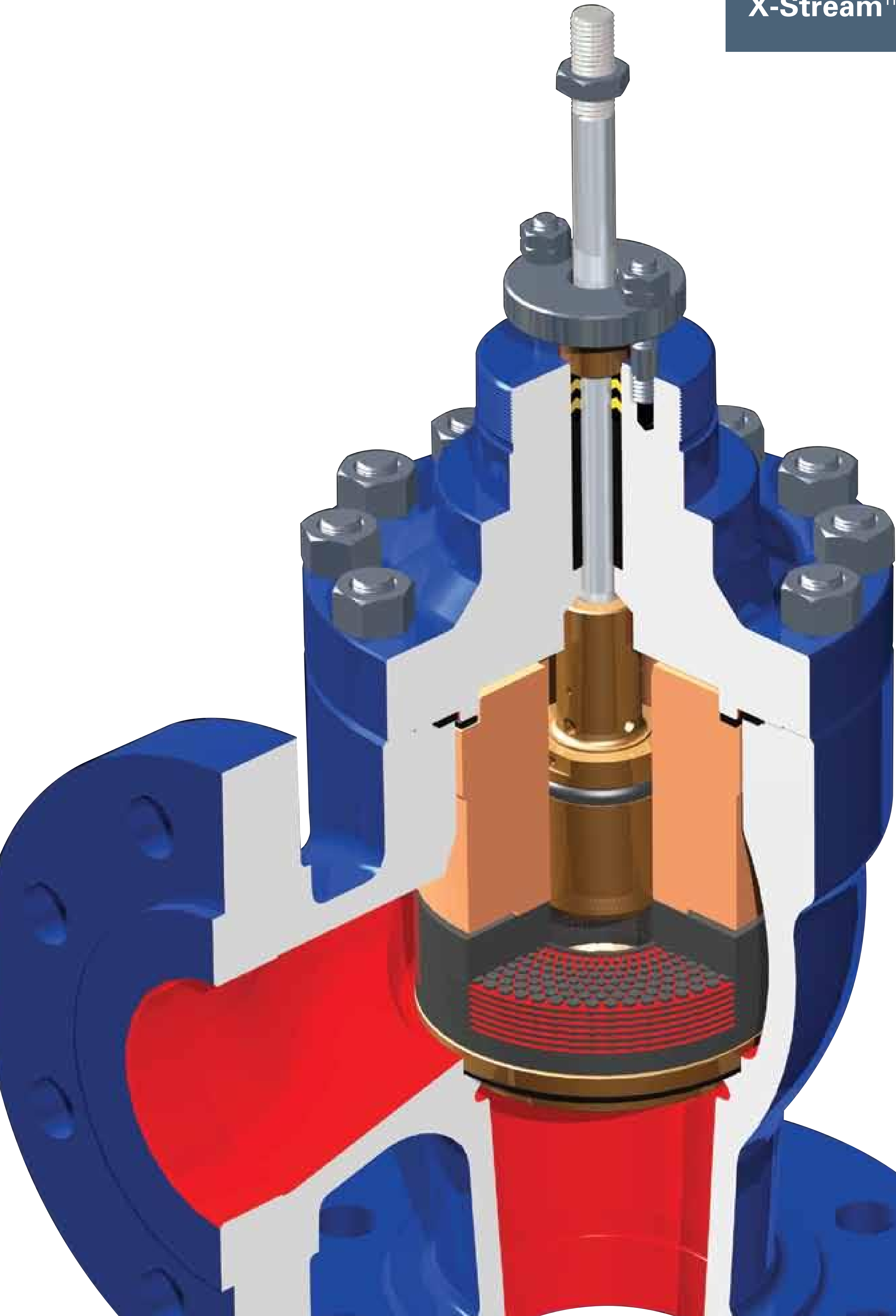
Blakeborough

X-Stream™



Trillium Flow Tecnologies UK Limited's purpose built factory at Elland.

