Content

1. INTRODUCTION

Mitech designs and manufactures a range of specialised retainers and devices to control or eliminate various problems encountered in process plants such as noise, cavitation, flashing, erosion and corrosion. The range of trims, chokes, diffuser plates and other devices for cavitation and noise control backs up Mitech's standard control valves. These associated devices and the control valves are available in materials selected for their resistance to cavitation, flashing, wear and corrosion.

2. THE CAUSE OF CAVITATION AND FLASHING

The term "Cavitation" refers to the formation of vapour bubbles in a liquid when the pressure in the liquid drops below the vapour pressure and their subsequent collapse where the pressure recovers above the vapour pressure. These vapour bubbles can cause damage to any surface near where the collapse takes place.
It is possible to predict when cavitation will occur by looking at pressure conditions and valve recovery factor only but it is important to recognise that the damage that occurs is dependent on the energy being dissipated and so it is flow dependant. It can happen that bubbles form near the plug and seat restriction but due to the downstream pressure being lower than the vapour pressure they do not collapse but persist and travel downstream. This condition is called "Flashing". Initially the flow can be considered as bubbles of vapour in a liquid flow, but as bubbles increase in size and number, the flow changes to droplets of liquid in a vapour flow. Due to the high velocities generated (able to reach sonic), these droplets are extremely abrasive and can erode any valve components with which they come into contact.

3. METHODS OF COMBATING CAVITATION AND FLASHING

3.1. Increase the life of the valve by making the vulnerable components more wear resistant.
3.2. Control where the vapour bubbles collapse keeping them away from the body and trim – Install Cavitation Control Retainer.
3.3. Ensure that the internal pressure of the fluid does not fall below the vapour pressure eliminating the formation of vapour bubbles – Install ZZ or ED disk stack trim.

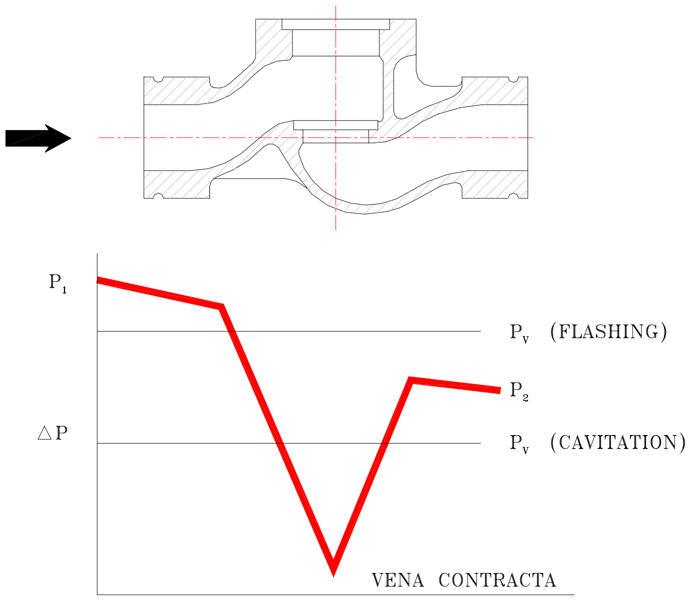


Figure 1: *Flow through a control valve*

4. PLUG AND SEAT MATERIAL

The severity of the valve conditions determines the material needed to prevent damage occurring to the plug and seat. Most severe service applications require the plug and seat to be stellite coated as this material is more wear resistant than stainless steel and therefore promotes longer life of the internals. Solid tungsten carbide can also be used where even greater wear resistance is required.

5. SELECTION STRATEGY FOR LIQUIDS

Simple cost saving devices are usable when conditions are not severe. These conditions occur when pressure drops are low and valve sizes small. Downstream Orifice plates can be used to increase the backpressure on the valve. Special materials for the plug and seat are also recommended.
For more severe conditions Mitech offers a range of trims that are capable or controlling and eliminating cavitation.
As a guide, figure 2 can help you ascertain what the condition of the application is like and what trims and materials are recommended to prevent damage.

