

## **V-CONTROL BALL VALVE SELECTION**

The control valve is the most important single element in any fluid handling system. This is because it regulates the flow of a fluid in the system. The automated valve is often referred to as the final control element, and is certainly the most important part of any piping system. The system will not operate at an efficient level without a properly sized valve. For valves that are too oversized, the results are poor controllability of the system and may cause the valve to hunt or cycle. Valves that are too undersized will require a larger pressure drop across the valve to maintain adequate flow and may not provide the required capacity. Undersizing a valve can cause the pump to work harder and make the valve susceptible to the effects of cavitation.

To properly select a control valve, it is helpful to have a general knowledge of fluid mechanics and of the components of the piping system. To select a V-Port or Round Port control valve for modulating service, you will need to have the following customer supplied information.

- > General description of the application
- > Media
- > Inlet Pressure
- > Temperature
- > Flow Rate (maximum, normal, minimum)
- > Pressure Drop or Outlet Pressure (maximum, normal, minimum)
- > Line Size
- > Specific Gravity of Media
- > Critical Pressure of Media

The key to remember is that valve sizing is not an exact science and that often you must select from the best options.

## **CALCULATE THE VALVE SIZE**

With the above information, the following steps are used to correctly size a valve in a piping system.

1. Cv value is obtained by using the appropriate ANSI/ISA-75.01.01 flow sizing formula or computer aided flow control sizing program that is based on these formulas.
2. Cavitation is checked by using the FL value (Liquid Pressure Recovery Factor), and the expansion factor needed for compressible fluids is obtained using the Xt values (Pressure Drop Ratio Factor). Both values are found in the Cv charts supplied on the following pages.
3. Select a nominal valve size from the Cv charts based on the calculated Cv.
  - > V-Port Ball Valves: Select a valve which offers calculated Cv for the minimum and maximum flow between 20% to 80% of port opening.
  - > Round Port Ball Valves: Select a valve which offers calculated Cv for the minimum and maximum flow between 30% to 80% of port opening.
4. Select the valve type (flanged, threaded or welded) and materials of construction.
5. Bray recommends Tek-Fil® valve seats for V-Ball Control Valve applications.
6. Select the actuator – for actuator sizing please see the Actuator Selection Guide, Technical Bulletin No. 1005 in the Actuation & Controls section of the Bray Product Manual.

Bray offers a computer aided flow control program to assist in selecting the proper control valve. The information required to operate the program is listed above. This program is available from the factory or your distributor.

## **SEAT MATERIAL OPTIONS FOR CONTROL VALVES**

- Tek-Fil®** A Bray registered trademark product. The seat includes TFM resin and special carbon/graphite fillers for enhanced performance. Exceptional chemical and heat resistance properties. Superior abrasion and wear resistance and has a low coefficient of friction for reduced valve torques. Service temperature range of -328°F to 550°F in modulating service and up to 650°F in on/off service.
- 50/50** Stainless Steel/PTFE. Combines the strength of metal with the lubricity of PTFE. 50% 316 stainless steel powder combined with 50% PTFE by weight / 15% SS by volume. Offers abrasion resistance of metal with higher pressure and temperature ratings than RPTFE. Service temperature range of -20°F to 500°F.
- PEEK** Polyetheretherketone. A high performance engineered thermoplastic. Excellent choice for high pressure and high temperature service. Offers excellent abrasion and corrosion resistance and is unaffected by continuous exposure to hot water or steam. Service temperature range of -70°F to 600°F.

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**V-CONTROL BALL VALVE FLOW COEFFICIENT Cv CHARTS**