Trillium Flow Technologies South Korea

Trillium Flow Technologies™ Control & Choke Valves provides critical service safety valves, specialist pumps and service support to flow control and rotating equipment.

Our world-wide reputation is based on engineering excellence applied to a comprehensive range of specialist products and effective customer support.

A proven track record

Trillium Flow Technologies™ have extensive references and a proven track record in the supply of valves across a number of key industries.
Our valves are industry renowned brands, each with an established reputation for quality engineering and reliability.

Valve testing

All pressure containing items are hydrostatically tested, seat leakage tested and functionally tested.

We can also perform gas, packing emission, cryogenic and advanced functional testing, as well as seismic testing for nuclear applications.

Material testing

- Non-destructive examination by radiography, ultrasonics, magnetic particle and liquid penetrant.
- Chemical analysis by computer controlled direct reading emission spectrometer.
- Mechanical testing for tensile properties at ambient and elevated temperatures, bend and hardness testing. Charpy testing at ambient, elevated and sub-zero temperatures.

Aftermarket solutions

Our valve aftermarket solutions are based on our engineering heritage, applying our OEM knowledge and expertise to maintenance strategies, life extension and upgrade projects.

Quality assurance

We are qualified to industry standards and working practices including:

- ASME BPVC Section III (N and NPT Stamp)
- NQA-1 Quality system
- 10CFR50 App. B
- 10CFR50 Part 21
- RCC-E
- RCC-M
- CSA Z299
- Performance testing and qualification to:
  ASME QME-1
  ASME B16.41
  IEEE 323
  IEEE 344
  IEEE 382
- ISO 9001
- ISO 14001
- PED 97/23/CE
- API Q1 TO API LICENCES:
  API 6D (6D-0182)
  API 6A (64-0445)
- OHSAS 18001
- ATEX 94/9/CE
- Lean manufacturing practices

ATWOOD & MORRILL™
Engineered Isolation & Check Valves
BATLEY VALVE®
High Performance Butterfly Valves
BDK™
Industrial Valves
BLAKEBOROUGH®
Control & Severe Service Valves
HOPKINSONS®
Parallel Slide Gate & Globe Valves
MAC VALVE®
Ball & Rotary Gate Valves
SARASIN-RSBD™
Pressure Safety Devices
SEBIM™
Nuclear Valves
TRICENTRIC®
Triple Offset Butterfly Valves

Portfolio of engineered service solutions and aftermarket support

FPAL empowered by Achilles

Member of BVAA

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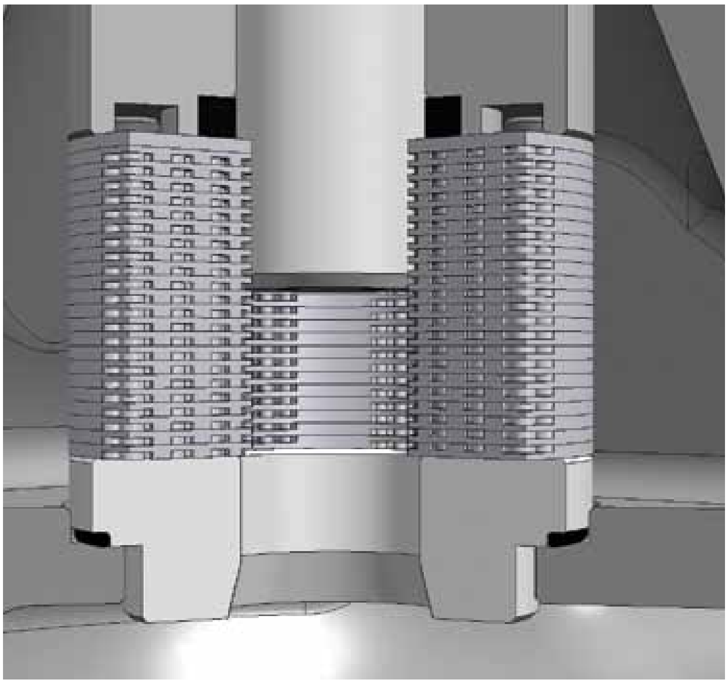


X-Stream® disc stack

Versatility

The Trillium Flow Technologies™ X-Stream® valve offers a wide choice of options to meet all severe service applications, eliminating or greatly reducing the multiplicity of valve designs that would otherwise be required.

