Varying Area Diffuser

VAD

The new approach to controlling flow, attenuating noise & dealing with cavitation.

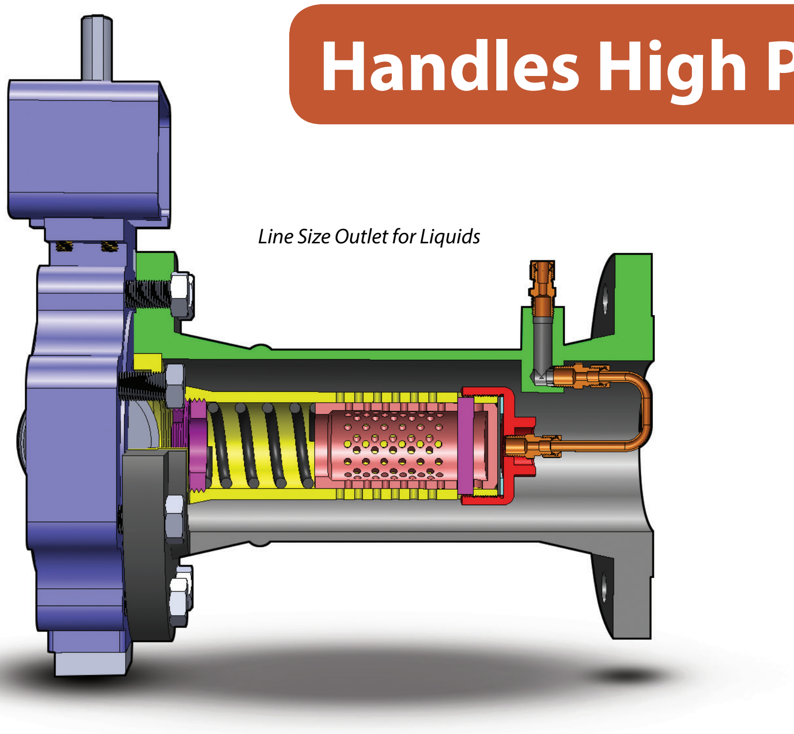
Patent applied for

YearyControls
Innovative Valve Technolgies

Varying Area Diffuser "VAD"

- **The new approach to controlling flow, attenuating noise, and dealing with cavitation.**
- **By taking up to 85% of the system pressure drop through the VAD, wear and tear on the throttling valve's trim is significantly reduced, allowing for simpler, less expensive, and more available valves to be used for control applications.**
- **By maintaining a very low, fixed pressure drop across the throttling valve, it can even turn butterfly and ball valves into excellent control valves capable of handling high pressure drops, noise, and cavitation.**

Handles High P



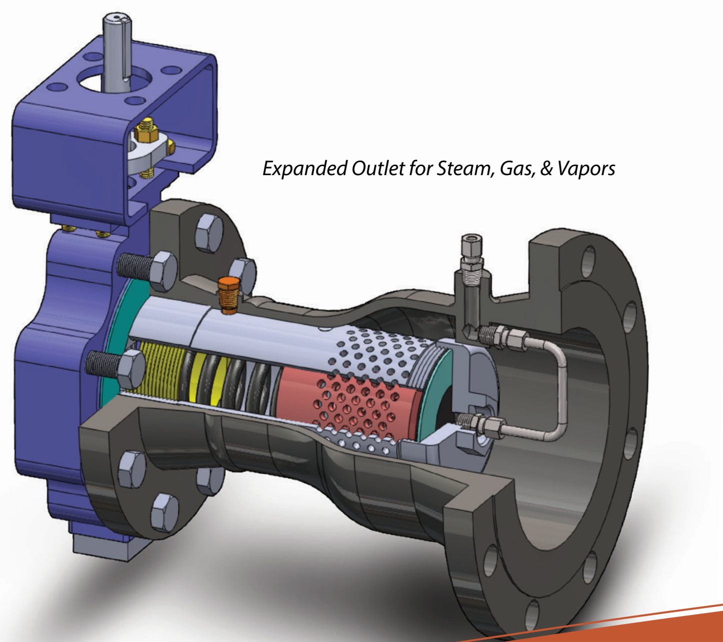
Saves Space & Stays Efficient

Excellent Control

A Varying Area Diffuser ("VAD") is an ideal control valve accessory, especially in systems that are subject to wide and sudden upsets. The force generated by the VAD's spring causes the size of every flow opening in its diffuser cylinder to vary in tandem, so as to maintain a nearly constant pressure drop across the control valve. And, by instantly responding to upsets in the system, the need for controller re-tunings will be significantly reduced.

