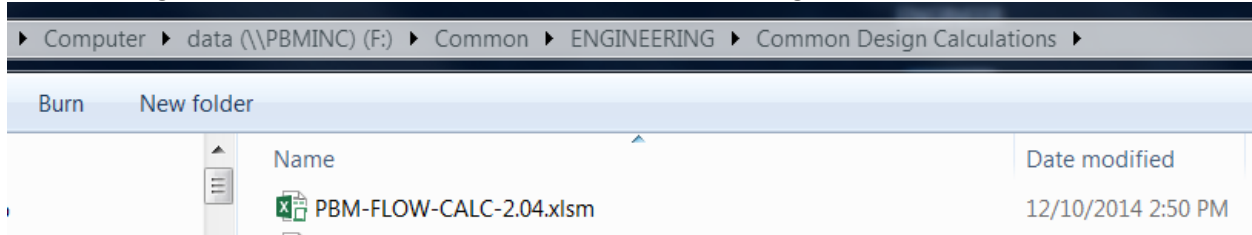
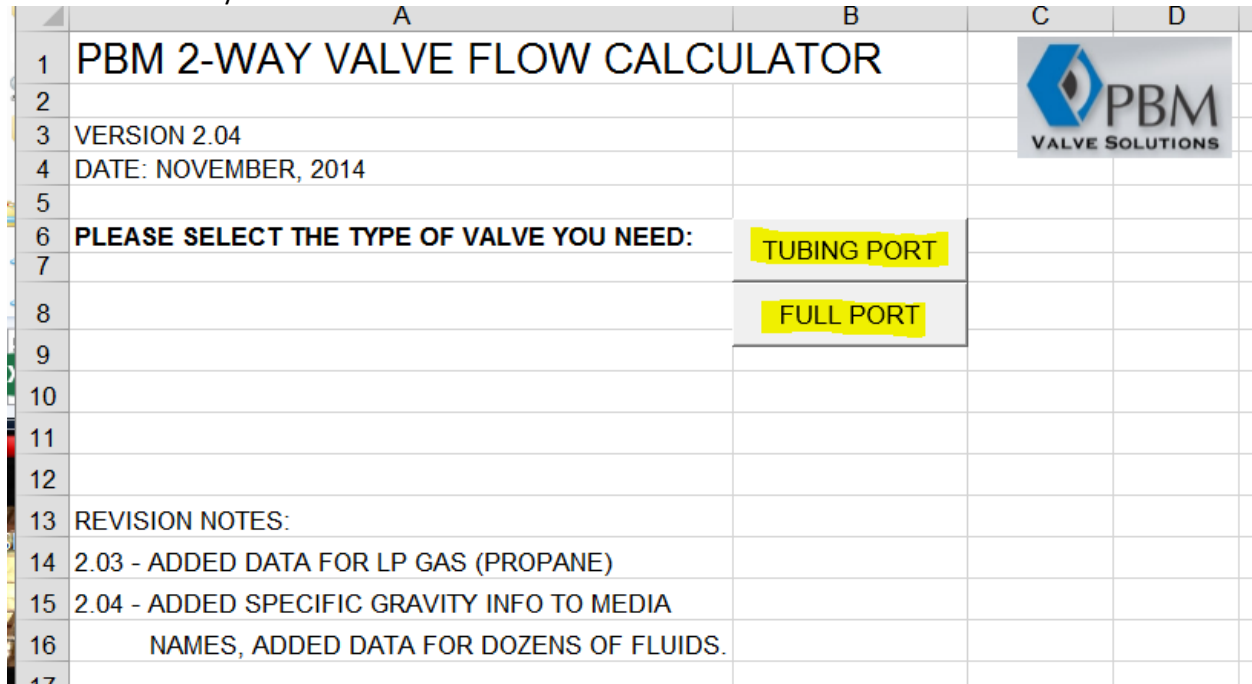


How to use the PBM Flow Calculator Spreadsheet (V2.04)