Features

- Total velocity control
- Natural anti-clogging
- Used for continuous letdown
- Cavitation control
- Noise control
- Erosion control
- Designed using 3D prediction techniques
- High flow capacity

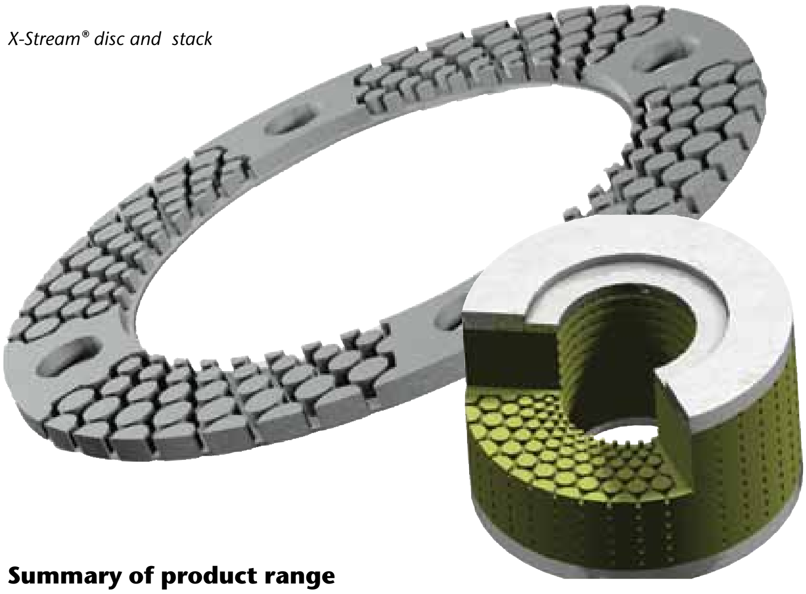
Main design standards

- ASME B16.34 – Valve – Flanged, Threaded & Welded Ends
- EN 12516 Part 1-Industrial Valves Shell Design Strength
- ASME FCI 70-2 – Control Valve Seat Leakage
- ASME B16.25 – Butt Weld Ends
- ASME B16.5 – Pipe Flanges & Flange Fittings
- NACE MR-01-75 ISO 15156 Valve Materials (option)
- BS1560 – Circular Flanges for Pipes, Valves & Fittings
- BS4504 – Circular Flanges for Pipes, Valves & Fittings

Pressure Ratings

- ANSI Class 150lb to 600lb (BV500 Series)
- ANSI Class 900lb to 4500lb (BV990 Series)
- Equivalent metric pressure ratings

X-Stream® disc and stack



Summary of product range

Size Range	2'' (50 mm) to 30'' (750mm), 1'' (25mm) also available but please consult factory for information
Pressure Class	ASME Class 150 to 4500 & PN10 to PN640 (consult factory for equivalent metric and other non standard pressure classes available)
Body Configuration	Globe & Angle Valve (Globe: BV500 & BV990, Angle: BV501 & BV992)
Cv Range	4µs to 500µs depending on valve size (consult factory for special designs which require higher or lower Cv's
Valve Characteristic	Linear, Modified Linear, Modified EQ%, Customised
Leakage Class	Up to Class V shut-off
Connection Type	Buttweld, Flanged, (Standard), Socket weld, Screwed (1''only) & Hubbed
Bonnet Style	Standard, Normalising & Cryogenic
Packing Type	PTFE Chevron, Graphite

What is a severe service application?

There are many definitions as to what is and is not considered to be a severe service application, which makes applications difficult to identify for valve manufacturers and customers alike. An application is therefore generally recognised as severe service either through past experience of problems associated with similar applications or due to the pressure drop which the valve is required to handle.

