
.4	2.2	5.9	3.7	9.5	5.9	13.9	7.8	17.5	9.7	20.4	11.6	23.4	17.1	32.4	20.7	38.3	29.8	53	38.8	68
.95	5.2	14	8.8	22.6	13.9	32.9	18.5	41.5	23	48.5	27.5	55.5	40.6	77	49.2	90.9	70.8	126	92.2	161
.99	5.4	14.6	9.2	23.5	14.5	34.3	19.3	43.3	24	50.6	28.6	57.8	42.3	80.2	51.3	94.8	73.7	131	96.1	168
1.1	6	16.2	10.2	26.2	16.1	38.1	21.5	48.1	26.7	56.2	31.8	64.3	47	89.1	57	105.3	81.9	146	106.8	187
1.3	7.1	19.2	12.1	31	19	45.1	25.4	56.8	31.5	66.4	37.6	75.9	55.5	24.3	67.4	124.4	96.8	172	126.2	221
1.8	9.8	27	18.7	43	26.3	62.4	35.1	78.7	43.7	91.9	52.1	105.2	76.9	145.8	93.3	172.3	134.1	238	174.7	306
2.2	12	32.4	20.4	52	32	76	43	96	53	112	63.6	128.5	94	178	114	210.6	164	291	213.6	373
2.5	13.6	37	23	59	37	87	49	109	61	128	72	146	107	203	130	239	186	331	243	424
3.3	18	49	31	79	48	114	64	144	80	169	95	193	141	267	171	316	246	437	320	560
3.6	19.6	53	34	86	53	125	70	157	87	184	104	210	154	292	187	345	268	477	349	611
3.8	20.7	56	35	90	56	132	74	166	92	194	110	222	162	308	197	364	283	503	369	645
4.0	22	59	37	95	58	139	78	175	47	204	116	234	171	324	207	383	298	530	388	679
5	27	74	47	119	73	173	98	219	121	255	145	292	214	405	259	479	372	662	485	848
5.5	30	81	51	131	80	191	107	240	1334	281	159	321	235	446	285	526	410	728	534	934
6	33	89	56	143	88	208	117	262	146	306	174	351	256	486	311	574	447	795	582	1018
6.2	34	91	58	147	91	215	121	271	150	317	179	362	265	502	321	593	462	821	602	1052
7.4	40	109	69	176	108	257	144	324	180	378	214	432	316	599	384	708	551	980	718	1256
7.5	41	111	70	178	110	260	146	328	182	383	217	438	320	608	389	718	559	994	728	1273
8.2	45	121	76	195	120	284	160	359	199	419	237	479	350	664	425	785	811	1086	796	1392
8.5	46	125	79	202	124	295	166	372	206	434	246	497	363	689	441	814	633	1126	825	1443
9.0	49	133	84	214	131	312	176	393	218	460	260	526	385	729	466	861	670	1192	874	1528
10.5	57	155	98	250	153	364	205	459	255	536	304	613	449	851	544	1005	782	1391	1019	1782
11	60	162	102	262	161	381	215	481	267	562	318	643	470	891	570	1053	819	1457	1068	1867
15	82	221	139	357	219	520	293	656	304	766	434	876	641	1215	777	1436	1117	1987	1456	2546
16	87	236	149	380	234	555	312	700	388	817	463	935	684	1296	829	1531	1192	2120	1553	2716
17.4	95	257	162	414	254	603	340	761	422	889	503	1016	743	1409	902	1665	1296	2305	1689	2954
25	136	369	232	594	365	867	488	1093	607	1277	723	1460	1068	2025	1296	2393	1862	3312	2427	4244
35.8	195	528	333	851	523	1241	699	1565	867	1828	1036	2091	1529	2900	1856	3427	2667	4742	3475	6077
40	218	590	372	951	584	1387	780	1749	970	2043	1157	2337	1709	3240	2073	3829	2980	5299	3883	6790
45	245	664	418	1070	657	1560	878	1967	1092	2298	1302	2629	1923	3645	2332	4307	3352	5961	4368	7639