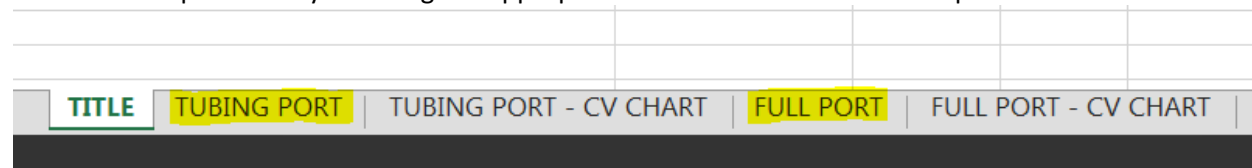
- o Navigate to the F:\Common\ENGINEERING\Common Design Calculations folder



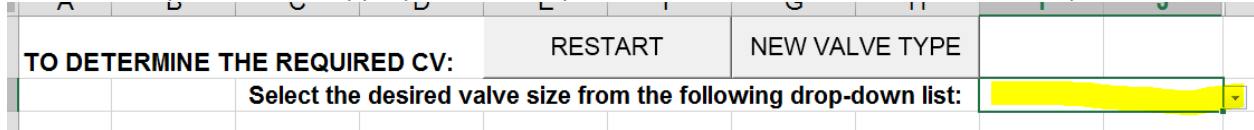
- o Open PBM-FLOW-CALC-2.04.xlsm
- o On the title page, the version, version date and revision notes are displayed. There are also buttons for you to select "TUBING PORT" or "FULL PORT". Here you will choose the type of valve for which you want to calculate flow.



- o The only function of these (2) buttons is to take you the appropriate sheet. You can also accomplish this by choosing the appropriate tabs at the bottom of the spreadsheet.



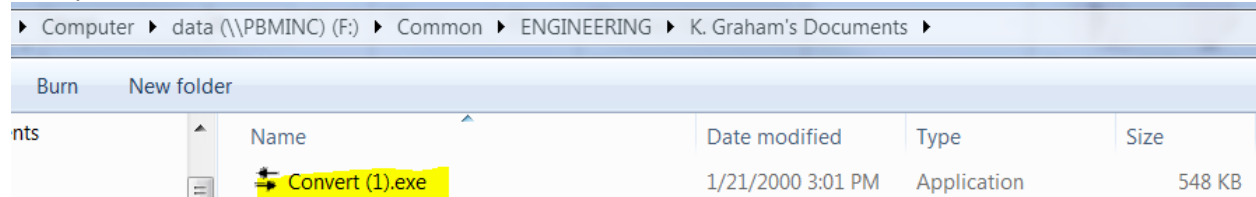
- Once you're on the appropriate sheet, you will choose the valve size from the drop down menu.



- There are (3) separate media types to choose from: Liquid, Saturated Steam, and Gas. The data you'll need to calculate flow is different for each of those media types.

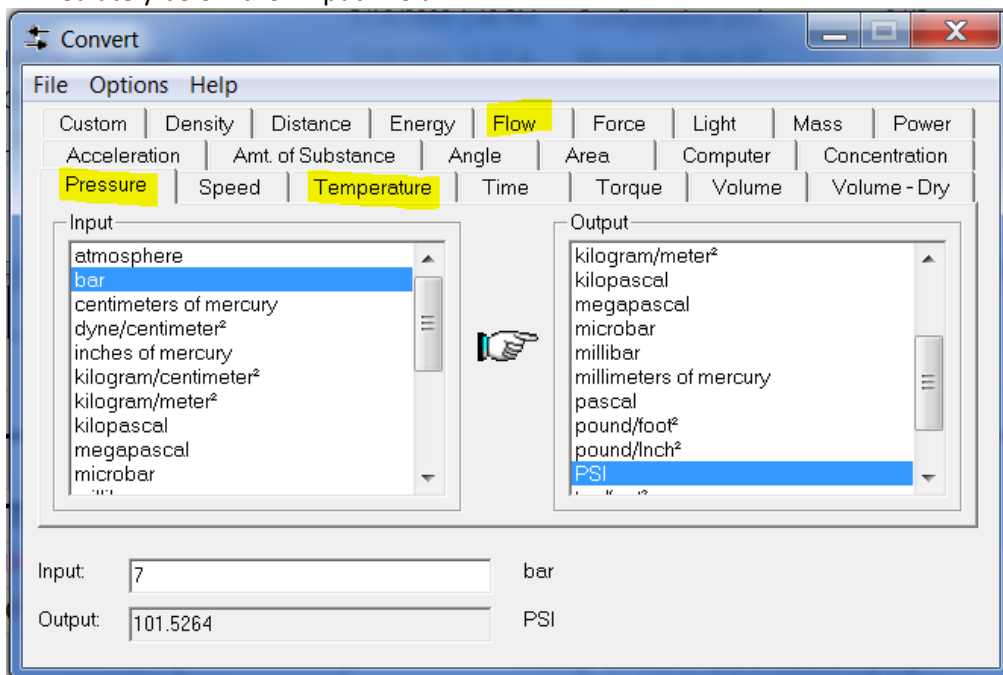
Side Note:

All fields in our spreadsheet utilize English (Imperial) units. If you have been given metric units, you will need to convert them to the units listed on the spreadsheet. Many websites offer free conversion calculators. We also have an executable file (Convert.exe) that you can copy to your machine and run locally. It is located in F:\Common\ENGINEERING\K. Graham's Documents



It is ***imperative*** that you use the proper units in the spreadsheet. If you enter garbage information, you'll get garbage results.

In the Convert program, you'll be using the Flow, Pressure, and Temperature Tabs the most. You simply click on the appropriate tab, choose the Input units, choose the Output units, and enter the Input value in the "Input" field at the bottom of the screen. The converted value is displayed in the "Output" field immediately below the "Input" field.



Actual Liquid Example:

Shawn,

Could you help me figure out V-Ball and valve size based on below info.

Reducing Valve / Control Valve / Ball valve with V-port

P1=13bar

P2=6bar

3,5 L/sec

PN16

Treaded ends

Media: Clean Drinking water

So, using the Convert program, we get the following values for use in the Flow Calculator spreadsheet:

Given

P1=188.5 PSIG

P2=87 PSIG

55.5 GPM

.62" ID (3/4" TUBING PORT)

Media: Clean Drinking water

| ETERMINE THE REQUIRED CV: | | RESTART | NEW VALVE TYPE | |
|--|--------------------|--|-------------------------|--|
| Select the desired valve size from the following drop-down list: | | | 3/4" Tubing Port (0.62) | |
| ENTER VALUES (LIQUID) | | DO NOT ENTER DATA HERE | | |
| UPSTREAM PRESSURE (PSI) | 188.5 | PRESSURE DROP (PSI) | 101.5 | |
| DOWNSTREAM PRESSURE (PSI) | 87 | Cavitation will occur | | |
| FLOW RATE (GPM) | 55.5 | REQUIRED CV | 5.51 | |
| FLUID | WATER [S.G. 1.000] | $\Delta P_{\text{incipient cavitation}}$ | 45.2 | |
| Temperature (°F) | | $\Delta P_{\text{critical}}$ | 67.9 | |

You can see that the temperature field was left blank. The temperature does not affect the required Cv. It only affects the ΔP Incipient Cavitation and ΔP Critical values.

You can also see that the values given to us result in Cavitation. This should be relayed back to the customer.

The value we need for slot sizing is displayed in the "REQUIRED CV" field (5.51 in this example).

| CV DATA (GPM of H₂O at 1 psi ΔP) | | | | | | |
|--|--------------|-------------------------|---------------|---------------|---------------|--------------------|
| Percent Open | Degrees Open | 3/4" Tubing Port (0.62) | 60 V Upstream | 45 V Upstream | 30 V Upstream | 1/8" Slot Upstream |
| 0 | 0.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5 | 4.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 10 | 9.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 15 | 13.5 | 0.05 | 0.05 | 0.04 | 0.01 | 0.10 |
| 20 | 18.0 | 0.22 | 0.09 | 0.07 | 0.04 | 0.21 |
| 25 | 22.5 | 0.38 | 0.14 | 0.11 | 0.11 | 0.31 |
| 30 | 27.0 | 0.43 | 0.21 | 0.14 | 0.16 | 0.41 |
| 35 | 31.5 | 0.57 | 0.36 | 0.25 | 0.25 | 0.51 |
| 40 | 36.0 | 0.87 | 0.61 | 0.47 | 0.47 | 0.64 |
| 45 | 40.5 | 1.27 | 0.86 | 0.63 | 0.62 | 0.87 |
| 50 | 45.0 | 1.60 | 1.07 | 0.83 | 0.77 | 1.14 |
| 55 | 49.5 | 1.93 | 1.60 | 1.07 | 1.02 | 1.37 |
| 60 | 54.0 | 2.40 | 1.87 | 1.42 | 1.41 | 1.56 |
| 65 | 58.5 | 3.20 | 2.58 | 1.81 | 1.70 | 1.74 |
| 70 | 63.0 | 4.13 | 2.94 | 2.21 | 2.07 | 2.02 |
| 75 | 67.5 | 5.53 | 3.93 | 2.65 | 2.37 | 2.20 |
| 80 | 72.0 | 7.20 | 4.39 | 3.31 | 2.85 | 2.43 |
| 85 | 76.5 | 9.40 | 5.61 | 4.17 | 3.47 | 2.68 |
| 90 | 81.0 | 12.20 | 7.44 | 4.99 | 4.10 | 2.86 |
| 95 | 85.5 | 16.27 | 9.38 | 6.21 | 4.75 | 2.99 |
| 100 | 90.0 | 25.00 | 11.98 | 8.46 | 5.00 | 3.11 |