Instant Response

VAD's respond very quickly to process changes because the total travel of the flow control piston is only equal to the diameter of one of its diffuser holes. By instantly reacting to the system's minor upsets, a VAD will provide for a more stable control loop with less controller tuning, because now the control valve will only need to deal with significant flow changes.



ressure Drops & Decreases Noise and Cavitation!

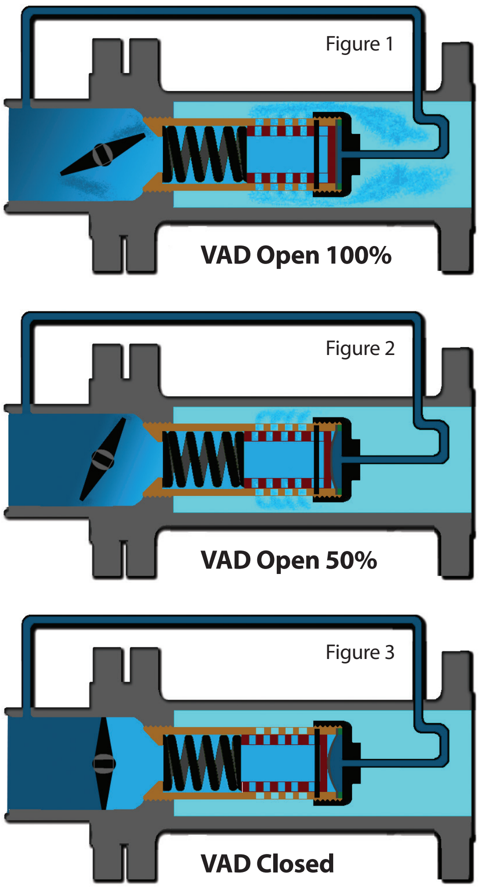
How a VAD Works

A VAD is an automatic, force-balance, differential pressure regulating device.

When a VAD is at rest (Figure 1), and before pressure is introduced into the system, its differential spring is pushing the head of the sliding cylinder against the diaphragm, located in the empty sensing chamber.* In this position the diffuser holes in the sliding cylinder and the fixed outer cylinder will be aligned and the device will be fully open. Then, when process pressure is introduced upstream of the still closed main control valve, it also will be introduced into the VAD's diaphragm chamber via the sensing line which will force the sliding piston to compress the differential spring and cause the sliding piston to move back in the direction of the primary control valve thereby covering-up the holes in the fixed outer diffuser to shut-it-off to flow (Figure 3).

On system start-up, the process controller signals the primary control valve to open which allows the fluid to flow into the VAD. When the pressure of the fluid, aided by the spring, creates enough force for the sliding cylinder to overcome the opposing force generated by the upstream pressure in the diaphragm chamber the VAD will open to allow flow into the downstream pipe (Figure 2). Therefore, whenever the reduced pressure from the primary control valve plus that of the differential spring is enough to overcome the opposing force in the diaphragm chamber, all of the holes in the sliding cylinder will begin opening in tandem to throttle flow across the orifices in the outer, fixed diffuser. Conversely, when the force generated by the pressure in the diaphragm chamber exceeds the combined forces of the sliding cylinder and its differential spring, the VAD will begin moving in the opposite direction to reduce and eventually shut-off the flow. An adjustable spring is used to set the desired pressure across the control valve.

*NOTE: A sealed piston is used for operating conditions that exceed pressure and temperature ratings of available diaphragm materials.



VAD Uses

Control Valve Performance Enhancement

VAD's can be used to convert ordinary on-off valves into excellent control valves.

Money Saving Alternative

VAD's can be used as an alternative to costly severe service control valve trims; silencers; and multiple stage diffuser plates.

Noise & Cavitation Control

VAD's can be used as a single, or multi-staged downstream control valve accessory to reduce noise and the effects of cavitation in pressure reducing, and in back pressure control applications.