$P_1 / P_2 > 3$

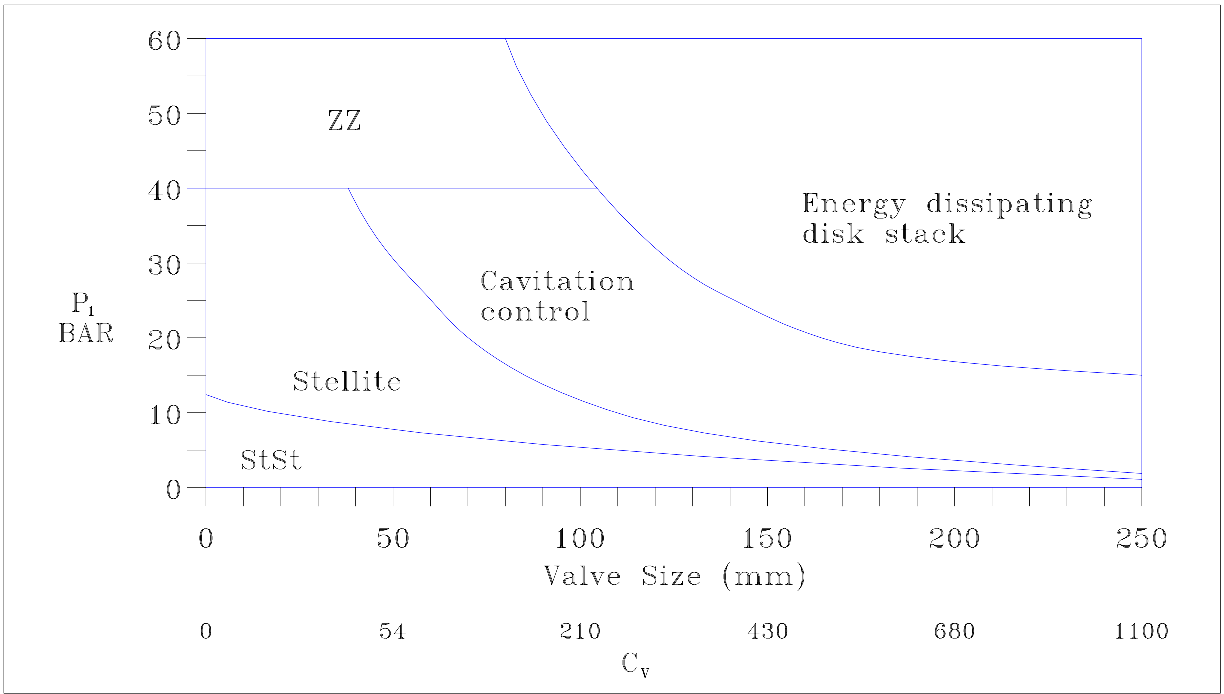


Figure2: Trim *Selection Guide : Liquid Applications*

Consulting figure 2, it is evident that a 100mm size valve operating at a pressure of 4 Bar down to 1 Bar falls under the stainless steel curve indicating that the standard seat retainer, seat ring and plug can be used without any additional device because operating conditions are not severe. If the pressure is 10 Bar down to 1 Bar on the same valve the operating point lies in the stellite region indicating that the plug and seat surface should be stellite treated to have harder surfaces. It is however still permissible to use a standard seat retainer. Increasing the upstream pressure for the above valve to 20 Bar will make conditions more severe and brings the operating point into the "cavitation control" area which calls for the use of additional devices to prevent cavitation damage.

Figure 2 is a guideline to the various Mitech trims and materials available to combat process conditions in liquid applications and therefore the graph must be treated as purely a guideline as in the sizing process more factors will be taken into account to establish the severity of the possible damage.

6. ENERGY DISSIPATING DOUBLE Z TRIM

Energy Dissipating ZZ Trims are used to gradually reduce the energy of the incoming liquid to prevent cavitation. This is achieved by ensuring that the internal pressure of the liquid never falls below the vapour pressure. The energy is dissipated through friction and abrupt direction changes when the fluid moves through the ZZ passages of the retainer. The double Z trim should only be used for valves from 25mm to 80mm with the correct operating conditions.