STEAM CAPACITY IN POUNDS PER HOUR

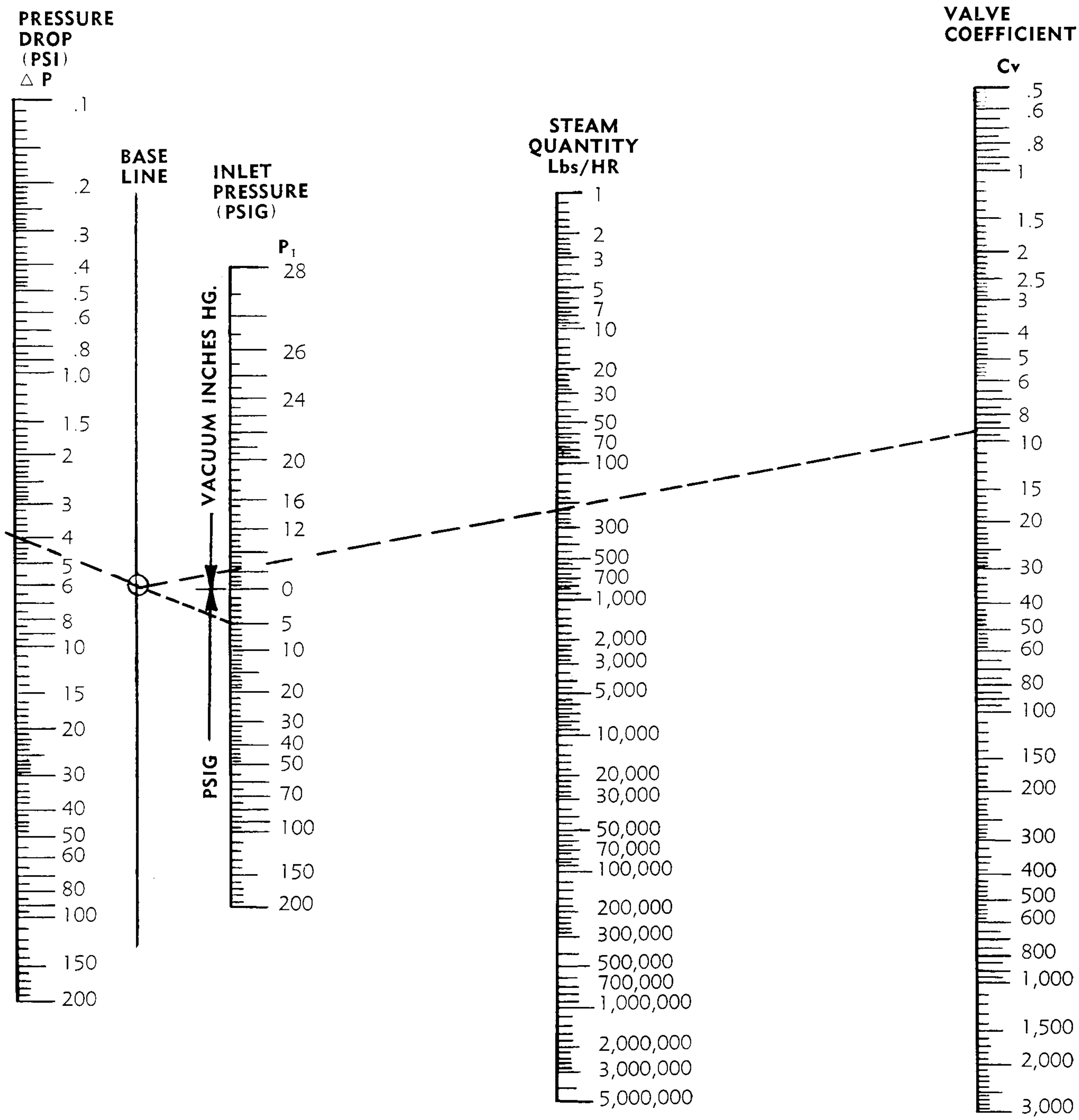
NOTE: Table is based on saturated steam

Inlet Pressure PSIG	2#		5#		10#		15#		20#		25#		40#		50#		75#		100#	
ΔP / C_v	.2	1.6	.5	4	1	8	1.5	12	2	14	2.5	16	4	23	5	27	7.5	37	10	48
56	305	826	521	1331	818	1942	1093	2448	1359	2860	1620	3271	2392	4536	2903	5360	4171	7418	5436	9506
70	381	1032	651	1664	1022	2427	1366	3061	1698	3575	2025	4089	2991	5670	3628	6670	5214	9273	6795	11882
75	409	1106	697	1783	1095	2601	1463	3279	1820	3830	2170	4381	3204	6075	3887	7179	5587	9935	7280	12731
85	463	1253	790	2021	1241	2947	1658	3716	2062	4341	2459	4966	3631	6885	4406	8136	6332	11260	8251	14429
100	545	1475	930	2377	1460	3468	1951	4372	2426	5107	2893	5842	4272	8101	5183	9571	7449	13247	9707	16975
115	627	1696	1069	2734	1680	3988	2244	5028	2790	5873	3327	6718	4913	9316	5961	11007	8566	15234	11163	19521
145	790	2138	1348	3447	2118	5028	2829	6340	3518	7405	4195	8471	6195	11746	7516	13878	10801	19208	14075	24613
170	926	2507	1580	4042	2483	5895	3317	7433	4124	8682	4918	9931	7263	13771	8811	16271	12663	22519	16502	28857
200	1090	2949	1859	4755	2921	6935	3902	8744	4852	10214	5786	11684	8544	16201	10366	19143	14898	26494	19414	33950
235	1281	3465	2184	5587	3432	8149	4585	10275	5701	12002	6799	13729	10040	19036	12180	22493	17505	31130	22812	39891
275	1499	4055	2556	6538	4016	9536	5366	12024	6672	14044	7956	16065	11749	22277	14254	26321	20484	36429	26695	46681
350	1907	5161	3253	8321	5112	12136	6829	15303	8491	17875	10126	20447	14953	28352	18141	33500	26071	46264	33975	59412
