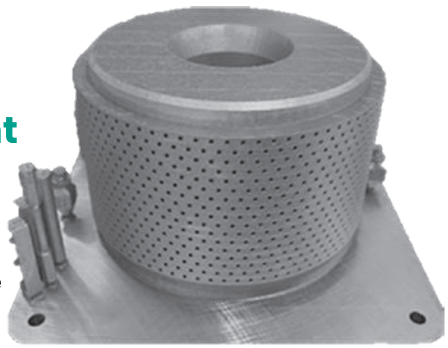
White Paper

V-LOG EVO Trim

The next evolution in low noise, energy management technology


Low-energy EVO trim

Masoneilan™ is pleased to announce our latest low-energy EVO Trim technology, an evolutionary change in control valve trim used for high pressure drop vapor fluids where flow capacity and aerodynamic noise are important application parameters for our customers. This new valve technology is an advancement in the industry, providing an innovative new method to reduce pressure using additive manufacturing to optimize flow path resistors, and achieve the most efficient and impactful energy letdown method available today.

Revolutionary Flow Path Design


Revolutionary flow path design

The patented low-energy Masoneilan EVO trim can achieve capacities of 160% over those achieved by conventional high pressure tortuous path gas flow trims, at the same time as cutting the sound pressure generated by half. This new trim achieves a similar 50:1 pressure ratio application range as that achieved by conventional energy management tortuous path trims.

Application Challenge

Control Valve applications involving high pressure drop ratio vapor fluids are known to be destructive to both surrounding equipment and to the noise sensitive environment, while at the same time these applications are some of the most critical applications found within the plant, often protecting key equipment such as compressors.

The high pressure reduction in these applications will result in vapor fluid expansion, causing negative effects such as extreme noise and system-damaging vibration. Traditional control valve solutions have been required to provide enhanced multistage, high resistance tortuous flow paths to gradually reduce the pressure drop and manage the velocity and energy within the trim. However, while this technology is effective for the application, it is often extremely inefficient due to high flow resistance and requires oversized valve internals to fit such complex flow paths. These valves are often very expensive to purchase and fit within a traditional piping system, making it difficult for plant designers to build a system around the valve.

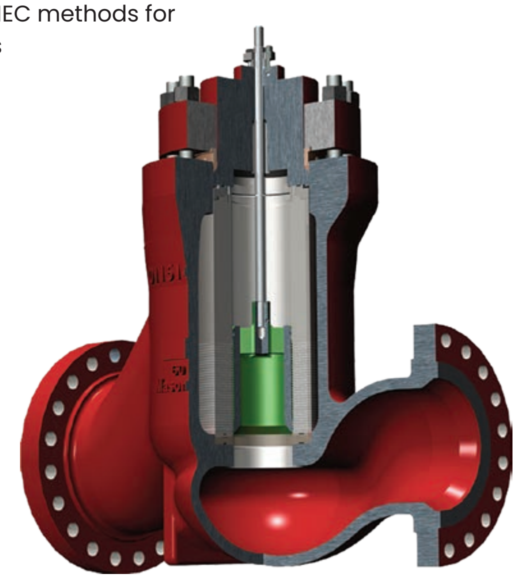
Traditional Market Solutions

In today's market, there are many solution providers using common methods of energy management, similar to Masoneilan V-LOG technology, that manage the high pressure drop in a series of expanding area stages to gradually reduce pressure while managing the resulting velocity as the vapor expands. The IEC methods for sizing and evaluating the valve performance in these applications is often seen as limited as it doesn't fully quantify the impacts of the aero-acoustic noise, nor high energy induced vibration effects.

ISA has since published other best practice guidelines to quantify the impact of the fluid on its surrounding environment. One established guideline is to limit the kinetic energy levels through the valve to a maximum level of 480 kPa at the trim exit. Using this limit, manufacturers have established minimum numbers of stages to manage the velocity and resulting energy limits to ensure the levels are within range to avoid excessive noise and vibration.

In many high pressure ratio applications, the kinetic energy guidelines can result in 40-stages or more of pressure reduction trim. These applications can be extremely inefficient, as the greater number of stages require more area and material within the valve and increases resistance that will reduce the flow capacity through the valve. The result in these applications is a larger, heavier valve design that will require piping modifications and added expense to fit within the pipeline.

To innovate and provide a more efficient resistor solution, we must first understand the application challenges and limitations that exist today.