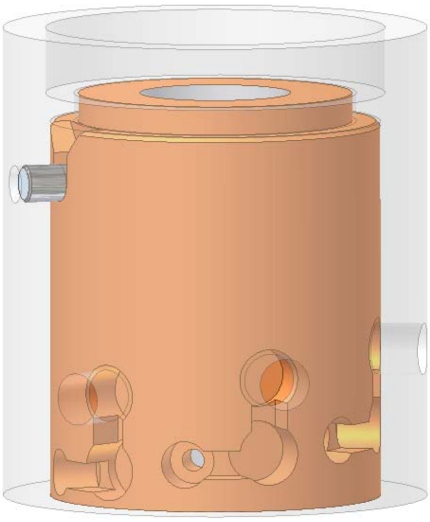


Figure 3: *ZZ TRIM*

Performance of Valves with Energy Dissipating Double Z Trims

Body Size	25mm	40mm	50mm	80mm
P1 / P2 Max	Maximum Cv			
15	5	9	14	29
50	3	5	8	17
100	1.3	2	3	10

Advantages	Disadvantages
Eliminates cavitation	Used only on clean liquids
Flow direction can be over or under the plug	Not suitable for large Cv values. Suitable only up to 80mm valves
Can handle very high pressure drops at low flows	Smallest Cv = +/- 1.0
Can be combined with cavitation control resulting in high rangeability (200: 1)	Each trim is specially designed to suit application

7. ENERGY DISSIPATING DISK STACK TRIM

Disk stack trims are needed in conditions involving high-pressure drops and high flow rates. As the liquid moves through the passages in the trim stack the energy is dissipated through wall friction, swirling, sharp direction changes and a series of expansion chambers and restrictions.
The total pressure drop is distributed over a series of restrictions so that the pressure drop over any stage is never so severe as to cause the internal fluid pressure to drop below the vapour pressure of the fluid. Bubbles do not form and consequently there are no bubbles that can cause damage when collapsing. Each disk in a stack is designed to handle the full pressure drop of the application but with only a percentage of the total flow. The number of disks will determine the total flow capability. If the pressure drop across the valve varies with flow then the disks will require a different design at the bottom and the top, and maybe in the middle. Which is achieved by installing a bi-linear & tri-linear characteristic.
The same principles used on liquids to prevent cavitation are also used for high-pressure drop applications on gases to reduce noise levels. By converting the high potential energy upstream directly into heat, high velocities are avoided, and so less noise is generated. The main mechanisms used in the case of gases and vapours to prevent excessive noise are contraction and expansion, with skin friction and changes of direction assisting the process. The flow is divided into many small streams and each path consists of a series of restrictions in which the gas contracts followed by expansion chambers.

Performance of Valves with Energy Dissipating Disk Stack

Body Size	80mm	100mm	150mm	200mm	250mm	300mm	400mm
P1 / P2	Cv Fully Open						
5	60	100	210	350	576	800	1200
10	27	45	105	169	288	427	600
20	12	24	52	84	144	227	320
40	5.5	13	25	41	75	113	160

Advantages	Disadvantages
Can be used for cavitation elimination on liquids and low noise on gases	Capacity (Cv) of valve is reduced compared with standard valve
Can be separated and cleaned due to loose disk design	Not suitable for small Cv valves (Min Cv = 10)
Can handle very high pressure drops at high flows	Special design to suit application
Flow direction on liquids can be over or under the plug	Flow direction on gases must be only under the plug

Since each stack is designed to suit the application it is recommended that the Mitech design engineers are consulted at an early stage of investigation.

Figure 4: *Single ED Disk*

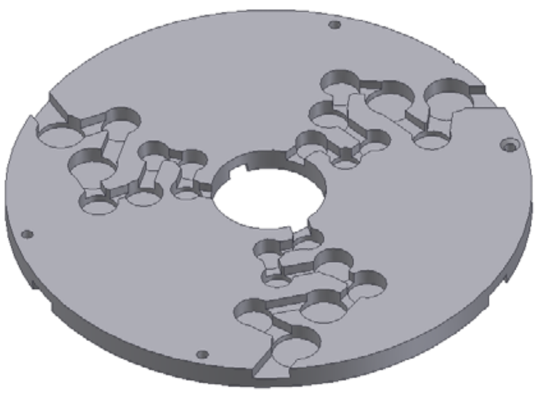
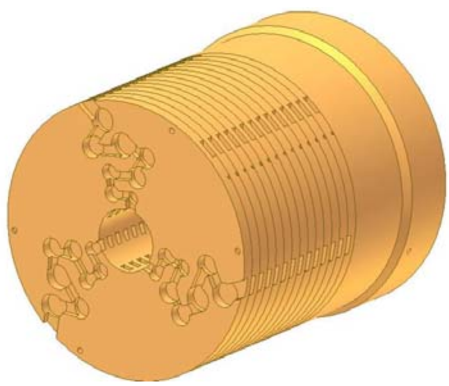