425	2316	6267	3950	10104	6207	14737	8292	18582	10311	21705	12296	24828	18157	34427	22028	40678	31658	56300	41256	72143
440	2398	6488	4090	10461	6426	15257	8585	19238	10675	22471	12730	25704	18798	35642	22806	42114	32775	58287	42712	74689
640	3488	9437	5949	15215	9347	22192	12487	27982	15527	32685	18516	37388	27342	51844	33172	61257	47672	84781	62126	108639
680	3706	10027	6321	16166	9931	23579	13268	29731	16498	34728	19673	39725	29051	55084	35245	65085	50652	90080	66009	115429
1125	6131	16589	10457	26746	16430	39010	21950	49187	27294	57454	32547	65722	48063	91131	58310	107678	83799	149029	109206	190967
1150	6267	16958	10689	27340	16796	39877	22438	50280	27900	58731	33271	67182	49131	93156	59606	110071	85661	152341	111633	195210
1750	9537	25805	16267	41604	25558	60682	34145	76513	42457	89373	50629	102234	74764	141760	90705	167499	130354	231823	169876	297059
1850	10082	27280	17196	43982	27019	64150	36096	80885	44883	94481	53522	108076	79036	149860	95888	177070	137803	245070	179583	314034
2600	14169	38339	24167	61812	37972	90157	50730	113677	63079	132783	75220	151890	111078	210614	134762	248855	193669	344422	252388	441345
2650	14442	39076	24632	63001	38703	91890	51706	115863	64292	135337	76667	154811	113214	214665	137353	253641	197394	351046	257241	449832
3400	18529	50136	31604	80831	49656	117897	66339	148654	82488	173640	98365	198625	145256	275419	176227	325426	253260	450398	330045	577143
4500	24524	66356	41828		65722		87802		109175		130189									
5400	29429	79628	50194		78866		105362													
7000	38148		65066		102234															
10000	54498		92952																	