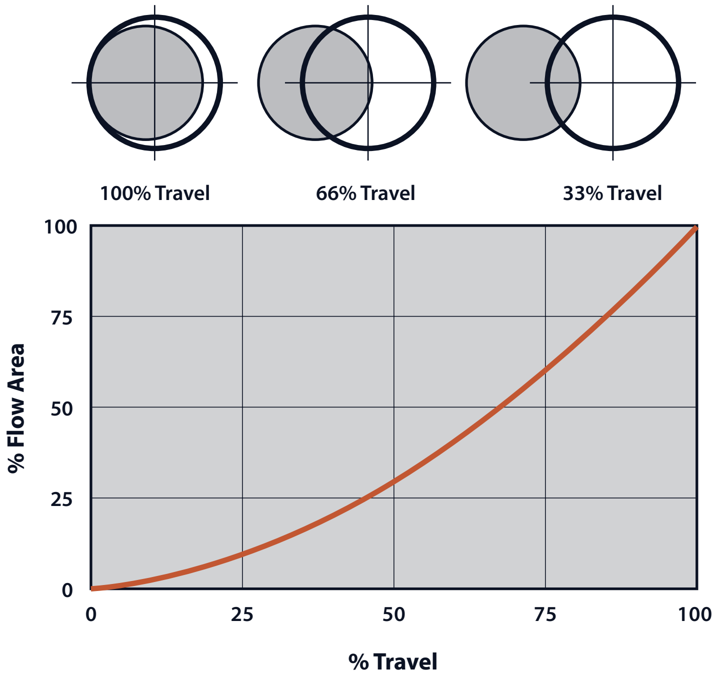
Flow Regulation

VAD's can be used to convert valves into constant flow regulators.

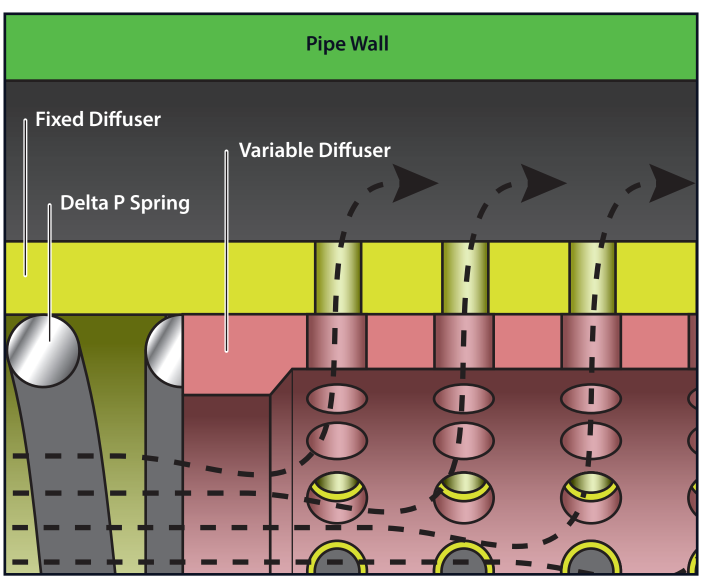
Performance Benefits

- **Excellent Control & Instant Response**
- **Nearly Constant Pressure Recovery (F_L)**
- **Equal Percentage Characteristic**
- **High Turndown Ratio (50:1)**
- **Saves Space & Stays Efficient**
- **Location Friendly**
- **Cost Effective & Easy Installation**
- **Fits all Valves**

Principle of Variable Area Technology

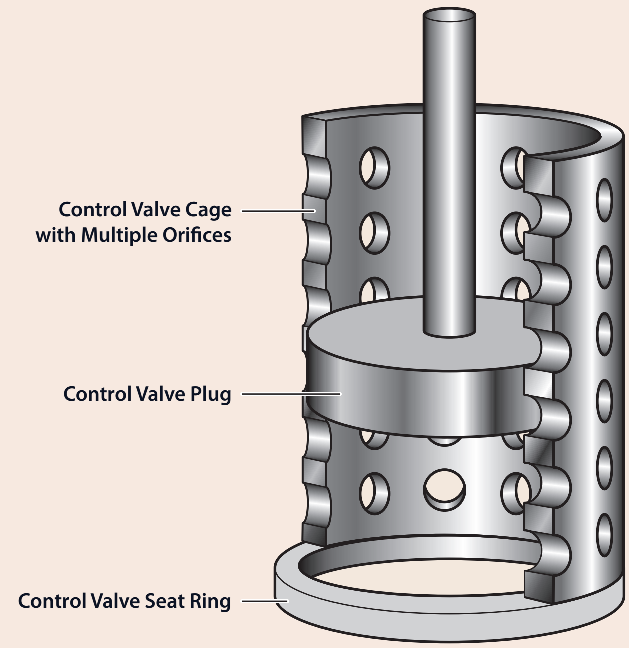


Flow Pattern of VAD



Jet Velocity Cleaning Effect

The very high jet velocity through the holes in the VAD will tend to keep them clean and free from scale build-up. In addition, the surfaces of the fixed diffuser and the variable diffuser are hardened to enhance the shearing of particles in the fluid.