Figure 5*: ED Disk Stack*



8. CAVITATION CONTROL RETAINER

When trying to prevent damage to the plug and seat a cavitation control retainer should be used inside the control valve. This type of retainer has many holes in its wall, which are covered or uncovered by the plug head as it moves up and down. With the flow from the outside of the retainer towards the centre, these orifices form jets of fluid that meet in the middle of the retainer. The pressure drop occurs across these holes and bubbles will form as the flow exits form these holes. The pressure recovers where all the streams meet – away from most of the components of the valve. The plug head and the bore of the seat ring are hard faced with stellite to reduce cavitation damage. Provided there is sufficient backpressure to collapse the bubbles inside the retainer the valve body will be protected.

Cavitation control retainers control where cavitation will take place.

By utilising a pattern of small holes at the lower part of the retainer and larger holes towards the top a bi-linear characteristic can be attained which increases the rangeability of the valve.

Performance of Valves with Cavitation Control Retainer

Body Size	**50mm**	**80mm**	**100mm**	**150mm**	**200mm**
P1 / P2 Max	Maximum Cv				
6	50	115	190	390	645

Advantages	**Disadvantages**
Works well over wide range of conditions	Needs clean liquid
Fits in standard valve – only new plug seat and retainer	Flow direction is only over the plug
No real loss in Cv relative to standard trim	Smallest Cv = +/- 5.0
Cost effective	Cavitation not eliminated therefore not suitable for high energy dissipating applications

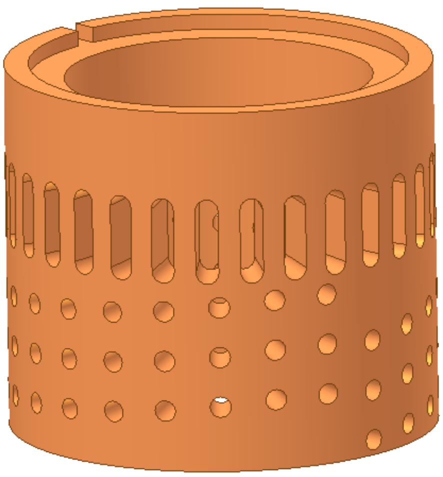


Figure 6: *Cavitation control with slots and holes*

9. LOW NOISE TRIM

Noise in control valves is generated by high velocity vapour or gas. High pressure upstream converts to high velocity inside the valve when the downstream pressure is low, unless intermediate devices such as low noise trims, double Z retainers and disk stacks absorb the energy. Since low downstream pressure leads to high noise an additional strategy to abate noise is to increase the intermediate pressure by a second downstream pressure reducing device, such as a diffuser plate and to drop the total pressure in more than one stage.

Mitech's Low Noise Trims feature a low noise retainer in which pressure is dropped across one or more restrictions. These trims are fitted in standard valve bodies to produce low noise valves, where noise level can be reduced by from 5 to 15 dBA.

Essentially a low noise retainer comprises a noise-reducing retainer combined with a robust plug and seat ring. The noise reducing retainers are available as one, two or three stage units and are fitted above the seat ring in the gallery of the valve. Each stage is a tube with many small holes drilled all around the tube wall.

By dropping some pressure between the plug and seat and some across the retainer it is possible to contain the velocity to a lower level and so reduce the noise generated.