Trillium Flow Technologies™ have found that most applications tend to fall into one of two categories, which are as follows;

- applications where there is a high pressure drop across the valve (for example in excess of 150 bar)

  or

- applications where there is likely to be problems, such as cavitation, high fluid velocities or noise.

Severe service applications are considered problematic because of typical problems which are found with the control valves fitted in these services. The valves are more susceptible to problems within these severe environments because of the large amount of potentially destructive energy which must be removed from the fluid flow as it passes through the valve.

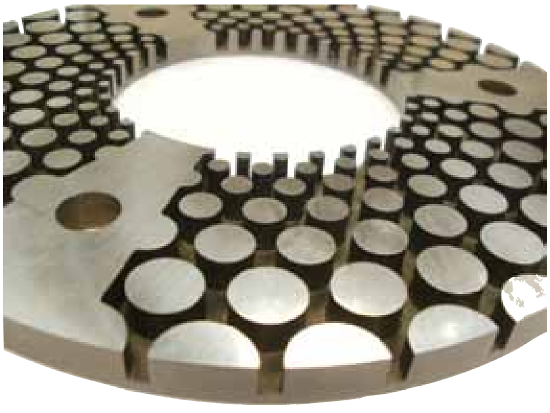
Typical problems include;

- high fluid velocities
- excessive noise
- cavitation
- severe erosion
- vibration
- seat leakage
- poor flow control and general valve stability

The advantages of 3D flow control and the X-Stream® trim

The X-Stream® trim is the first in a new and advanced generation of control valve technology, designed to manage the most severe of process environments with continued safe and reliable operation.

Tungsten carbide X-Stream® disc for erosion control on contaminated fluids



Controlling a new dimension

Severe service applications are notorious for causing problems in the control valves responsible for handling these arduous conditions. Typical problems include poor flow stability, cavitation, erosion (often first seen in the form of seat leakage) and excessive noise and vibration, all of which can have significant effects on the successful performance of the valve. However, although these problems appear varied, in most cases they can be attributed to a poor control of the fluid flow as it passes through the valve, leading to high pressure gradients, high fluid velocities and damaging levels of kinetic energy within the fluid flow. Consequently, a typical severe service control valve will use a number of stages of letdown (either through a labyrinthine style flow path or through a concentric sleeve type cage design) to reduce the pressure drop across each stage, resulting in a reduction of both the fluid velocity and kinetic energy levels. Unfortunately, this simplistic one-dimensional approach to the problem does not take into account the three-dimensional formation of the fluid flow as it passes through the valve. Recent research has shown that this can be just as damaging if left uncontrolled.

No sharp corners

The primary feature of the X-Stream® trim is the valve cage, a disc stack cage configuration that incorporates a series of flow paths which are located in an array of staggered cylinders. By forcing the fluid through these tightly packed cylinder arrays, the flow is passed through a labyrinthine tortuous path which is able to dissipate the fluid energy efficiently with limited pressure recovery between stages and without the unnatural movement of the flow around sharp angled corners, such as those found in other severe service trims on the market. This type of unnatural movement has been found to result in numerous problems due to uncontrolled three-dimensional fluid formations within the flow, such as separation and areas of re-circulation.

Controlling fluid formations

As well as providing a method by which the overall design of the valve trim can be improved to more effectively handle the fluid flow, 3D Flow Control also allows the effect of any three-dimensional fluid formations within the flow to be understood and controlled by providing additional and more accurate information which can then be easily incorporated into the standard valve sizing procedures.