Typical Severe Service Control Valve Trim

Unlike the VAD, which automatically adjusts its hole sizes for maximum efficiency, typical severe service control valves open and close, rows of fixed area orifices.

Typical Severe & Special Services

- Cavitating Liquids
- Noise Reduction in Gas, Steam, & Vapor
- Two Phase Fluids
- Cryogenic Liquids & Gasses
- Fire Safe Shut-off plus Control
- Metal to Metal Tight Shut-off plus Control

Typical Standard Services

- Pump By-pass Control
- Pressure Reducing
- Back Pressure Control
- Compressor Surge Control
- Flow Control & Balancing
- Ballast Water Flow Control
- Overboard Discharge
- Fire Water Ring Control
- Brine Blowdown
- Jetty Loading Control
- Sea-Water Re-Circulation & Drain
- Cooling Tower Bypass
- Brine Well Injection
- Steam Condensor Inlet
- Steam Venting
- Natural Gas Pressure Control

Industries Served

- Oil & Gas Production
- Refining Storage/Transmission
- Electric Power Generation
- Chemicals & Petrochemical
- Textiles
- Pulp & Paper
- Mining & Metals
- Micro-Electronics
- Pharmaceutical & Biotech
- Water Pumping & Transport
- Office Buildings & Hotels
- Water Treatment
- Aircraft, Aerospace, & Military
- Ship Building & Marine

VAD Sizing & Set-up

The VAD is Ideal for Most Applications

Almost any style of valve (butterfly, ball, globe, etc.) can be made to provide excellent control by combining it with a VAD.

Pressure Reducing or Back Pressure Control

When a VAD is used for either pressure reducing, or for back pressure control, it is installed downstream of the primary control valve, which is responding to the signal output of the process pressure controller.

A sensing line is run from the pipe upstream of the primary control valve into the diaphragm chamber port connection on the VAD. The upstream pressure in the diaphragm chamber will now be opposing the combined forces of the valve outlet pressure, plus the constant spring force, that is inside the sliding cylinder. As the control valve modulates flow into the VAD, these opposing forces will cause the cylinder to move back and forth to vary the size of the VAD's holes, to automatically hold a nearly constant pressure drop across the control valve, independent of upstream or down-stream pressure variations.

Flow Control

The same set-up described above, is used for constant automatic flow regulation. The primary control valve can now be adjusted either manually, or automatically to pass the desired flow because the VAD will be holding a constant pressure drop across the valve which serves as a fixed orifice.

Downstream Pipe Sizes

Liquids

For liquid application, where there is no flashing, the VAD can be installed in a downstream pipe of identical size as the pipe leading to the control valve.

Vapors

When gases, steam or flashing liquids are controlled, the VAD typically is installed in a larger downstream pipe owing to the volume increase caused by the expanding gas.

Note: To save piping cost, one may install the VAD directly into the downstream pipe; or into the vessel, tank, or reservoir.

Advantages for Control Loops

A major advantage of using a Control Valve/VAD system is that in critical control loops the VAD will automatically take care of the small instabilities or up-sets which then allows for the Control Valve to only need to respond to major up-sets or load changes. This makes frequent re-tunings of the controller unnecessary. Another important advantage of a VAD is that it can respond in milliseconds making it ideal for fast loop installations, or when emergency shut-downs are required. In the latter case a faster valve closure is possible due to a low pressure drop being required across the valve making it easier for the valve's actuator to respond.

Specifications for VAD Sizing

A VAD allows for taking a much lower pressure drop across the control valve. Therefore, in most applications, the primary throttling control valve will be sized to have three times the capacity of the VAD.

Control Valve Selection Up-stream of VAD

- Rated pressure drop should be 15% to 25% of P1-P2
- Cv of valve should be three times the Cv of the VAD

Liquid Services

- Both the inlet pipe size to the VAD, and its outlet pipe size can be the same.

Gas & Steam Services

- The VAD's outlet pipe size may need to be enlarged to avoid excessive velocity (above 250 feet per second).