| Standard Port - ¾" to 2½" Triad and Standard Port - 2" to 12" RF15/RF30 |                 |    |      |       |        |        |        |        |         |         |         |         |
|-------------------------------------------------------------------------|-----------------|----|------|-------|--------|--------|--------|--------|---------|---------|---------|---------|
| Percent and Angle of Ball Rotation                                      |                 |    |      |       |        |        |        |        |         |         |         |         |
| Valve Size<br>Inch                                                      | V-Port<br>Angle | 0% | 10%  | 20%   | 30%    | 40%    | 50%    | 60%    | 70%     | 80%     | 90%     | 100%    |
| ¾                                                                       | 15              | 0  | 0.02 | 0.08  | 0.20   | 0.28   | 0.44   | 0.71   | 0.86    | 1.20    | 1.52    | 1.81    |
| ¾                                                                       | 30              | 0  | 0.02 | 0.11  | 0.24   | 0.41   | 0.67   | 1.00   | 1.39    | 1.94    | 2.55    | 3.04    |
| ¾                                                                       | 60              | 0  | 0.02 | 0.13  | 0.36   | 0.55   | 0.97   | 1.55   | 2.23    | 3.56    | 5.01    | 6.74    |
| ¾                                                                       | 90              | 0  | 0.02 | 0.38  | 0.60   | 0.75   | 1.42   | 2.29   | 3.38    | 5.53    | 8.31    | 10.46   |
| 1                                                                       | 15              | 0  | 0.02 | 0.14  | 0.42   | 0.66   | 1.04   | 1.70   | 2.13    | 2.87    | 3.68    | 4.32    |
| 1                                                                       | 30              | 0  | 0.02 | 0.21  | 0.56   | 0.96   | 1.58   | 2.39   | 3.43    | 4.62    | 6.15    | 7.26    |
| 1                                                                       | 60              | 0  | 0.02 | 0.30  | 0.78   | 1.24   | 2.27   | 3.59   | 5.28    | 8.29    | 11.60   | 15.50   |
| 1                                                                       | 90              | 0  | 0.02 | 0.48  | 1.23   | 2.30   | 3.50   | 5.40   | 7.70    | 10.80   | 12.10   | 19.70   |
| 1¼                                                                      | 15              | 0  | 0.02 | 0.20  | 0.60   | 0.95   | 1.50   | 2.44   | 3.06    | 4.13    | 5.29    | 6.21    |
| 1¼                                                                      | 30              | 0  | 0.02 | 0.30  | 0.81   | 1.38   | 2.27   | 3.44   | 4.93    | 6.64    | 8.94    | 10.44   |
| 1¼                                                                      | 60              | 0  | 0.02 | 0.43  | 1.12   | 1.78   | 3.26   | 5.16   | 7.59    | 11.92   | 16.68   | 22.28   |
| 1¼                                                                      | 90              | 0  | 0.02 | 0.69  | 1.77   | 3.31   | 5.03   | 7.76   | 11.07   | 15.53   | 17.39   | 28.32   |
| 1½                                                                      | 15              | 0  | 0.02 | 0.23  | 0.71   | 1.42   | 2.35   | 3.44   | 5.04    | 6.92    | 9.24    | 11.06   |
| 1½                                                                      | 30              | 0  | 0.02 | 0.41  | 1.16   | 2.12   | 3.51   | 5.22   | 7.56    | 10.28   | 13.71   | 16.28   |
| 1½                                                                      | 60              | 0  | 0.02 | 0.57  | 1.74   | 2.99   | 5.59   | 9.07   | 13.16   | 19.80   | 28.42   | 37.51   |
| 1½                                                                      | 90              | 0  | 0.02 | 0.66  | 2.48   | 4.59   | 8.74   | 14.55  | 20.63   | 30.07   | 44.25   | 57.75   |
| 2                                                                       | 15              | 0  | 0.02 | 0.33  | 1.02   | 2.03   | 3.36   | 4.92   | 7.20    | 9.88    | 13.20   | 15.80   |
| 2                                                                       | 30              | 0  | 0.02 | 0.55  | 1.72   | 3.65   | 6.00   | 8.26   | 12.10   | 16.60   | 22.20   | 29.00   |
| 2                                                                       | 60              | 0  | 0.02 | 0.70  | 2.64   | 4.90   | 9.32   | 15.50  | 22.20   | 32.10   | 47.20   | 61.60   |
| 2                                                                       | 90              | 0  | 0.02 | 0.88  | 3.30   | 6.13   | 11.65  | 19.40  | 27.50   | 40.10   | 59.00   | 77.00   |
| 2½                                                                      | 15              | 0  | 0.02 | 0.47  | 1.50   | 3.00   | 4.80   | 7.20   | 10.37   | 14.42   | 19.38   | 23.39   |
| 2½                                                                      | 30              | 0  | 0.02 | 0.80  | 2.55   | 5.07   | 8.27   | 12.02  | 17.82   | 24.57   | 32.42   | 37.65   |
| 2½                                                                      | 60              | 0  | 0.03 | 1.02  | 3.92   | 7.01   | 13.89  | 22.91  | 32.87   | 46.55   | 70.26   | 91.52   |
| 2½                                                                      | 90              | 0  | 0.03 | 1.28  | 4.91   | 9.15   | 17.12  | 28.52  | 37.46   | 58.68   | 86.87   | 112.82  |
| 3                                                                       | 15              | 0  | 0.04 | 0.56  | 1.85   | 4.17   | 6.00   | 8.41   | 12.20   | 16.71   | 19.92   | 24.00   |
| 3                                                                       | 30              | 0  | 0.05 | 0.75  | 2.60   | 5.95   | 10.00  | 16.78  | 24.38   | 33.62   | 43.72   | 53.83   |
| 3                                                                       | 60              | 0  | 0.07 | 0.95  | 4.20   | 9.91   | 18.40  | 29.02  | 46.12   | 66.88   | 93.91   | 121.06  |
| 3                                                                       | 90              | 0  | 0.08 | 1.20  | 5.45   | 13.21  | 25.75  | 43.41  | 66.23   | 100.91  | 148.65  | 225.00  |
| 4                                                                       | 15              | 0  | 0.05 | 0.22  | 1.58   | 2.48   | 4.52   | 8.21   | 11.94   | 18.61   | 27.94   | 41.50   |
| 4                                                                       | 30              | 0  | 0.07 | 0.44  | 1.89   | 4.62   | 9.18   | 16.13  | 23.51   | 36.63   | 55.22   | 81.74   |
| 4                                                                       | 60              | 0  | 0.10 | 1.03  | 4.59   | 11.34  | 24.68  | 37.37  | 54.47   | 84.86   | 127.91  | 189.92  |
| 4                                                                       | 90              | 0  | 0.14 | 1.85  | 8.27   | 20.41  | 37.05  | 66.98  | 98.04   | 150.50  | 230.34  | 340.86  |
| 6                                                                       | 15              | 0  | 0.06 | 0.32  | 2.26   | 3.56   | 6.48   | 11.78  | 17.14   | 26.70   | 40.09   | 59.54   |
| 6                                                                       | 30              | 0  | 0.10 | 0.64  | 2.71   | 6.62   | 13.17  | 23.14  | 33.74   | 52.56   | 79.23   | 117.28  |
| 6                                                                       | 60              | 0  | 0.15 | 1.47  | 6.59   | 16.27  | 35.41  | 53.61  | 78.15   | 121.75  | 183.52  | 272.50  |
| 6                                                                       | 90              | 0  | 0.20 | 2.66  | 11.86  | 29.28  | 53.16  | 96.09  | 140.67  | 215.93  | 330.48  | 489.06  |
| 8                                                                       | 15              | 0  | 0.15 | 0.74  | 5.26   | 8.28   | 15.05  | 27.36  | 39.81   | 62.02   | 93.14   | 138.32  |
| 8                                                                       | 30              | 0  | 0.23 | 1.48  | 6.29   | 15.39  | 30.59  | 53.77  | 78.36   | 122.11  | 184.07  | 272.46  |
| 8                                                                       | 60              | 0  | 0.34 | 3.42  | 15.30  | 37.79  | 82.27  | 124.55 | 181.56  | 282.85  | 426.36  | 633.08  |
| 8                                                                       | 90              | 0  | 0.46 | 6.18  | 27.55  | 68.02  | 123.50 | 223.25 | 326.80  | 501.66  | 767.79  | 1136.20 |
| 10                                                                      | 15              | 0  | 0.30 | 1.44  | 10.25  | 16.13  | 29.30  | 53.28  | 77.52   | 120.77  | 182.04  | 269.36  |
| 10                                                                      | 30              | 0  | 0.44 | 2.89  | 12.88  | 31.75  | 57.72  | 104.71 | 152.63  | 237.80  | 358.46  | 530.58  |
| 10                                                                      | 60              | 0  | 0.67 | 6.66  | 29.79  | 73.59  | 160.21 | 242.53 | 353.57  | 550.82  | 830.28  | 1232.80 |
| 10                                                                      | 90              | 0  | 0.89 | 12.03 | 53.65  | 150.00 | 300.00 | 500.00 | 725.00  | 1020.00 | 1495.20 | 2212.70 |
| 12                                                                      | 15              | 0  | 0.58 | 2.77  | 19.73  | 31.05  | 56.40  | 102.56 | 149.23  | 232.48  | 350.43  | 518.52  |
| 12                                                                      | 30              | 0  | 0.85 | 5.56  | 24.79  | 61.12  | 111.11 | 201.57 | 293.81  | 457.77  | 690.04  | 1021.37 |
| 12                                                                      | 60              | 0  | 1.29 | 12.82 | 57.35  | 141.66 | 308.40 | 466.87 | 680.62  | 1060.33 | 1598.29 | 2373.14 |
| 12                                                                      | 90              | 0  | 1.71 | 23.16 | 103.28 | 250.00 | 550.00 | 900.00 | 1325.00 | 1880.55 | 2878.26 | 4259.45 |
| FI                                                                      |                 | 0  | 0.96 | 0.95  | 0.94   | 0.93   | 0.92   | 0.90   | 0.89    | 0.86    | 0.82    | 0.75    |
| Xt                                                                      |                 | 0  | 0.98 | 0.77  | 0.71   | 0.67   | 0.64   | 0.63   | 0.62    | 0.55    | 0.43    | 0.40    |