You will select the slot size that will handle the required Cv and offer the most precise control. Usually, that means selecting the smallest slot possible. The tighter the angle, the more precise the control, generally speaking. You also want to allow for a little room over the calculated required Cv. For example, if the required Cv would have been 8.25, we should select a 60° Vee as opposed the 45° Vee.

Actual Gas Example:

Bob,

I don't think the V-ball is the best valve for the application, which Miranda unfortunately didn't describe to you. This valve will be used to control air pressure on a 1" air line. Air in this line will have flow range of 5-10 SCFM

Control Valve

Inlet pressure = 30psig

Outlet pressure = 15psig

If the V-ball is not the appropriate valve, does PBM offer something that would work for this scenario?

30 PSIG = 44.7 PSIA (PSIA = PSIG+14.7)

15 PSIG = 29.7 PSIA

10 SCFM = 600 SCFH (10 standard cubic feet per minute * 60 minutes = 600 std. cubic feet per hour)

Temperature was not given, so we'll assume ambient (~70°F)

TO DETERMINE THE REQUIRED CV:

Select the desired valve size from the following drop-down list:

1" Tubing Port (0.87)

ENTER VALUES (LIQUID)

| | |
|---------------------------|--|
| UPSTREAM PRESSURE (PSI) | |
| DOWNSTREAM PRESSURE (PSI) | |
| FLOW RATE (GPM) | |
| FLUID | |
| Temperature (°F) | |

DO NOT ENTER DATA HERE

| | |
|---------------------------------|------|
| PRESSURE DROP (PSI) | 0.0 |
| REQUIRED CV | #N/A |
| ΔP incipient cavitation | #N/A |
| ΔP critical | #N/A |

ENTER VALUES (SATURATED STEAM)

| | |
|----------------------------|--|
| UPSTREAM PRESSURE (PSIA) | |
| DOWNSTREAM PRESSURE (PSIA) | |
| FLOW RATE (LB/HR) | |

DO NOT ENTER DATA HERE

| | |
|------------------------------|---------|
| PRESSURE DROP (PSI) | 0 |
| REQUIRED CV | #DIV/0! |
| Temp of saturated steam (°F) | #VALUE! |
| | #VALUE! |
| Predicted noise level (dBA) | #VALUE! |

ENTER VALUES (GAS)

| | |
|----------------------------|-------------------|
| GAS | AIR [S.G. 1.0000] |
| UPSTREAM PRESSURE (PSIA) | 44.7 |
| DOWNSTREAM PRESSURE (PSIA) | 29.7 |
| TEMPERATURE (DEGREES F) | 70 |
| FLOW RATE (SCFH) | 600 |

DO NOT ENTER DATA HERE

| | |
|-----------------------------|-------|
| SPECIFIC GRAVITY | 1.000 |
| PRESSURE DROP (PSI) | 15 |
| REQUIRED CV | 0.62 |
| | #N/A |
| Predicted noise level (dBA) | #N/A |