Severe Service Options

- Multiple diffuser stages
- Additonal downstream fixed diffuser plates

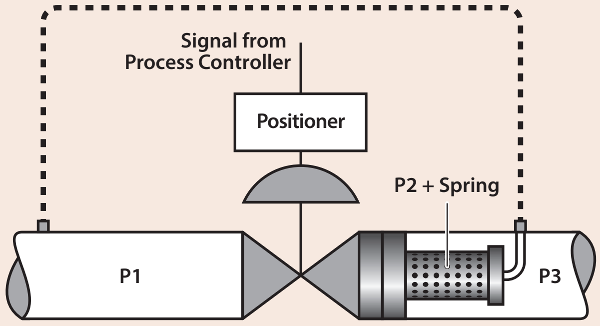
VAD Sizing Information

Inlet Diameter*	VAD Diameter	VAD C_V	F_L	X_{FZ}	Sound Level dBA**
2	1	15	0.99	0.50	76
3	2	35	0.99	0.40	77.5
4	3	72	0.99	0.33	79
6	4.5	170	0.99	0.30	80
8	6	325	0.99	0.25	82
10	7	550	0.99	0.20	84
12	8	980	0.99	0.17	86
14	9	1200	0.99	0.16	87
16	12	1380	0.99	0.16	89

**Above based on 50% of rated Cv with water at 100 psig inlet and 1 psig outlet pressure

Typical PRV Set-up

VAD with wafer body allows for insertion into downstream pipe.



Exceptional (0.99) Pressure Recovery Factor (FL)

Most low noise control valves use cylindrical cages containing rows of fixed slots, or round holes, that are opened and closed one row at a time. A VAD, on the other hand, automatically varies the opening of every orifice simultaneously to provide maximum noise and cavitation reductions from full open to closed.

Equal Percentage Characteristic

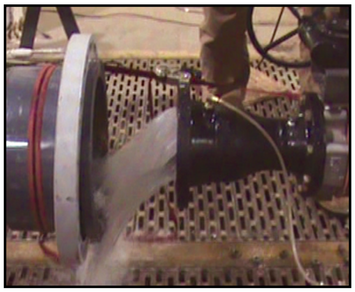
As the inner cylinder travels, it changes the shape of the VAD's openings in such a way as to produce an equal percentage flow characteristic.

High Turndown Ratio (50:1)

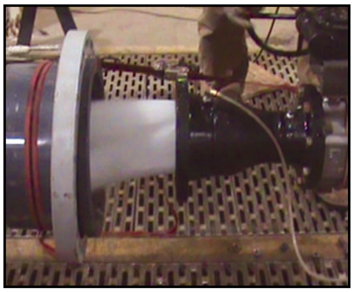
The VAD effectively attenuates noise, and reduces the effects of cavitation, over flow rate changes as high as 50:1, as compared to the 2:1 turndown efficiency of fixed area downstream flow restrictors.

Location Friendly

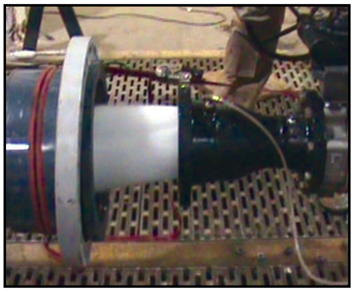
VAD's can be installed away from the primary control valve, such as in less noise sensitive or more convenient areas. For example: inside a flash tank; inside a vessel; underground; or in a well.