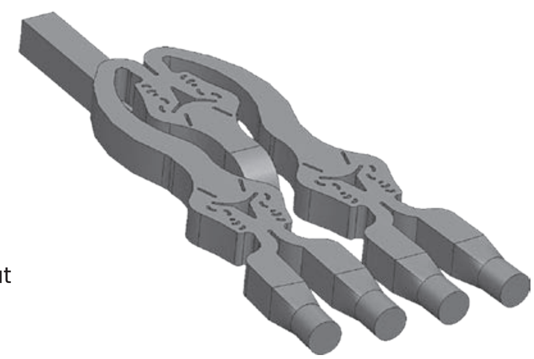


Masoneilan 49000 Series
V-LOG Control Valve

C_V Capacity Coefficient

C_V, the capacity coefficient of a control valve, is a function of the total resistance created through the trim and is primarily calculated by using a pressure drop factor for a certain geometry where pressure drop across the valve trim is achieved by a combination of two mechanisms: 1) contraction and expansion of the fluid, and 2) turning the direction of the flow. These two methods are well documented through the IEC-60534-2-1 code and have been successfully used for decades by control valve manufacturers to design and size control valves, but now need to be modified to account for technological advancements.

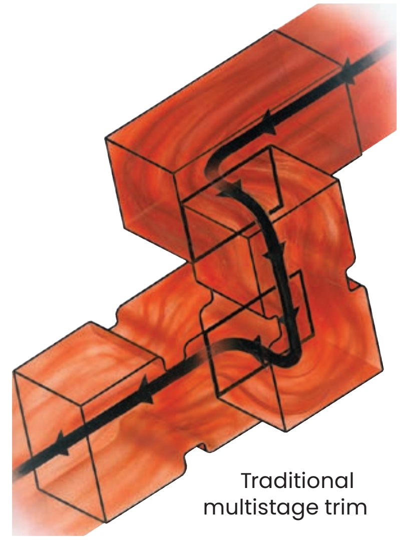
The evolutionary advancement of the low-energy Masoneilan EVO trim design incorporates a patented method of creating additional pressure drop across the valve trim resistors, namely targeted mixing of the process vapor. The mixing is achieved by splitting a portion of the entrance flow, turning it 180° and having it re-mix with the rest of the flow. The mixed flow is now steered through several turning blades, re-mixed and finally exiting the trim with similar outlet pressure achieved through a more compact flow area.



New flow path resistor, creating incremental pressure drop across a consistent flow area

Enhanced Flow Path Optimization

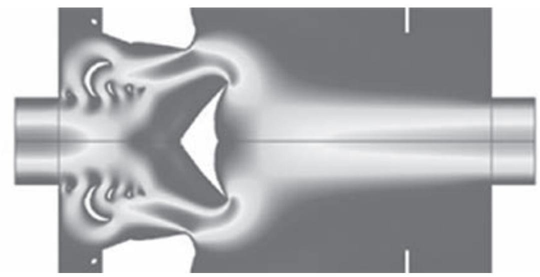
Traditional manufacturing methods of producing multistage tortuous path trim involve laser or EDM cutting disks that are brazed together to produce a high resistance cage. These flow paths are typically 90-degree turns, and often use a rectangular flow passage for the fluid, given the limitations of traditional manufacturing methods.



Traditional multistage trim

As the vapor moves through traditional laser cut, rectangular 90-degree turn tortuous flow paths, the flow momentum drives the fluid to hug the trim flow path walls as it changes direction through the turns, thus not taking advantage of the entire potential of the flow area, resulting in a capacity inefficiency that limits the output creating yet another requirement for larger area trim. Due to manufacturing limitations, it has historically been recognized that the hydraulic flow area within these trim designs were outside of control of the valve manufacturer, and these limitations have traditionally been accepted.

Today, using additive manufacturing, also known as 3D printing, manufacturers can modify the flow passage geometry into any desired orientation. Through CFD modeling, Baker Hughes has found an optimally rounded flow resistor that utilizes a greater amount of the flow path, and as a result, adds an increased factor in flow capacity that can be managed through the valve trim.



CFD modeling

The unique internal splitting and steering of the process fluid within the Masoneilan EVO trim, along with the optimization of the hydraulic flow area, means that these new technologies add an additional factor to optimize pressure reduction and deviates from the idealized control valve method used exclusively by valve manufacturers and users in the world today. The IEC-60534-2-1 sizing factors need to be adjusted to account for the increase in capacity with respect to Cv. They rely on proprietary laboratory noise and flow testing, as well as CFD where extensive testing has found that an adjusted flow factor of 1.6 can be used to account for the benefits of increased capacity.

Energy and Valve Vibration

Flowing large amounts of fluid with high pressure drop through a restricted area has natural vibration challenges that come along with it. Managing the resulting velocity or kinetic energy, appropriately to reduce the vibration, usually means an oversized valve to provide greater amounts of high-resistance pressure reduction stages. Valves designed for this service often include a larger diameter plug and longer stroke trim, as well as expanded pipe outlet sizes to accommodate downstream velocity effects to overall reduce high energy induced vibration.

High kinetic energy in long stroke valves has been known to produce torsional vibrations low enough to interact with the first torsional mode of the plug-stem system, and produce destructive energies large enough to destroy the valve stem, and in some cases the actuator diaphragm and accessories mounted on the valve.