FI = Liquid Pressure Recovery Factor      Xt = Pressure Drop Ratio Factor (Gas)

**V-CONTROL BALL VALVE FLOW COEFFICIENT Cv CHARTS**

| Full Port - 1/2" to 4" Triad and Full Port - 1/2" to 12" F15/F30 |                 |    |      |       |        |        |        |         |         |         |         |         |
|------------------------------------------------------------------|-----------------|----|------|-------|--------|--------|--------|---------|---------|---------|---------|---------|
| Percent and Angle of Ball Rotation                               |                 |    |      |       |        |        |        |         |         |         |         |         |
| Valve Size<br>Inch                                               | V-Port<br>Angle | 0% | 10%  | 20%   | 30%    | 40%    | 50%    | 60%     | 70%     | 80%     | 90%     | 100%    |
| 1/2                                                              | 15              | 0  | 0.04 | 0.17  | 0.43   | 0.68   | 0.98   | 1.62    | 2.09    | 2.84    | 3.61    | 4.18    |
| 1/2                                                              | 30              | 0  | 0.04 | 0.23  | 0.47   | 0.77   | 1.19   | 1.83    | 2.47    | 3.43    | 4.65    | 5.55    |
| 1/2                                                              | 60              | 0  | 0.04 | 0.28  | 0.73   | 1.11   | 1.83   | 2.92    | 4.29    | 7.00    | 9.43    | 12.78   |
| 1/2                                                              | 90              | 0  | 0.06 | 0.47  | 0.85   | 1.28   | 2.05   | 3.24    | 4.74    | 8.26    | 11.61   | 14.72   |
| 3/4                                                              | 15              | 0  | 0.05 | 0.20  | 0.51   | 0.88   | 1.30   | 2.13    | 2.75    | 3.74    | 4.75    | 5.51    |
| 3/4                                                              | 30              | 0  | 0.07 | 0.30  | 0.61   | 0.99   | 1.57   | 2.42    | 3.25    | 4.52    | 6.12    | 7.30    |
| 3/4                                                              | 60              | 0  | 0.07 | 0.35  | 0.93   | 1.46   | 2.42   | 3.85    | 5.64    | 9.21    | 12.41   | 16.25   |
| 3/4                                                              | 90              | 0  | 0.08 | 0.59  | 1.11   | 1.69   | 2.69   | 4.27    | 6.24    | 10.85   | 15.28   | 19.37   |
| 1                                                                | 15              | 0  | 0.06 | 0.30  | 0.93   | 1.49   | 2.31   | 3.75    | 4.67    | 6.47    | 8.46    | 9.84    |
| 1                                                                | 30              | 0  | 0.08 | 0.45  | 1.25   | 2.06   | 3.54   | 5.30    | 7.70    | 10.49   | 12.84   | 15.48   |
| 1                                                                | 60              | 0  | 0.09 | 0.68  | 1.74   | 2.78   | 5.13   | 8.00    | 11.88   | 18.71   | 23.22   | 32.81   |
| 1                                                                | 90              | 0  | 0.11 | 0.93  | 2.78   | 5.09   | 7.74   | 12.20   | 17.33   | 22.50   | 31.40   | 43.89   |
| 1 1/4                                                            | 15              | 0  | 0.03 | 0.27  | 0.83   | 1.64   | 2.78   | 4.07    | 5.88    | 7.99    | 10.81   | 12.82   |
| 1 1/4                                                            | 30              | 0  | 0.05 | 0.48  | 1.37   | 2.47   | 4.12   | 6.08    | 8.62    | 11.76   | 14.87   | 17.37   |
| 1 1/4                                                            | 60              | 0  | 0.07 | 0.67  | 2.04   | 3.41   | 6.47   | 10.80   | 15.39   | 22.35   | 33.37   | 43.45   |
| 1 1/4                                                            | 90              | 0  | 0.08 | 0.78  | 2.92   | 5.41   | 10.23  | 17.28   | 25.50   | 35.60   | 51.76   | 65.81   |
| 1 1/2                                                            | 15              | 0  | 0.05 | 0.37  | 1.15   | 2.26   | 3.82   | 5.59    | 8.08    | 10.99   | 14.86   | 17.62   |
| 1 1/2                                                            | 30              | 0  | 0.07 | 0.65  | 1.88   | 3.39   | 5.66   | 8.36    | 12.12   | 16.17   | 20.44   | 23.88   |
| 1 1/2                                                            | 60              | 0  | 0.09 | 0.92  | 2.81   | 4.69   | 8.89   | 14.85   | 21.16   | 30.73   | 45.88   | 59.74   |
| 1 1/2                                                            | 90              | 0  | 0.10 | 1.07  | 4.01   | 7.44   | 14.06  | 22.60   | 31.90   | 48.03   | 71.17   | 90.49   |
| 2                                                                | 15              | 0  | 0.06 | 0.69  | 2.23   | 4.45   | 7.24   | 10.68   | 15.38   | 21.39   | 28.75   | 34.69   |
| 2                                                                | 30              | 0  | 0.09 | 1.18  | 3.79   | 7.53   | 12.26  | 17.83   | 26.44   | 36.45   | 48.09   | 55.85   |
| 2                                                                | 60              | 0  | 0.11 | 1.51  | 5.80   | 10.39  | 20.60  | 33.98   | 48.75   | 69.04   | 104.23  | 135.75  |
| 2                                                                | 90              | 0  | 0.16 | 1.89  | 7.28   | 13.58  | 25.38  | 42.30   | 55.56   | 87.04   | 129.75  | 167.34  |
| 2 1/2                                                            | 15              | 0  | 0.07 | 0.77  | 2.40   | 5.23   | 8.06   | 11.73   | 16.42   | 22.31   | 27.24   | 31.30   |