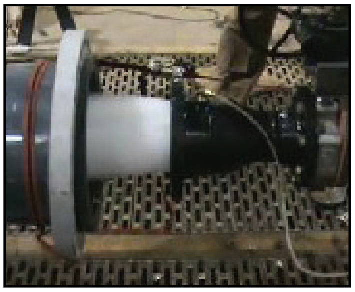
VAD Flow Pattern at 10% Open



VAD Flow Pattern at 33% Open

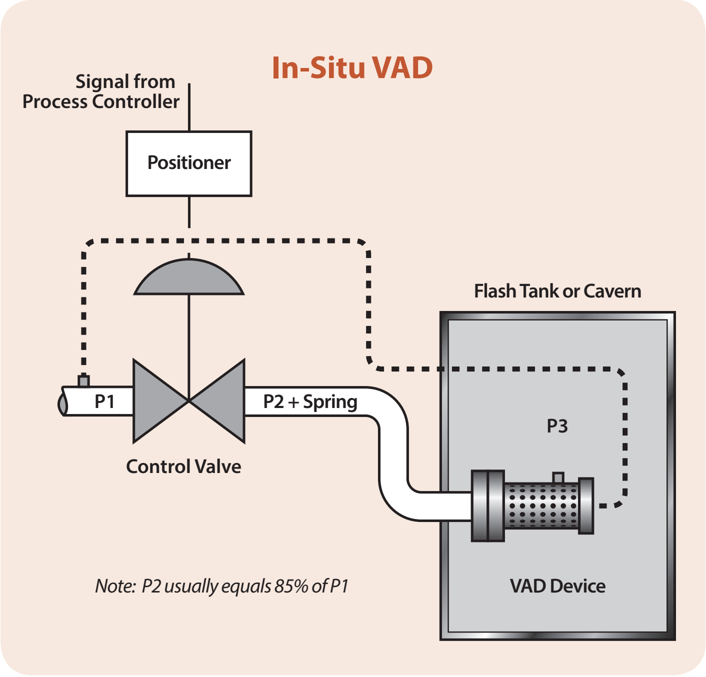


VAD Flow Pattern at 66% Open

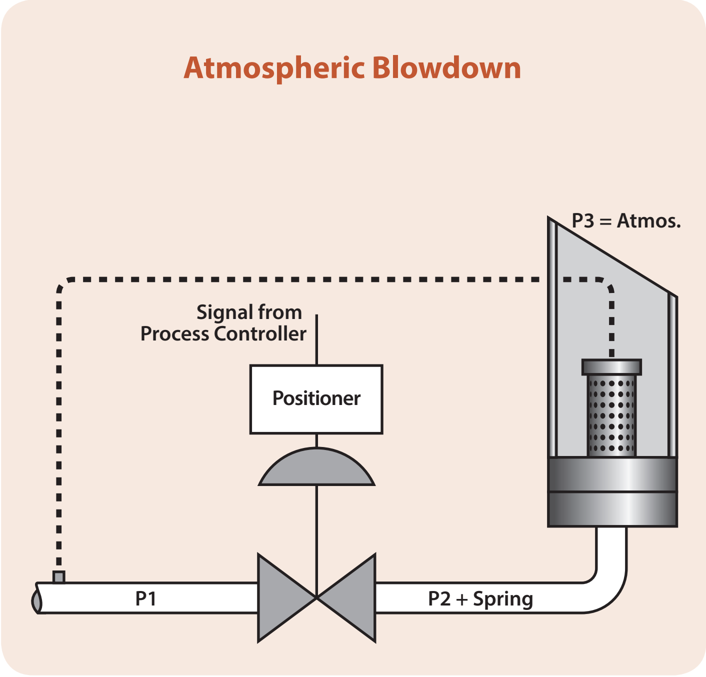


VAD Flow Pattern at 100% Open

Note: Above test conditions: Inlet = 105 psi, Outlet = Atmosphere

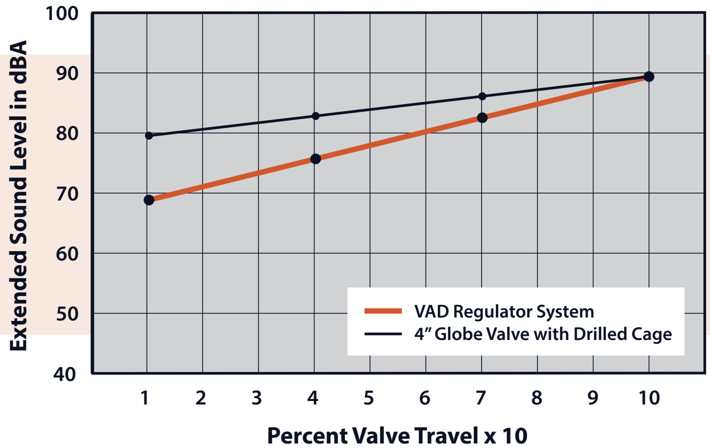


"In-Situ VAD" illustration, above, shows how a VAD can be placed at a distance from the main control valve providing the pressure upstream of the control valve can be piped into the VAD's diaphragm chamber.



"Atmospheric Blowdown" illustration, above, shows how a VAD can reduce the required pressure drop across the on-off blowdown valve while also attenuating the noise level at the discharge point.