CV DATA (GPM of H₂O at 1 psi ΔP)

| Percent Open | Degrees Open | 1" Tubing Port (0.87) | 60 V Upstream | 45 V Upstream | 30 V Upstream | 3/16" Slot Upstream |
|--------------|--------------|-----------------------|---------------|---------------|---------------|---------------------|
| 0 | 0.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5 | 4.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 10 | 9.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 15 | 13.5 | 0.13 | 0.09 | 0.07 | 0.03 | 0.22 |
| 20 | 18.0 | 0.53 | 0.18 | 0.14 | 0.09 | 0.43 |
| 25 | 22.5 | 0.90 | 0.27 | 0.21 | 0.21 | 0.65 |
| 30 | 27.0 | 1.02 | 0.42 | 0.28 | 0.32 | 0.87 |
| 35 | 31.5 | 1.32 | 0.71 | 0.49 | 0.49 | 1.07 |
| 40 | 36.0 | 2.10 | 1.20 | 0.93 | 0.93 | 1.35 |
| 45 | 40.5 | 3.06 | 1.69 | 1.24 | 1.23 | 1.82 |
| 50 | 45.0 | 3.84 | 2.10 | 1.63 | 1.52 | 2.40 |
| 55 | 49.5 | 4.62 | 3.15 | 2.11 | 2.00 | 2.88 |
| 60 | 54.0 | 5.76 | 3.68 | 2.80 | 2.78 | 3.28 |
| 65 | 58.5 | 7.80 | 5.07 | 3.56 | 3.35 | 3.67 |
| 70 | 63.0 | 9.60 | 5.80 | 4.35 | 4.07 | 4.26 |
| 75 | 67.5 | 12.00 | 7.73 | 5.22 | 4.67 | 4.64 |
| 80 | 72.0 | 17.40 | 8.65 | 6.53 | 5.61 | 5.12 |
| 85 | 76.5 | 22.80 | 11.05 | 8.22 | 6.82 | 5.65 |
| 90 | 81.0 | 29.40 | 14.66 | 9.82 | 8.07 | 6.02 |
| 95 | 85.5 | 39.00 | 18.47 | 12.23 | 9.36 | 6.30 |
| 100 | 90.0 | 60.00 | 23.59 | 16.65 | 9.86 | 6.55 |

The required Cv for the described parameters is practically zero. The 30° Vee (as Bob quoted) is the most appropriate choice. They could use a slot, but 30° Vee is truly the best choice.

Actual Steam Example:

I am working with a customer that would like me to size a steam v-ball valve for the following conditions:

- High temperature service 320PSI / 450F
- inlet pressure 200-300 PSI
- control to 60-90 PSI
- steam flow 200-800lbs/hr
- CS with SS internals
- no actuator, actuator existing
- connection dependent on size, 300LB flanged for 2", BW for smaller, SW OK too

Can you have someone look at the P&T ratings of the SD V-Ball control valve and recommend an appropriate v notch for the given services? I have sized other valves that are in the 1" size and approx. a Cv of 5.0.

We want to ensure that we calculate the maximum possible required Cv. So, we use the lowest upstream pressure, the highest downstream pressure and the maximum flow rate:

200 PSIG = 215 PSIA (PSIA = PSIG+14.7)

90 PSIG = 105 PSIA

800 LB/HR

Also, we usually use "40" for the pipe schedule sizing. It really only affects the Predicted noise level.

TO DETERMINE THE REQUIRED CV:

Select the desired valve size from the following drop-down list:

1" Full Port

Select the pipe schedule from the following drop-down list:

40

ENTER VALUES (LIQUID)

| | |
|---------------------------|--|
| UPSTREAM PRESSURE (PSI) | |
| DOWNSTREAM PRESSURE (PSI) | |
| FLOW RATE (GPM) | |
| FLUID | |
| Temperature (°F) | |

DO NOT ENTER DATA HERE

| | |
|---------------------------------|------|
| PRESSURE DROP (PSI) | 0.0 |
| REQUIRED CV | #N/A |
| ΔP incipient cavitation | #N/A |
| ΔP critical | #N/A |

ENTER VALUES (SATURATED STEAM)

| | |
|----------------------------|-----|
| UPSTREAM PRESSURE (PSIA) | 215 |
| DOWNSTREAM PRESSURE (PSIA) | 105 |
| FLOW RATE (LB/HR) | 800 |

DO NOT ENTER DATA HERE

| | |
|---|-------|
| PRESSURE DROP (PSI) | 110 |
| REQUIRED CV | 3.39 |
| Temp of saturated steam (°F) | 387.9 |
| Sound generated at the outlet is negligible | |
| Predicted noise level (dBA) | 10.1 |