The goal is to limit the oversizing of the valve and design a unique trim that will provide innovative methods of pressure reduction to manage the energy and natural frequencies within the valve. The first modal frequency is inversely proportional to the square root of the plug polar mass. Reducing trim size directly impacts the plug mass. This simply means the goal of all applications is to get greater flow capacity through a fixed area, while continuing to manage energy and velocity levels through that area.

A single fluid resistor within the EVO trim can reduce as much energy as approximately 8 stages of turns through a conventional tortuous path trim. Using additive manufacturing technology, fluid resistors are designed using a patented 3-dimensional routing of the flow from the inside diameter to the outside diameter of the cage. This 3D path utilizes more of the total “dead” area of the trim that has historically been unused or designed for guiding purposes only, allowing valve designers to maximize the flow and flow areas within the valve.

As the outlet area of the trim covers a greater axial span than the inlets, and more area of the cage can be utilized for flow passages, the EVO trim can now have more than 3-times the number of outlets within the same cage to accommodate the higher flow rates. With the potential for additional flow outlets, it’s now possible to reduce the exit flow area of each individual jet while still gaining twice the total exit flow area. By doubling the total exit area, the outlet velocity can be dropped in half. Using kinetic energy theory as a guideline, the doubling of the flow area means that at the same flow capacity, the energy to produce noise would result in a minimum of 10 dB loss and considerably reduced effects from associated vibration within the valve.

In addition to kinetic energy, basic designing the valve to optimize the natural frequencies is imperative to manage vibration. Higher natural frequencies of the valve internals are ideal, making it more unlikely for the valve system to be affected by the high energy process fluid. If the natural frequency of the valve internals drops too low, the system becomes compliant and can be affected by broadband noise generated by the fluid. This broadband noise energy will excite the low frequency components causing further destructive vibrations, displacements and rotations.

Low-energy EVO trim technology increases valve capacity by 160%, resulting in an increase of natural frequency of 126% to reduce vibrational damage to the surrounding system.

Aero-acoustic Noise

High pressure gas valves such as these, can generate large amounts of aero-acoustic noise. This noise is viewed as an industrial pollutant and is typically noted on the valve datasheet as a key performance indicator, typically with a limit of 85 dBA or less, measured at 1 meter from the downstream pipe wall. Values of aero-acoustic noise are predicted using IEC 60534-8-3 and have been verified in acoustic flow laboratory tests, with noise levels quantified by the exit jet of the flow stream generated by the pressure drop across the final stage upon exit of the trim.

Similar to other proven tortuous path methods, the new technology minimizes the exit jet by limiting the pressure reduction at the final stage. The stream power of this jet is calculated through the IEC standard, depending on the Mach number, and converted to an internally generated sound pressure level in dB. The pressure drop across the last stage depends on the number of stages and this correlation has been determined by CFD and verified by flow laboratory testing. Traditional contraction, expansion and directional turning, combined with the new EVO trim technology to re-mix the fluid against itself further reduces the velocity and exit jet force to minimize the total noise within the system.

Understanding the impact of the exit jets on noise allows CAD software to optimize the EVO trim geometry to include flow path outlets that are round versus the traditional rectangular outlets, previously limited by a laser cutting manufacturing process. The smaller rounded outlets flow more efficiently and can also be spaced closer together, allowing for more total flow paths within the trim, while still avoiding jet-to-jet interaction upon exit. Additionally, the smaller diameter outlets shift the resonant frequency higher per the Strouhal number.

These phenomena additionally benefiting the unique EVO trim design can’t be evaluated by the Kinetic Energy Theory alone. The IEC standard describes the impact of shifting the frequency and how much can be filtered out on the dBA scale through the metal pipe itself. With this additional flow passage optimization advantage, the EVO trim flow testing has shown to have up to 2 times the flow capacity, while still attenuating noise by up to 50% within the same valve.

Conclusion

Packaging of many more flow passages into the same size trim, without cluttering the outlet area, allows for a reduction in trim size to meet a similar valve capacity without increasing the velocity or energy, hence noise generation.

The increase in flow capacity through a valve has benefits for both the valve manufacturer and customers. Although pipeline sizes are usually fixed at the time of plant design, the design between the flanges has a lot of flexibility for the manufacturer to optimize. Both the diameter and height of the trim and valve body can be reduced using this new technology by reducing the plug size and valve stroke through more efficient flow path optimization. These reductions in bulk valve size create an improved compact valve design, higher structural frequencies, and consequently lower valve vibrations. In addition, the ability to design smaller plug diameters and stroke lengths reduces the need for large thrust, long stroke actuation, and improves the dynamic control performance of the valve in high-speed applications, such as compressor antisurge.

Baker Hughes

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