Variable Orifice Sized Trim vs. Fixed Dia. Holes



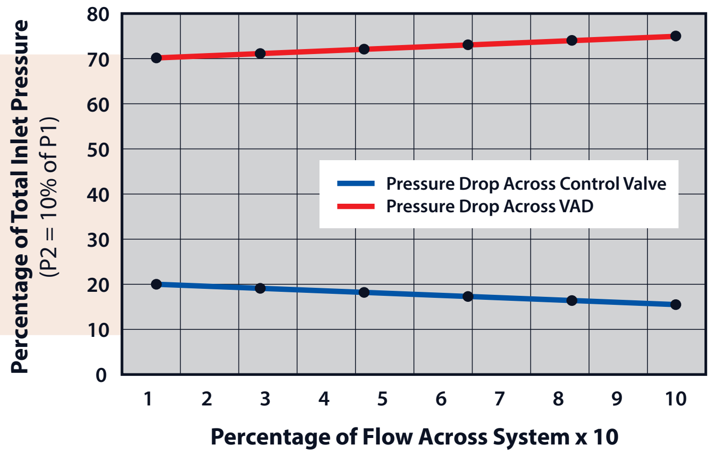
Effect of VAD's Variable Area Flow Passage on Areodynamic Noise

In this example, the VAD system is up to the 10 dB less noisy than the cage trim.

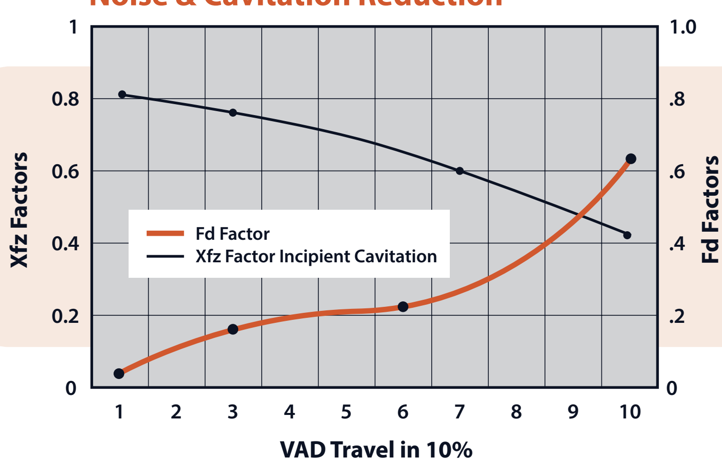
Note: Fluid air, P1 = 100 psig, P2 = 30 psig, Cv maximum = 194

Distribution of Total Pressure Between Control Valve & Variable Resistance Trim

In this example, there is nearly constant high pressure drop across the low-noise VAD and very little pressure loss across the control valve.



Noise & Cavitation Reduction



Effect of Variable Resistance on Noise and Cavitation Reduction

In this example, data shows that at 75% travel, the VAD design having an Xfz factor of 0.55 can reduce 55% of the absolute inlet pressure of water, compared to only 22% with a conventional globe valve, without experiencing incipient cavitation.

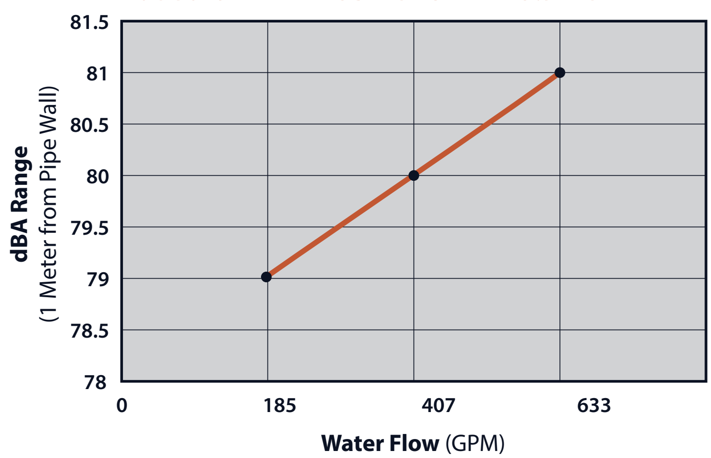
Empirically Tested and Proven For:

- Cv's
- Noise
- Cavitation
- Verification of Performance
- Pressure Recovery Factor (FL)

Tests performed at Utah State University Flow Laboratory.