| 2 1/2                                                            | 30              | 0  | 0.09 | 1.15  | 4.42   | 7.91   | 13.39  | 20.05   | 30.43   | 41.92   | 56.30   | 76.95   |
| 2 1/2                                                            | 60              | 0  | 0.13 | 1.46  | 5.91   | 11.90  | 23.24  | 37.92   | 59.31   | 83.29   | 113.65  | 162.50  |
| 2 1/2                                                            | 90              | 0  | 0.17 | 1.83  | 7.29   | 16.45  | 31.16  | 53.53   | 77.89   | 118.29  | 177.32  | 239.45  |
| 3                                                                | 15              | 0  | 0.08 | 0.89  | 2.96   | 6.65   | 9.58   | 13.42   | 19.47   | 26.67   | 31.79   | 38.31   |
| 3                                                                | 30              | 0  | 0.12 | 1.20  | 4.15   | 9.49   | 15.96  | 26.78   | 38.91   | 53.31   | 69.77   | 85.91   |
| 3                                                                | 60              | 0  | 0.15 | 2.89  | 6.70   | 15.82  | 29.36  | 46.32   | 73.60   | 106.74  | 149.88  | 193.20  |
| 3                                                                | 90              | 0  | 0.20 | 4.12  | 8.65   | 21.09  | 41.09  | 69.27   | 105.91  | 161.04  | 237.23  | 359.21  |
| 4                                                                | 15              | 0  | 0.11 | 1.40  | 3.73   | 8.86   | 16.76  | 27.91   | 41.85   | 59.24   | 75.49   | 96.37   |
| 4                                                                | 30              | 0  | 0.16 | 1.75  | 7.84   | 18.59  | 35.21  | 58.60   | 87.89   | 124.41  | 158.53  | 196.35  |
| 4                                                                | 60              | 0  | 0.26 | 2.20  | 12.44  | 33.67  | 62.98  | 106.26  | 160.49  | 233.96  | 329.50  | 437.29  |
| 4                                                                | 90              | 0  | 0.35 | 4.37  | 19.68  | 50.29  | 91.83  | 157.43  | 240.51  | 365.15  | 546.62  | 830.86  |
| 6                                                                | 15              | 0  | 0.20 | 2.50  | 6.64   | 15.77  | 29.85  | 49.70   | 74.54   | 105.51  | 134.44  | 171.62  |
| 6                                                                | 30              | 0  | 0.29 | 3.12  | 13.97  | 33.11  | 62.70  | 104.37  | 156.53  | 221.56  | 282.33  | 349.69  |
| 6                                                                | 60              | 0  | 0.46 | 5.41  | 22.15  | 59.97  | 112.16 | 189.24  | 285.82  | 416.68  | 586.83  | 800.80  |
| 6                                                                | 90              | 0  | 0.66 | 7.79  | 35.05  | 89.56  | 163.55 | 280.37  | 428.34  | 650.32  | 973.50  | 1479.70 |
| 8                                                                | 15              | 0  | 0.34 | 4.23  | 11.32  | 26.84  | 50.80  | 84.58   | 126.84  | 195.00  | 345.50  | 692.07  |
| 8                                                                | 30              | 0  | 0.49 | 5.32  | 23.77  | 56.35  | 106.70 | 177.62  | 266.39  | 377.06  | 480.47  | 595.11  |
| 8                                                                | 60              | 0  | 0.79 | 6.66  | 23.81  | 102.06 | 190.87 | 322.06  | 486.41  | 709.11  | 998.69  | 1325.38 |
| 8                                                                | 90              | 0  | 1.05 | 13.26 | 59.64  | 152.42 | 278.33 | 477.14  | 728.86  | 1106.69 | 1656.77 | 2518.18 |
| 10                                                               | 15              | 0  | 0.53 | 6.62  | 17.69  | 41.94  | 79.38  | 132.15  | 198.20  | 350.00  | 545.00  | 856.36  |
| 10                                                               | 30              | 0  | 0.77 | 8.31  | 37.14  | 88.05  | 166.73 | 277.53  | 416.24  | 589.16  | 750.74  | 929.87  |
| 10                                                               | 60              | 0  | 1.23 | 10.41 | 37.20  | 159.47 | 298.23 | 503.22  | 760.02  | 1107.99 | 1560.45 | 2070.90 |
| 10                                                               | 90              | 0  | 1.64 | 20.72 | 93.20  | 238.16 | 434.90 | 745.53  | 1139.00 | 1729.20 | 2588.70 | 3934.65 |
| 12                                                               | 15              | 0  | 0.74 | 9.26  | 24.76  | 58.72  | 111.13 | 185.01  | 277.47  | 564.00  | 1101.07 | 1638.90 |
| 12                                                               | 30              | 0  | 1.07 | 11.63 | 52.00  | 123.27 | 233.42 | 388.54  | 582.73  | 824.82  | 1051.03 | 1301.81 |
| 12                                                               | 60              | 0  | 1.72 | 14.57 | 52.08  | 223.25 | 417.52 | 704.51  | 1064.03 | 1551.19 | 2184.63 | 2899.26 |
| 12                                                               | 90              | 0  | 2.29 | 29.00 | 130.47 | 333.42 | 608.85 | 1043.74 | 1594.59 | 2420.88 | 3624.18 | 5508.51 |
| FI                                                               |                 | 0  | 0.96 | 0.95  | 0.94   | 0.93   | 0.92   | 0.90    | 0.89    | 0.86    | 0.82    | 0.75    |
| Xt                                                               |                 | 0  | 0.98 | 0.77  | 0.71   | 0.67   | 0.64   | 0.63    | 0.62    | 0.55    | 0.43    | 0.40    |