Performance of Valve with Low Noise Trim

Size	Seat Diameter (mm)	Cv @ 100%	No. of Stages	Stroke (mm)
40	32	29	1	25
50	41 25	46 25	1 2	38 19
80	66 41 32	106 50 36	1 2 3	50 38 25
100	90 66 41	190 120 62	1 2 3	64 50 38
150	127 90 76	400 240 180	1 2 3	76 69 50
200	160 127 90	630 510 260	1 2 3	100 76 64

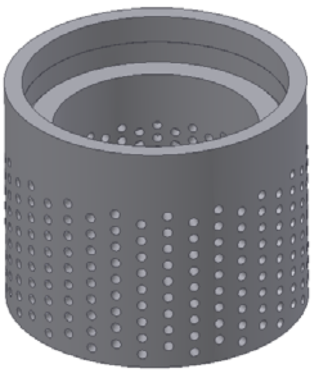
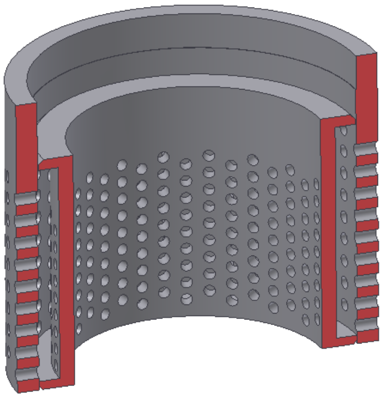


Figure 7: *2 stage Low Noise Trim*



10. RESTRICTION PLATES

10.1. Diffuser Plates (gases)

A diffuser plate increases the backpressure to the control valve when installed immediately downstream of the valve. Reducing the pressure drop across the control valve and increasing the backpressure will decrease valve gas velocity and noise generated in the immediate vicinity of the valve. One or more diffuser plates or multistage diffusers should be installed immediately downstream of the valve if the required P1 / P2 ratio exceeds the maximum for which the valve is intended

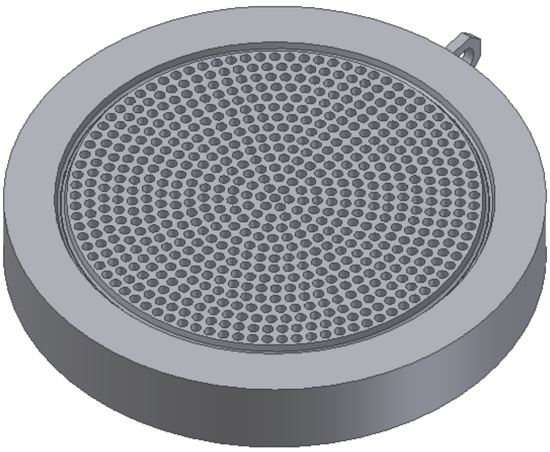
The diffuser plate is a disk with many holes drilled through the middle portion and which must be fitted between adjacent flanges in a pipeline. The size given to a diffuser is nominal and is the size of the pipeline or flanges in which it must be fitted. Its actual outside diameter is made to observe a suitable clearance between the flange bolts and the plate perimeter.

When considering whether or not and how a diffuser should be used it must be noted that the pressure drop over the diffuser plates decreases drastically as the flow rate reduces, and will only be fully effective at the maximum flow rate for which it is designed.

For initial sizing purposes, the pressure drop across the plate must be no more than 25% of total pressure drop with velocity max at .18 Mach.

The table below can be consulted for available sizes, Cv values and max pressure ratios.

Plate Size (mm)	1st Stage - Max Cv	2nd Stage - Max Cv	3rd Stage - Max Cv
50	25	18	15
80	62	40	34
100	105	75	58
150	215	160	130
200	390	280	225
250	600	430	350
300	860	610	500
400	1540	1150	900
500	2400	1720	1400



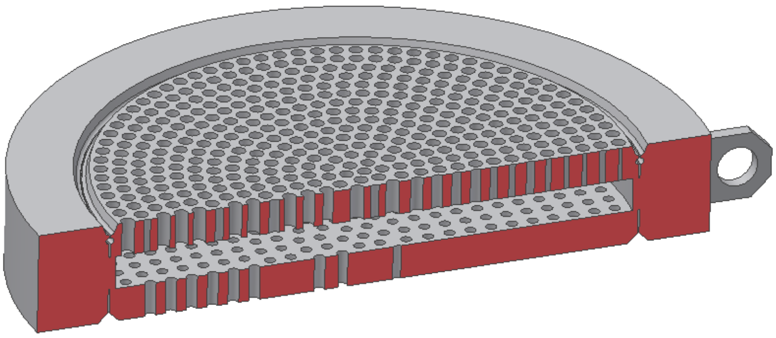


Figure 8: *Double Diffuser Plate with housing*

10.2. ORIFICE PLATE (Liquids)

When the actual pressure drop is a little higher than that recommended for a certain trim type by the curves of figure 1, it may be cost effective to reduce the pressure drop across the valve by installing a Mitech orifice plate downstream of the valve, thereby increasing the valve back pressure and consequently reducing the formation of vapour bubbles inside the valve.