ENTER VALUES (GAS)

| | |
|----------------------------|-------------------|
| GAS | AIR [S.G. 1.0000] |
| UPSTREAM PRESSURE (PSIA) | |
| DOWNSTREAM PRESSURE (PSIA) | |
| TEMPERATURE (DEGREES F) | |
| FLOW RATE (SCFH) | |

DO NOT ENTER DATA HERE

| | |
|-----------------------------|---------|
| SPECIFIC GRAVITY | 1.000 |
| PRESSURE DROP (PSI) | 0 |
| REQUIRED CV | #DIV/0! |
| Predicted noise level (dBA) | #N/A |

CV DATA (GPM of H₂O at 1 psi ΔP)

| Percent Open | Degrees Open | 1" Full Port | 60 V Upstream | 45 V Upstream | 30 V Upstream | 3/16" Slot Upstream |
|--------------|--------------|--------------|---------------|---------------|---------------|---------------------|
| 0 | 0.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5 | 4.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 10 | 9.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 15 | 13.5 | 0.15 | 0.12 | 0.09 | 0.04 | 0.25 |
| 20 | 18.0 | 0.64 | 0.24 | 0.19 | 0.11 | 0.50 |
| 25 | 22.5 | 1.10 | 0.36 | 0.28 | 0.28 | 0.75 |
| 30 | 27.0 | 1.24 | 0.55 | 0.37 | 0.42 | 1.00 |
| 35 | 31.5 | 1.61 | 0.93 | 0.64 | 0.65 | 1.23 |
| 40 | 36.0 | 2.56 | 1.59 | 1.23 | 1.23 | 1.55 |
| 45 | 40.5 | 3.72 | 2.24 | 1.64 | 1.62 | 2.09 |
| 50 | 45.0 | 4.67 | 2.77 | 2.15 | 2.01 | 2.76 |
| 55 | 49.5 | 5.62 | 4.17 | 2.79 | 2.64 | 3.31 |
| 60 | 54.0 | 7.01 | 4.86 | 3.70 | 3.68 | 3.78 |
| 65 | 58.5 | 9.49 | 6.70 | 4.70 | 4.43 | 4.21 |
| 70 | 63.0 | 11.68 | 7.66 | 5.75 | 5.38 | 4.90 |
| 75 | 67.5 | 14.60 | 10.21 | 6.89 | 6.17 | 5.33 |
| 80 | 72.0 | 21.17 | 11.43 | 8.62 | 7.41 | 5.88 |
| 85 | 76.5 | 27.74 | 14.59 | 10.86 | 9.02 | 6.49 |
| 90 | 81.0 | 35.77 | 19.36 | 12.97 | 10.66 | 6.92 |
| 95 | 85.5 | 47.45 | 24.40 | 16.16 | 12.37 | 7.24 |
| 100 | 90.0 | 73.00 | 31.16 | 22.00 | 13.02 | 7.53 |

The maximum required Cv for the described parameters is 3.39. The 3/16" slot would be the best choice, but a 30° Vee would work, too.

Notes:

Often, flow rates will be given in units other than what we have in the spreadsheet. If you need help calculating a conversion that is not calculable in the Convert program, contact your Engineering representative.

Lastly, a word about cavitation:

Cavitation is the formation of vapor cavities in a liquid – i.e. small liquid-cavitation-free zones ("bubbles" or "voids") – that are the consequence of cavitation forces acting upon the liquid. It usually occurs when a liquid is subjected to rapid changes of pressure that cause the formation of cavities where the pressure is relatively low. When subjected to higher pressure, the voids implode and can generate an intense shockwave.