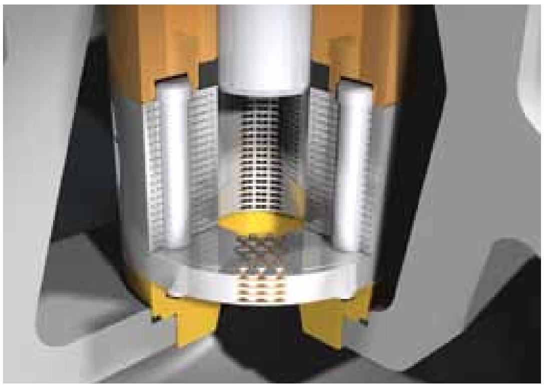
With the addition of these 3D Flow Control parameters in the standard control valve sizing methodology, each X-Stream® trim is designed to maximise performance for each and every set of process conditions supplied. With a pressure drop capability of the equivalent to 60 stages of letdown the X-Stream® is capable of safely handling pressure drops of up to 600 bar and outlet pressures that are very close to the vapour pressure of the line fluid without the onset of cavitation.

Severe service trims

The X-Stream® was developed for applications where standard caged trim designs could not meet the necessary noise attenuation, vibration levels and trim velocity control limits. Using a series of stacked plates/discs, multiple stages of pressure letdown are provided using a series of complex flow paths. The X-Stream® is exceptionally versatile and even its method of manufacture can be altered to provide a custom design solution (For example, clamped disc stacks for individually replaceable discs).

Features

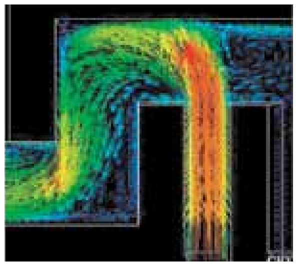
The X-Stream® flow path, was developed using the latest in computational fluid dynamics software and fluid dynamics research. Most disc stack trim designs now conform to the internationally recognised trim exit velocity limits, in order to reduce the erosive impact of the fluid. However Weir also believe that velocity must also be controlled and limited at all points of the trim and have thus proposed 'Total Velocity Control'.



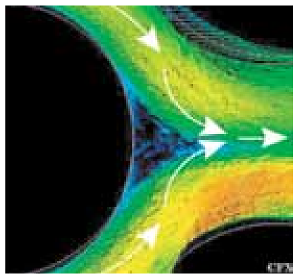
During extensive research, it was discovered that a number of other disc stack designs were too focused on limiting the trim exit velocity and as such were suffering from exceptionally high velocities at the first few stages of pressure letdown, as they tried to expand the flow area too quickly, thus increasing the erosion potential at these areas.

- The X-Stream® trim, is custom designed for each application and uses fixed areas for the first few stages of pressure letdown, providing Total Velocity Control across the entire disc, keeping velocities within a set limit.
- The X-Stream® trim uses 3 of the methods of pressure reduction;
  1. Contraction and Expansion of the Fluid
  2. Change of Direction (The most popular method)
  3. Self Impingement - This splits the flow stream into multiple parts and directs two or more of them into each other.
- The trim has reduced areas of high turbulence, by using a more streamlined approach to change of direction than other disc stack designs. Sharp right angle turns increase the potential for blockage and areas of high velocity, X-Stream® 'smooth' flow path approach minimises velocity and contains a natural anti-clogging /self cleaning flow path which reduces maintenance time and costs.
- X-Stream® can be offered with a wide variety of dynamic performance characteristics, from standard Linear, Equal percentage and other custom characteristics.
- Conforming to the latest developments in Aero and Hydrodynamic noise calculations, X-Stream's unique design, minimises noise by avoiding jet coalescence and with added features on Gas applications to further reduce noise by incorporating a 'mesh' of columns at the exit of the trim.
- The overall ability to custom design nearly all aspects of the X-Stream® disc, make this trim exceedingly versatile. The extensive research carried out in conjunction with some of the leading experts in the field of Fluid Dynamics, means X-Stream® is the optimal solution for Severe Service.

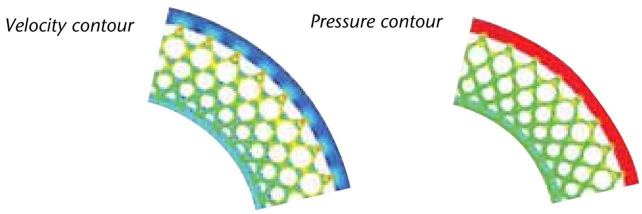
In trims with a tortuous path there are large areas of re-circulating flow (blue area). When debris is present in the flow these areas can cause blockages. Additionally, in trims with a tortuous flow path localised sections of high velocity (red area) can cause premature erosion and loss of control.