FI = Liquid Pressure Recovery Factor    Xt = Pressure Drop Ratio Factor (Gas)

## ROUND PORT BALL VALVE FLOW COEFFICIENT Cv CHARTS

### Standard Port - ¾" to 2½" SP Triad and 1" to 12" RF15/RF30

| Percent and Angle of Ball Rotation |    |        |        |         |         |         |         |         |         |         |         |
|------------------------------------|----|--------|--------|---------|---------|---------|---------|---------|---------|---------|---------|
| Valve Size<br>Inch                 | 0% | 10%    | 20%    | 30%     | 40%     | 50%     | 60%     | 70%     | 80%     | 90%     | 100%    |
| ¾                                  | 0  | 0.21   | 0.43   | 0.70    | 1.05    | 1.62    | 2.64    | 4.00    | 6.40    | 9.60    | 12.00   |
| 1                                  | 0  | 0.58   | 1.15   | 1.90    | 2.80    | 4.30    | 7.00    | 10.50   | 17.00   | 26.00   | 32.00   |
| 1¼                                 | 0  | 0.83   | 1.65   | 2.67    | 4.05    | 6.50    | 10.00   | 15.20   | 24.60   | 36.00   | 46.00   |
| 1½                                 | 0  | 1.48   | 2.95   | 4.75    | 7.20    | 11.00   | 18.00   | 27.00   | 44.00   | 65.50   | 82.00   |
| 2                                  | 0  | 2.16   | 4.33   | 6.95    | 10.50   | 16.20   | 26.40   | 39.60   | 64.00   | 96.00   | 120.00  |
| 2½                                 | 0  | 3.75   | 7.40   | 26.30   | 51.20   | 80.00   | 111.40  | 144.20  | 177.40  | 209.80  | 240.00  |
| 3                                  | 0  | 6.40   | 12.60  | 20.20   | 31.10   | 47.40   | 77.80   | 115.00  | 187.00  | 280.00  | 350.00  |
| 4                                  | 0  | 13.10  | 26.00  | 42.10   | 63.10   | 97.20   | 159.00  | 230.00  | 385.00  | 575.00  | 720.00  |
| 6                                  | 0  | 18.40  | 36.70  | 59.00   | 90.00   | 138.00  | 224.00  | 338.00  | 545.00  | 815.00  | 1020.00 |
| 8                                  | 0  | 34.00  | 68.00  | 109.00  | 165.00  | 254.00  | 415.00  | 620.00  | 1010.00 | 1500.00 | 1880.00 |
| 10                                 | 0  | 55.50  | 299.50 | 646.60  | 1065.20 | 1534.20 | 2033.90 | 2547.30 | 3057.80 | 3548.90 | 4000.00 |
| 12                                 | 0  | 138.70 | 625.00 | 1299.20 | 2105.80 | 3005.00 | 3960.10 | 4939.30 | 5911.10 | 6844.40 | 7700.00 |

### Full Port - ½" to 4" FP Triad and F15/F30 and 7000/8000

| Percent and Angle of Ball Rotation |    |        |         |         |         |         |          |          |          |          |          |
|------------------------------------|----|--------|---------|---------|---------|---------|----------|----------|----------|----------|----------|
| Valve Size<br>Inch                 | 0% | 10%    | 20%     | 30%     | 40%     | 50%     | 60%      | 70%      | 80%      | 90%      | 100%     |
| ½                                  | 0  | 0.00   | 0.00    | 0.70    | 3.70    | 7.80    | 12.60    | 17.90    | 23.30    | 28.60    | 32.00    |
| ¾                                  | 0  | 0.00   | 0.00    | 2.50    | 7.70    | 14.20   | 21.70    | 29.70    | 38.00    | 46.20    | 54.00    |
| 1                                  | 0  | 0.00   | 1.20    | 8.60    | 19.40   | 32.40   | 46.70    | 61.90    | 77.30    | 92.40    | 105.00   |
| 1¼                                 | 0  | 0.00   | 5.30    | 20.70   | 41.30   | 65.40   | 91.70    | 119.30   | 147.20   | 174.50   | 200.00   |
| 1½                                 | 0  | 0.00   | 3.40    | 22.70   | 50.70   | 83.90   | 120.80   | 159.70   | 199.40   | 238.40   | 275.00   |
| 2                                  | 0  | 0.00   | 15.50   | 54.80   | 106.60  | 166.60  | 232.00   | 300.40   | 369.50   | 437.00   | 500.00   |
| 2½                                 | 0  | 0.00   | 25.80   | 87.60   | 168.60  | 262.10  | 363.90   | 470.20   | 577.50   | 682.30   | 780.00   |
| 3                                  | 0  | 0.00   | 33.80   | 123.70  | 242.70  | 380.80  | 531.50   | 689.30   | 848.70   | 1004.50  | 1150.00  |
| 4                                  | 0  | 7.50   | 118.90  | 296.20  | 516.20  | 766.50  | 1035.80  | 1314.30  | 1592.70  | 1861.80  | 2100.00  |
| 6                                  | 0  | 14.15  | 224.30  | 631.80  | 1149.90 | 1746.30 | 2392.50  | 3064.20  | 3738.80  | 4393.30  | 5000.00  |
| 8                                  | 0  | 63.70  | 600.70  | 1416.30 | 2418.30 | 3552.30 | 4768.20  | 6023.10  | 7275.90  | 8485.10  | 9600.00  |
| 10                                 | 0  | 184.20 | 1085.20 | 2381.60 | 3950.90 | 5712.40 | 7591.50  | 9523.90  | 11447.00 | 13298.40 | 15000.00 |
| 12                                 | 0  | 139.30 | 1314.00 | 3046.40 | 5290.00 | 7770.70 | 10430.50 | 13175.60 | 15916.10 | 18561.20 | 21000.00 |