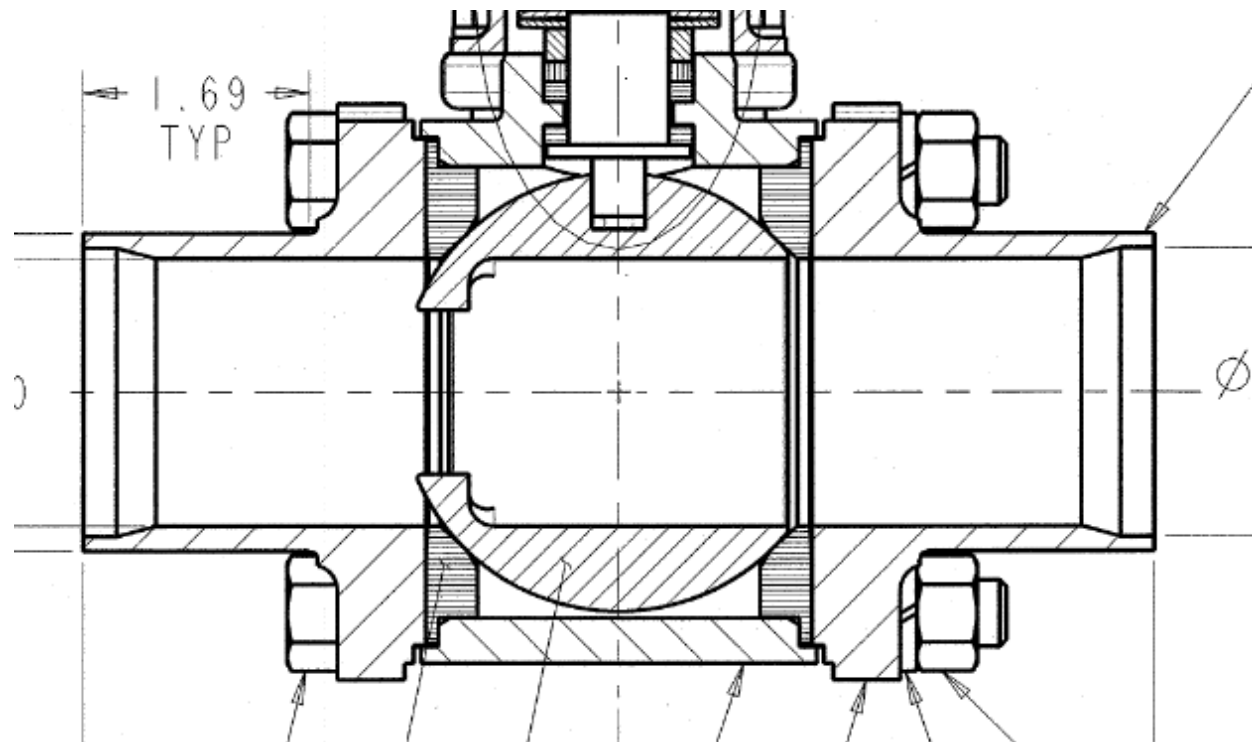
Cavitation is a significant cause of wear in some engineering contexts. Collapsing voids that implode near to a metal surface cause cyclic stress through repeated implosion. This results in surface fatigue of the metal causing a type of wear also called "cavitation". The most common examples of this kind of wear are to pump impellers, and bends where a sudden change in the direction of liquid occurs.

Since the shock waves formed by collapse of the voids are strong enough to cause significant damage to moving parts, cavitation is usually an undesirable phenomenon. It is very often specifically avoided in the design of machines such as turbines or propellers, and eliminating cavitation is a major field in the study of fluid dynamics.

Control valves

Cavitation can occur in control valves. If the actual pressure drop across the valve as defined by the upstream and downstream pressures in the system is greater than the sizing calculations allow, pressure drop flashing or cavitation may occur. The change from a liquid state to a vapor state results from the increase in flow velocity at or just downstream of the greatest flow restriction which is normally the valve port. To maintain a steady flow of liquid through a valve the flow velocity must be greatest at the point where the cross sectional area is the smallest. This increase in flow velocity is accompanied by a substantial decrease in the fluid pressure which is partially recovered downstream as the area increases and flow velocity decreases. This pressure recovery is never completely to the level of the upstream pressure. If the pressure at the point where the cross sectional area is the smallest drops below the vapor pressure of the fluid, bubbles will form in the flow stream. If the pressure recovers after the valve to a pressure that is once again above the vapor pressure, then the vapor bubbles will collapse and cavitation will occur.

FLOW



As the media flows through the slot, pressure increases. Immediately after the slot, the pressure decreases rapidly. Our valves are designed for the V-slot to be upstream. If cavitation occurs, it should be within the ball, not the system piping. Balls are easier to replace than piping.