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

Water Temperature °F	Vapor Pressure psia	Water Temperature °F	Vapor Pressure psia
40	0.12	140	2.89
50	0.18	150	3.72
60	0.26	160	4.74
70	0.36	170	5.99
80	0.51	180	7.51
90	0.70	190	9.34
100	0.95	200	11.53
110	1.28	210	14.12
120	1.69	220	17.19
130	2.22	230	20.78

Appendix F

Heating and Cooling Formulas

Steam Coil

Condensing Capacity of a Steam Coil:

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

$$= \frac{\text{cfm} \times 60 \times \text{weight per cu ft} \times \text{sp ht} \times (T - T_0)}{\text{Latent heat of steam in Btu per lb}}$$

$$= \frac{\text{cfm} \times 60 \times .075 \times .24 \times (T - T_0)}{970}$$

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

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

$$= \frac{\text{cfm} \times \Delta T}{890}$$

Equivalent Direct Radiation (EDR):

EDR = Btu/240

lb per hr = EDR/4

Hot Water Coil

Capacity of Hot Water Coil:

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

$$= \frac{\text{Coil heat load, air (Btu per hr)}}{(T_3 - T_1) \times 60 \times 8.34 \text{ lb per gal}}$$

$$= \frac{\text{cfm} \times 1.08 \times (T - T_0)}{(T_3 - T_1) \times 500}$$

Equivalent Direct Radiation (EDR):

EDR = Btu/150

Chilled Water Coil

Capacity of Chilled Water Coil:

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

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

Properties of Air

Sensible Heat (Air): Btu per hr = cfm x 1.08 x $(T - T_0)$
Latent Heat (Air): Btu per hr = cfm x 0.68 x gr per lb std air
Number Air Changes (N) /Hour: $N = \frac{60 \times \text{cfm}}{\text{cu ft of space}}$

Heat Exchangers (Steam to Water)

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

$$= \frac{\text{gpm} \times 60 \times \text{weight per gal} \times (T_1 - T_2)}{\text{Latent heat of steam (Btu per lb)}}$$

$$= \frac{\text{gpm} \times 60 \times 8.0 \times (T_1 - T_2)}{970}$$

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

$$= 0.5 \times \text{gpm} \times (T_1 - T_2)$$

$$= 0.5 \times \text{gpm} \times \Delta T$$

Heat Exchangers (Water to Water)

Water Btu per hr = Sensible heat of water (Btu per hr)

$$= \text{gpm} \times 60 \times \text{weight per gal} \times (T_1 - T_2)$$

$$= \text{gpm} \times 60 \times 8.34 \times (T_1 - T_2)$$

$$= \text{gpm} \times 500 \times (T_1 - T_2)$$

Terms

cfm	= Cubic feet of air per minute passing through the coil.
Weight per cu ft	= Weight of 1 pound (.075).
sp ht	= Btu required to raise the temperature of 1 lb of air 1°F (.24).
T_0	= Temperature of air entering coil, in °F.
T	= Temperature of air leaving coil, in °F.
1 EDR	= 240 Btu per hour.
T_1	= Temperature of water leaving coil, in °F.
T_2	= Temperature of water entering coil, in °F.
EDR	= Emission 150 Btu per hour.
H_1	= Enthalpy of entering air.
H_2	= Enthalpy of leaving air.
.075	= Specific weight of standard air in lb per cu ft

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 value 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.

Packing 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 flow 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.

F-13755-5

Schneider Electric
1354 Clifford Avenue
P.O. Box 2940
Loves Park, IL 61132-2940

www.schneider-electric.com/buildings

Schneider Electric