Utah State University Water Research Laboratory
Logan, Utah USA

VAD Sound Level in dBA Based on P_2 = 105 PSI & P_2 = 0.9 PSI

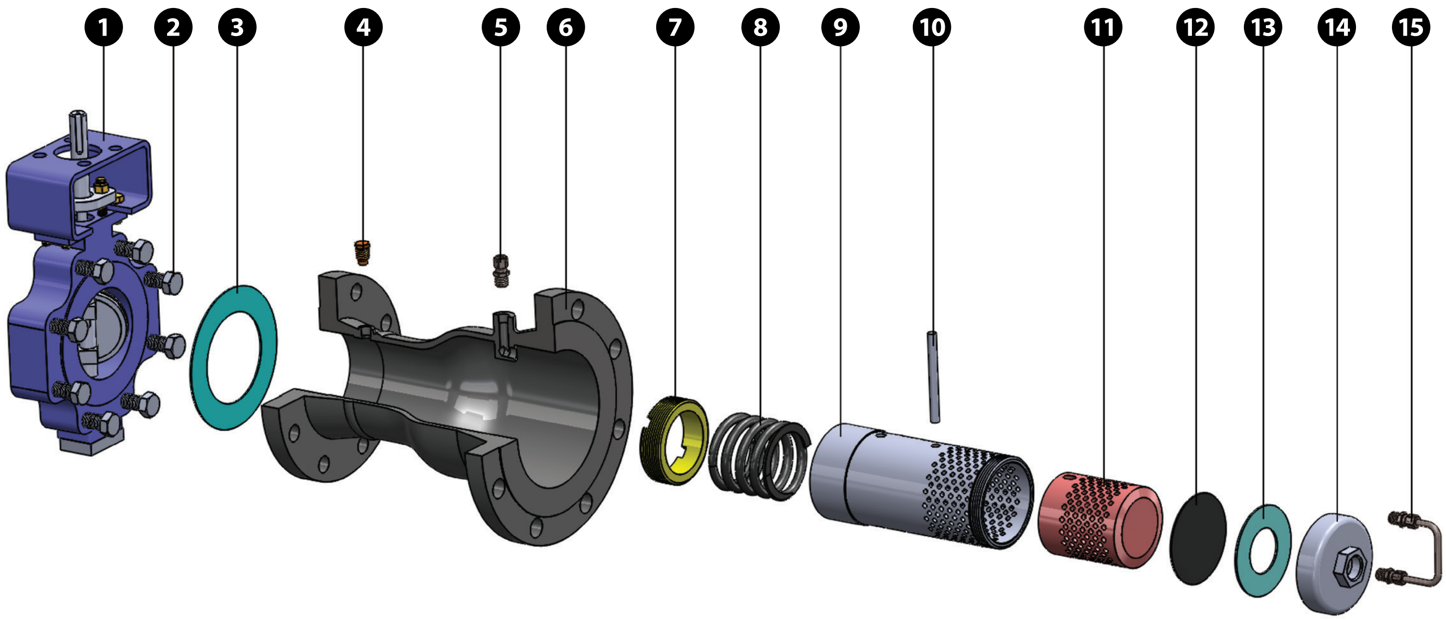


VAD

Represented by:

Varying Area Diffuser - Expanded View

1 Control Valve
2 Flange Bolt
3 Flange Gasket
4 Piston Chamber Port Plug
5 Upstream Pressure Port Fitting
6 VAD Body
7 Spring Adjuster Follower
8 Delta P Spring
9 Fixed Diffuser
10 Travel Limit Pin
11 Variable Diffuser
12 Diaphragm
13 End Cap Gasket
14 End Cap Diaphragm Chamber
15 Tubing



Design Optimized by Dr. Hans Baumann

Hans D. Baumann, PhD, P.E. is widely recognized as one of the foremost experts in control valve design and related technologies. His resume represents an unparalleled body of work specializing in control valve development and tactical business evolution. Yeary Controls is proud to have Dr. Baumann serve as its primary technology consultant in the design, development and implementation of the VAD technologies. Dr. Baumann is currently the founder and president of HB Services Partners LLC, a premier consultancy to the valve industry.

About Yeary Controls

Yeary Controls has specialized in the development and integration of innovative valve technologies and solutions for energy and various process industries for over forty years. Additional Yeary products include:

Sharktooth® Control Valve: a triple eccentric butterfly control valve exclusively designed for process control and throttling purposes.

Quadrosphere® Ball Valve: a trunnion ball valve with self-cleaning seats, and self-flushing body cavity that is ideal for handling viscous fluids and fluids containing sand, debris, waxes and scale.

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Ask about our Quadrosphere® & Sharktooth® Valves