Jet impingement causes pressure reduction without the negative effects of trim damage.



The X-Stream® trim is designed to minimise sections of high velocity so the velocity gradient is spread across the trim profile.



Cavitation Elimination

Cavitation is potentially one of the most damaging processes for a control valve. Fortunately cavitation can be totally eliminated by utilising the X-Stream® trim design. In simple terms, by using a tortuous flow path the pressure is gradually reduced through the many twists and turns of the trim, ultimately meaning that the static pressure never passes below the vapour pressure and therefore cavitation is eliminated.

Total Velocity Control

A number of disc stack designs are too focused on limiting the trim exit velocity through turning the flow around 90º bends. As such they suffer from exceptionally high internal velocities. The X-Stream® trim is designed to control both the velocity of the fluid as it passes through the trim and also at the trim exit.

The theory of dropping pressure through a control valve is related to creating a restriction in the flow orifice. As the flow orifice is restricted then a drop in pressure is induced, however, as a consequence of dropping the pressure then there is a consequent rise in velocity of the fluid.

Severe service applications normally have a high pressure drop and unless the cage exit velocity is controlled then premature erosion and vibration can occur.

The X-Stream® trim is the only valve on the market where the trim is design to control the velocity from the inlet of the trim through to the trim exit. The trim exit velocity meets the velocity limits imposed by the ISA standards. At the trim inlet where there is potentially more likelihood of damage then the fluid velocities are controlled to reduce the effect of erosion. The table below shows the limiting velocities that Weir impose as part of their trim design.

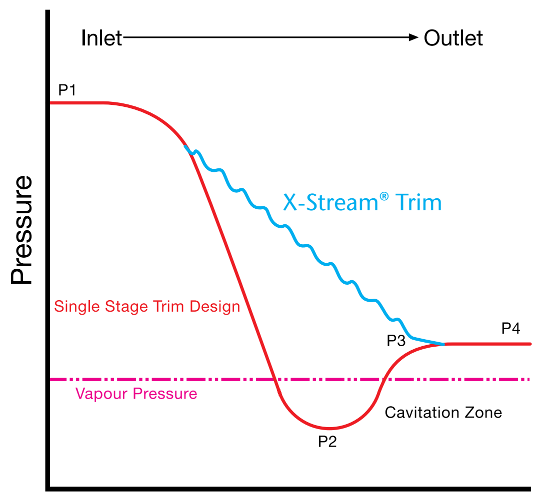
Liquids are incompressible and therefore the trim exit velocity can be expressed in terms of a velocity in m/s and ft/s. On gas applications as the pressure is reduced through the valve trim then the gas expands and therefore the gas velocity accelerates. Gas velocity is therefore normally expressed in terms of the kinetic energy, the 'velocity head', that is the static pressure which would be required to produce the limiting velocity.

Natural Anti Clogging

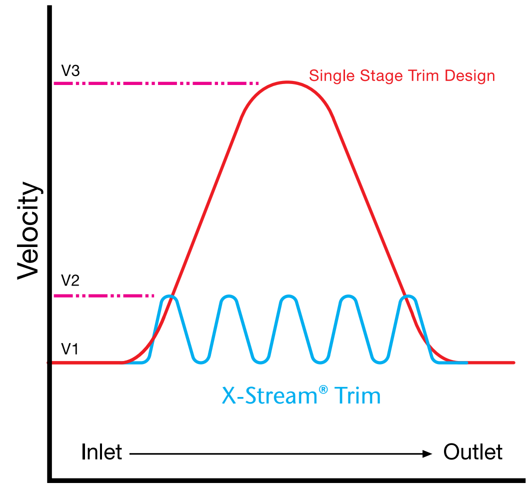
Many severe service valves on the market are susceptible to debris in the process system. Most severe service valves use a series of 90º bends to achieve the pressure drop and as the flow passes around the bends then debris can be collected in the 90º turns. Other severe service valves on the market have a large inlet opening and a smaller fluid exit. This means that where debris is present then it can enter the trim but not completely pass through, once again leading to a blockage of the valve.