| Percent and Angle of Ball Rotation |    |      |      |      |      |      |      |      |      |      |      |
|------------------------------------|----|------|------|------|------|------|------|------|------|------|------|
|                                    | 0% | 10%  | 20%  | 30%  | 40%  | 50%  | 60%  | 70%  | 80%  | 90%  | 100% |
| FI                                 | 0  | 0.92 | 0.91 | 0.91 | 0.90 | 0.86 | 0.86 | 0.72 | 0.65 | 0.61 | 0.50 |
| Xt                                 | 0  | 0.78 | 0.74 | 0.71 | 0.67 | 0.62 | 0.56 | 0.49 | 0.38 | 0.26 | 0.15 |

FI = Liquid Pressure Recovery Factor      Xt = Pressure Drop Ratio Factor (Gas)

**SLOTTED PORT BALL VALVE FLOW COEFFICIENT Cv CHARTS**

| Standard Port - Slot ½" to 1½" |                    |                                    |      |      |      |      |      |      |      |      |      |      |
|--------------------------------|--------------------|------------------------------------|------|------|------|------|------|------|------|------|------|------|
| Valve Size<br>Inch             | Slot Width<br>Inch | Percent and Angle of Ball Rotation |      |      |      |      |      |      |      |      |      |      |
|                                |                    | 0%                                 | 10%  | 20%  | 30%  | 40%  | 50%  | 60%  | 70%  | 80%  | 90%  | 100% |
| ½                              | ⅛                  | 0                                  | 0.02 | 0.03 | 0.07 | 0.12 | 0.16 | 0.20 | 0.24 | 0.28 | 0.32 | 0.36 |
| ½                              | 1/16               | 0                                  | 0.02 | 0.07 | 0.20 | 0.33 | 0.46 | 0.60 | 0.73 | 0.86 | 0.99 | 1.10 |
| ¾                              | ⅛                  | 0                                  | 0.02 | 0.04 | 0.08 | 0.13 | 0.18 | 0.23 | 0.27 | 0.32 | 0.37 | 0.41 |
| ¾                              | 1/16               | 0                                  | 0.02 | 0.08 | 0.23 | 0.38 | 0.52 | 0.68 | 0.83 | 0.10 | 1.13 | 1.25 |
| ¾                              | 1/8                | 0                                  | 0.02 | 0.14 | 0.39 | 0.65 | 0.90 | 1.18 | 1.44 | 1.69 | 1.94 | 2.16 |
| 1                              | ⅛                  | 0                                  | 0.02 | 0.06 | 0.14 | 0.22 | 0.29 | 0.37 | 0.45 | 0.53 | 0.60 | 0.68 |
| 1                              | 1/16               | 0                                  | 0.02 | 0.13 | 0.38 | 0.63 | 0.87 | 1.14 | 1.39 | 1.63 | 1.88 | 2.09 |
| 1                              | 1/8                | 0                                  | 0.02 | 0.23 | 0.66 | 1.09 | 1.52 | 1.99 | 2.42 | 2.85 | 3.28 | 3.64 |
| 1½                             | ⅛                  | 0                                  | 0.02 | 0.10 | 0.22 | 0.34 | 0.46 | 0.58 | 0.70 | 0.82 | 0.94 | 1.07 |
| 1½                             | 1/16               | 0                                  | 0.02 | 0.21 | 0.59 | 0.98 | 1.36 | 1.78 | 2.16 | 2.55 | 2.93 | 3.26 |
| 1½                             | 1/8                | 0                                  | 0.02 | 0.36 | 1.05 | 1.73 | 2.41 | 3.15 | 3.83 | 4.51 | 5.20 | 5.77 |