Such a orifice plate may even be used on a high-pressure drop control valve incorporating an elaborate cavitation control device to improve its operating conditions. For modulating duties the choke can be installed at any point downstream of a valve. In many cases the best point is at the end of a line if it is discharging into an open vessel. Orifices shall preferably not be installed immediately upstream of any other device or an elbow. For on / off duties it is recommended that the choke shall be installed close to the valve.

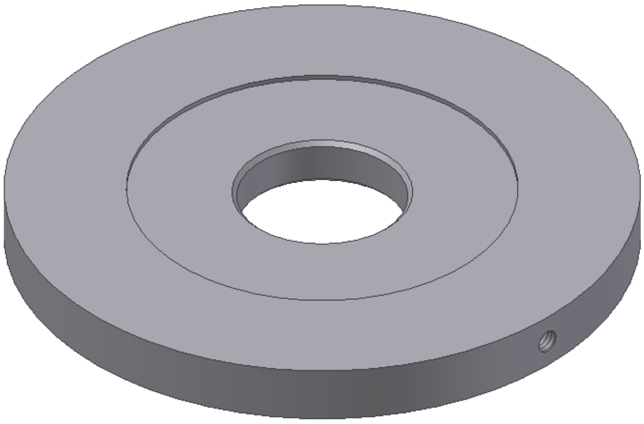


Figure 9: *Orifice Plate*

11. RETROFIT

The valve body represents a significant part of the cost and is responsible for most of the lead-time of a large globe control valve. In many cases when an existing valve needs to be replaced in a plant the body is still in good condition but the trim is no longer suitable or in good condition. In these cases Mitech can offer a retrofit service where it will fit new internals and top works to the original valve body. The trims will be designed to suit the application. Materials will be chosen to ensure safe operation and long life. Below 150mm or 600# the cost of retrofitting generally will not be justifiable but with larger sizes and high pressure rating valves, it becomes progressively more worthwhile.

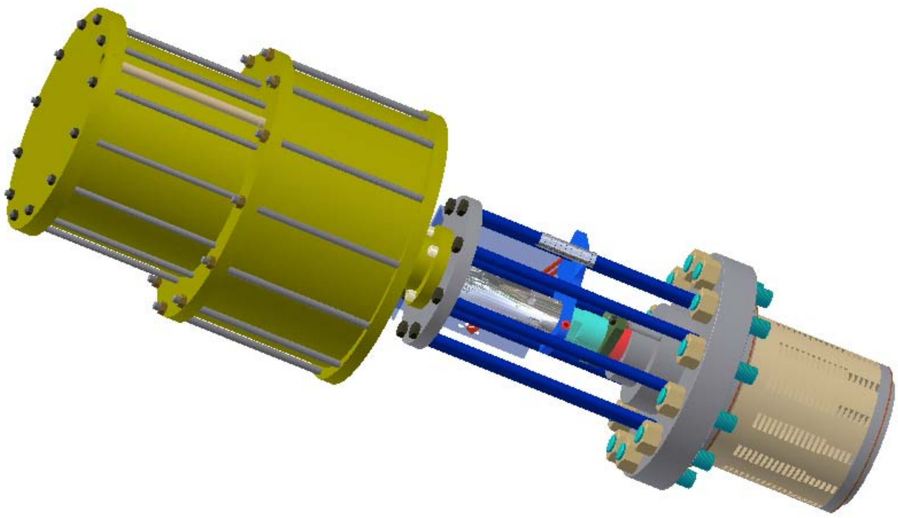


Figure 10: *Mitech Actuator and Energy Dissipating Disk stack to be fitted to existing body*