The X-Stream® trim is the only valve on the market to be designed with a natural anti-clogging feature. The disc flow path is designed with a series of smooth radius corners. The flow area gradually increases through the trim. This means that if debris is present in the process flow then it will pass through the trim without becoming trapped.

Pressure drop profile



Velocity profile



Why Control Velocity?

The theory of dropping pressure through a control valve is related to creating a restriction in the flow orifice. As the flow orifice is restricted then a drop in pressure is induced, however, as a consequence of dropping the pressure then there is a consequent rise in velocity of the fluid.

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Velocity/Velocity Head Criteria	**Compressible flow**				**Incompressible flow**			
Service conditions	**Exit velociy head**		**Max velocity head**		**Exit velocity**		**Max velocity**	
	Psia	**KPa**	**Psia**	**KPa**	**ft/s**	**m/s**	**ft/s**	**m/s**
Continuous service single phase fluids	70	480	175	1200	100	30	300	75
Multi-phase fluid outlet	40	275	100	688	75	23	188	58
Vibration sensitive system	11	75	28	188	40	12	100	32

Feedwater applications

Recent feedwater applications have been quite challenging due to the need to control cavitation at low valve openings, but yet pass the flow capacity at higher valve openings.

When filling the boiler on a power station there is generally a high pressure at the valve inlet, but a low outlet pressure, often only 1 bar. This condition would result in severe cavitation if a single stage trim was to be applied. Using the X-Stream® trim the pressure drop is staged across the disc which prevents the static pressure falling below the vapour pressure, thus eliminating cavitation and protecting the valve and the trim from damage.

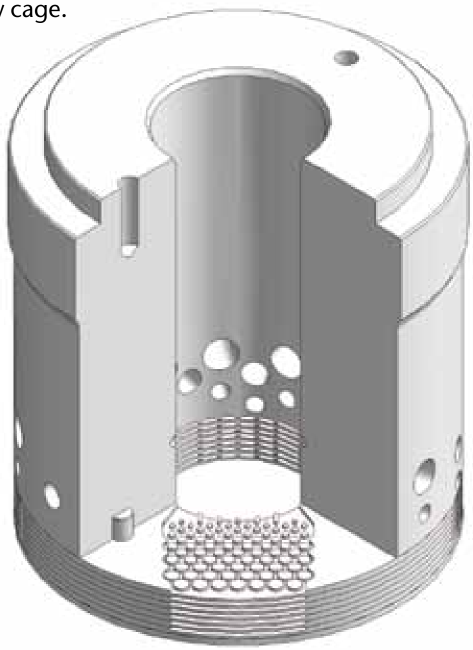
When the plant is running, the boiler is charged and the feedwater valve is required to maintain the water flow rate into the boiler. This condition would normally require high flow rates, but relatively low pressure drops resulting in low coefficients.

Historically power stations would be built with two valves working in split range operation, one on boiler fill designed to control cavitation and one for normal operation to control flow. The demand for cost reduction in power station construction now means that engineers are demanding one control valve to fulfil both these applications.

To specifically address this application Weir have developed the X-Stream® Vari-stage trim. This trim has been designed using the patented X-Stream® disc stack at the bottom of the trim to control low valve Cv's and eliminate cavitation, but at higher valve openings the valve trim is designed with a more standard multi-flow trim to obtain the flow capacity.