## CONTROL TERMINOLOGY

|                                         |                                                                                                                                                                                                                                       |
|-----------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Absolute Pressure</b>                | The total pressure measured from an absolute zero. It is the sum of gauge pressure and the prevailing atmospheric pressure. Expressed as psia 14.7 + gauge pressure (psi).                                                            |
| <b>Actuator</b>                         | That part of an automatic control valve which causes the valve stem to move from a signal.                                                                                                                                            |
| <b>Ambient Temperature Rating</b>       | Pressure, design or operations at ambient temperature.                                                                                                                                                                                |
| <b>Booster Pump</b>                     | Pump used in secondary loops of systems to raise pressure for that section of the system.                                                                                                                                             |
| <b>Calibration</b>                      | Adjustment of end points of control valve stroke/position with respect to known signal.                                                                                                                                               |
| <b>Cavitation</b>                       | The forming and imploding of vapor bubbles in a liquid due to decreased, then increased, pressure as the liquid flows through a restriction.                                                                                          |
| <b>Choked Flow</b>                      | The maximum flow that can occur through a valve without an increase in inlet (upstream) pressure. This occurs when critical pressure drop is achieved.                                                                                |
| <b>Compressible Fluids</b>              | Capable of being compressed. Gas and Vapor are compressible fluids.                                                                                                                                                                   |
| <b>Control Loop</b>                     | An assembly of equipment designed to effect control of flow (the process) through a piping system. Includes the process, controller, measuring element and the control valve.                                                         |
| <b>Control Valve</b>                    | The control element through which the fluid passes which adjusts the amount of its opening as directed by a controller to change the flow rate of the fluid.                                                                          |
| <b>Controller</b>                       | A device that has a variable output which causes a control valve to maintain the process within desired limits.                                                                                                                       |
| <b>Critical Pressure Drop</b>           | The pressure drop across a valve at which the media is just beginning to exit flash or cavitation (liquids) or sonic port velocity (gases).                                                                                           |
| <b>Deadband</b>                         | The range through which an input signal can be varied without initiating a response.                                                                                                                                                  |
| <b>Direct Acting</b>                    | A rotary control valve which opens with an increase in instrument signal (3 psi=closed, 15 psi=full open, 4 ma=closed, 20 ma=full open).                                                                                              |
| <b>Direction of Flow</b>                | The correct flow of the controlled fluid through the valve is usually indicated on the valve body. Most valves are bidirectional unless unidirectional as indicated.                                                                  |
| <b>Dynamic Pressure</b>                 | The pressure of a fluid resulting from its motion.<br>Total Pressure - Static Pressure = Dynamic Pressure (Pump head).                                                                                                                |
| <b>End Fitting</b>                      | Part of the valve body that connects to the piping. Union, screwed, flared, sweat, and flanged are typical examples of end fittings.                                                                                                  |
| <b>Equal Percentage Characteristics</b> | An inherent flow characteristic that for equal increments of valve opening will give equal percentage changes of the previous existing flow                                                                                           |
| <b>Flanged-End Connections</b>          | A valve that connects to a pipe by bolting a flange on the valve to a flange on the pipe. Flanged connections are typically used on large valves.                                                                                     |
| <b>Flashing</b>                         | Condition resulting when the pressure downstream of a control valve is less than the upstream vapor pressure causing part of the liquid to change to a vapor. In effect the liquid suddenly flashes to a vapor (precedes cavitation). |
| <b>Flow Characteristic</b>              | Relation between flow through the valve and percent travel as the valve is opened 0 and 100%.                                                                                                                                         |
| <b>Flow Characteristic, Inherent</b>    | Flow characteristic when constant pressure drop is maintained across the valve.                                                                                                                                                       |
| <b>Flow Characteristic, Installed</b>   | Flow characteristic when pressure drop across the valve varies as dictated by flow and related system conditions.                                                                                                                     |

|                                         |                                                                                                                                                                                                                                                                                                                                                   |
|-----------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Flow Coefficient, Cv</b>             | The number in U.S. gallons of water per minute at 60°F, that will flow through a given valve with pressure drop of 1 psi (also called capacity index).                                                                                                                                                                                            |
| <b>Flow Rate</b>                        | 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.                                                                                                                                                                                                           |
| <b>Full Port</b>                        | Maximum flow capacity possible for particular end fitting size, or valve seat diameter.                                                                                                                                                                                                                                                           |
| <b>Gain</b>                             | Measure of change in output expressed as a ratio to change in input for a control device. (Normally refers to positioners).                                                                                                                                                                                                                       |
| <b>Gauge Pressure</b>                   | Pounds per square inch (psi) as read on a gauge.                                                                                                                                                                                                                                                                                                  |
| <b>GPM</b>                              | Gallons per minute.                                                                                                                                                                                                                                                                                                                               |
| <b>Hunting</b>                          | An undesirable oscillation in valve position, persisting after external stimuli are removed.                                                                                                                                                                                                                                                      |
| <b>Hysteresis</b>                       | The maximum difference in output valve for any single input valve during a calibration cycle, excluding errors due to deadband.                                                                                                                                                                                                                   |
| <b>Incompressible</b>                   | Description of liquids, because their change in volume due to pressure is negligible.                                                                                                                                                                                                                                                             |
| <b>I/P Transducer</b>                   | A device which takes a signal measured in current and changes it into a signal measured pressure (converts 4-20 ma to 3-15 psi).                                                                                                                                                                                                                  |
| <b>Laminar Flow</b>                     | Also known as viscous or streamlined flow. A non-turbulent flow regime in which the stream filaments glide along the pipe axially with essentially no transverse mixing.                                                                                                                                                                          |
| <b>Linear Characteristic</b>            | An inherent flow characteristic that can be represented by a straight line on a plot of flow versus percent opening. Equal increments of travel yield equal increments of flow at a constant pressure drop.                                                                                                                                       |
| <b>Maximum Pressure and Temperature</b> | The maximum pressure and temperature limitations of fluid flow that a valve can withstand. These ratings may be due to valve packing, body, disc material, or actuator limitations. The actual valve body ratings are exclusively for the valve body and the maximum pressure and temperature ratings are for the complete valve (body and trim). |
| <b>Mixing Valve</b>                     | Three way valve having 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.                                                                                                                                                   |
| <b>Normally Closed (N.C.)</b>           | Condition of the valve upon a loss of power or control signal to the actuator. A valve which closes when the signal is removed.                                                                                                                                                                                                                   |
| <b>Normally Open (N.O.)</b>             | Condition of the valve upon a loss of power or control signal to the actuator. A valve which opens when the signal is removed.                                                                                                                                                                                                                    |
| <b>Packing</b>                          | Material used to seal the valve stem so that the controlled medium will not leak.                                                                                                                                                                                                                                                                 |
| <b>Port</b>                             | Flow controlling opening between the seat and ball when the valve is wide open.                                                                                                                                                                                                                                                                   |
| <b>Positioner</b>                       | Device which receives a signal from a controller and forces the actuator to the desired valve position.                                                                                                                                                                                                                                           |
| <b>Pressure Drop (ΔP)</b>               | The difference in pressure between inlet and outlet of the control valve.                                                                                                                                                                                                                                                                         |
| <b>PSI</b>                              | Unit of measure. Pounds per square inch. PSIA - Pounds per square inch absolute. PSIG - Pounds per square inch gauge.                                                                                                                                                                                                                             |
| <b>Quick Opening</b>                    | An inherent flow characteristic yielding maximum flow in minimum opening.                                                                                                                                                                                                                                                                         |
| <b>Range</b>                            | The maximum difference in input signal valves.                                                                                                                                                                                                                                                                                                    |

|                                  |                                                                                                                                                                                                                                                                                                 |
|----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Rangeability</b>              | The ratio of the maximum controllable flow to the minimum controllable flow. For instance, a valve with a rangeability of 50 to 1 having a total flow capacity of 100 gal/min, fully open, will control flow accurately down as low as 2 gal/min. The valve may or may not have tight shut-off. |
| <b>Recovery Coefficient</b>      | A value used to measure the valve's ability to recover pressure before the fluid exits the valve. Ball and butterfly valves exhibit recovery coefficients of approximately 0.3 when fully open, and are considered to be high recovery valves.                                                  |
| <b>Reduced Port</b>              | Smaller flow capacity than connecting pipe.                                                                                                                                                                                                                                                     |
| <b>Reducer</b>                   | A pipe fitting that is used to couple a pipe of one size to a pipe of a different size.                                                                                                                                                                                                         |
| <b>Repeatability</b>             | The closeness of agreement among a number of consecutive measurements of the output for the same value of the input under the same operating conditions, approaching from the same direction, for all range traverses. (not including Hysteresis).                                              |
| <b>Reverse Acting</b>            | A rotary control valve which opens with a decrease in instrument signal (15 psi=closed, 3 psi=full open, 20 ma=closed, 4 ma=full open).                                                                                                                                                         |
| <b>Reynold's Number</b>          | It is proportional to the ratio of dynamic forces to viscous forces: the product of diameter, velocity, and density divided by absolute viscosity.                                                                                                                                              |
| <b>Saturated Steam</b>           | The maximum amount of vapor that can exist at specific temperature and pressure.                                                                                                                                                                                                                |
| <b>Screwed-End Connection</b>    | A valve with threaded pipe connection. Valve threads are usually female, but male connections are available for special applications.                                                                                                                                                           |
| <b>Seat</b>                      | The stationary portion of the valve which when in contact with the movable portion (valve disc, stem, etc.) stops flow completely.                                                                                                                                                              |
| <b>Sensitivity</b>               | The ratio of the change in output magnitude to the change of the input which causes it after the steady-state has been reached.                                                                                                                                                                 |
| <b>Set Point</b>                 | The desired value of the measured variable. Basic reference point against which a control application is regulated.                                                                                                                                                                             |
| <b>Signal Instrument</b>         | The output from an automatic controller that is used to operate a control valve. Can be pneumatic or electric.                                                                                                                                                                                  |
| <b>Span</b>                      | Used interchangeably with "range".                                                                                                                                                                                                                                                              |
| <b>Specific Gravity</b>          | For liquids, the ratio of the density of the liquid to the density of water at 60°F. For gases, the ratio of the density of the gas to the density of air at 60°F.                                                                                                                              |
| <b>Split Range</b>               | Ability to use two positioners to control process as in 3-9 psi and 9-15 psi rather than 3-15 psi for full travel of valve. This is done when the process requirements exceed the rangeability of a single valve.                                                                               |
| <b>Static Pressure</b>           | Pressure inside that will tolerate before leaking. Pressure varies with temperature.                                                                                                                                                                                                            |
| <b>Superheated Steam</b>         | Steam at a temperature higher than saturation temperature at the given pressure.                                                                                                                                                                                                                |
| <b>System Pressure Drop (ΔP)</b> | The difference in pressure between supply and return mains in a system.                                                                                                                                                                                                                         |
| <b>Total Pressure</b>            | The sum of the Static Pressure and the Dynamic Pressure.                                                                                                                                                                                                                                        |
| <b>Three-Way Valve</b>           | Valve with three connections, one of which is a common and two flow paths.                                                                                                                                                                                                                      |
| <b>Tight Shut-off</b>            | A valve having tight shut-off that will have virtually no flow or leakage in its closed position.                                                                                                                                                                                               |
| <b>Trim</b>                      | All parts of the valve which are in contact with the flowing media but are not part of the valve shell.                                                                                                                                                                                         |

|                                  |                                                                                                                                                                                                                                                 |
|----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Turbulent Flow</b>            | A flow regime characterized by random motion of the fluid particles in the transverse direction as well as motion in the axial direction. This occurs at high Reynolds numbers and is the type of flow most common in industrial fluid systems. |
| <b>Two Way Valve</b>             | Valve with single flow path-one inlet and one outlet.                                                                                                                                                                                           |
| <b>Vapor Pressure</b>            | The pressure at which a liquid changes to a gas.                                                                                                                                                                                                |
| <b>Valve</b>                     | A control device which will vary the rate of flow of medium.                                                                                                                                                                                    |
| <b>Valve Body</b>                | The portion of the valve through which the controlled medium flows.                                                                                                                                                                             |
| <b>Valve Disc</b>                | A movable part of the valve which makes contact with the valve seat when the valve is closed.                                                                                                                                                   |
| <b>Valve Flow Characteristic</b> | The relationship between the stem travel, expressed in percent of travel, and the flow of the fluid through the valve, expressed in percent of full flow.                                                                                       |
| <b>Valve Pressure Drop</b>       | Portion of the system pressure drop which appears across the valve. For valve sizing this drop is across a fully open valve.                                                                                                                    |
| <b>Velocity</b>                  | Speed with which media passes through pipe measured in feet/sec.                                                                                                                                                                                |
| <b>Vena Contract A</b>           | The location in the flow stream with maximum velocity, minimum area, and minimum pressure. Normally directly downstream of the control valve.                                                                                                   |
| <b>Viscosity</b>                 | Measure of the thickness and flow characteristic of a liquid as compared to water.                                                                                                                                                              |
| <b>WOG</b>                       | Designation for Water, Oil and Gas at maximum cold working pressure (CWP).                                                                                                                                                                      |

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