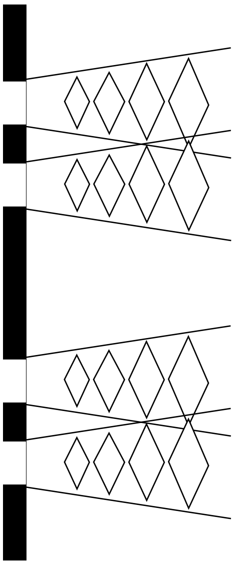
The picture shows a sectioned view of the X-Stream® trim. The lower section of the trim is designed with 8 discs stacked together and vacuum welded onto a multi-flow cage.

This design can be incorporated on applications where multi-stage control is required at low valve openings, but where higher capacities are required at higher valve openings.

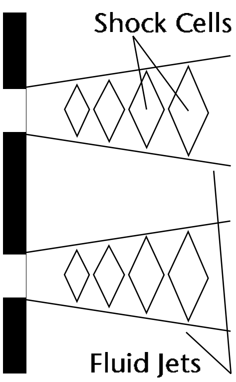


Gas Noise Reduction

Much research has been undertaken into the theory of shock cell formation in gas flows. It is the shock cell formation and jet interaction that creates high noise levels. In a cage trim valve the size of the exit hole is a crucial factor in determining the noise level generated. On large holes shock cells are generated which propagate outwards. As the cells coalesce they produce larger shock cell formation which in turn generates higher levels of noise.

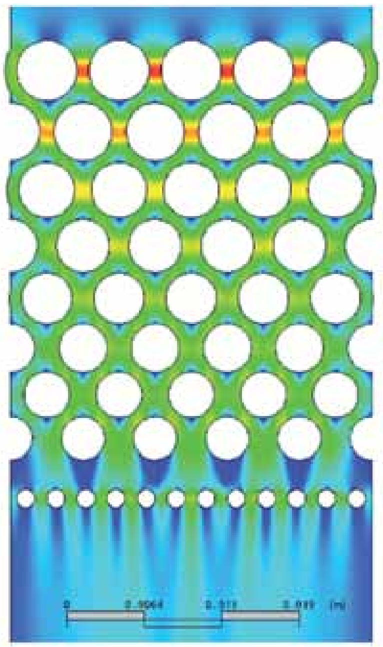


It therefore follows that the best method of reducing valve generated noise is to prevent the shock cells coalescing by spacing the jets wider apart.

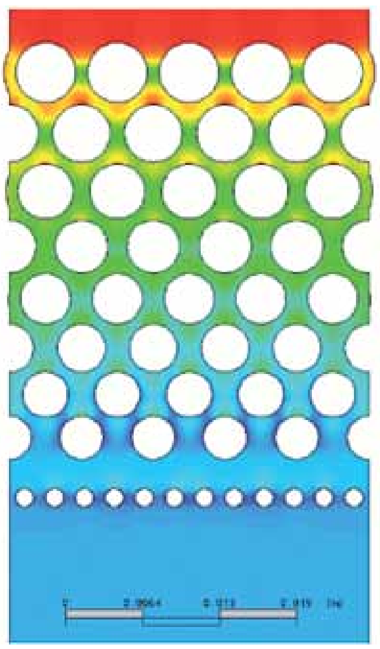


In developing the X-Stream® for gas applications several disc patterns were modelled using the 3D computerised fluid dynamics models as described for liquid applications. Velocity profiles of gases passing through the pattern of columns were analysed to establish the best velocity profile to be employed. The CFD model of the most effective flow path is shown below.

Mach number profile



Pressure profile



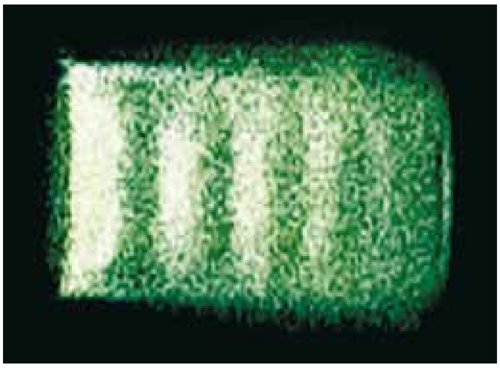
Shock Cell Visualisation

To establish the integrity of the CFD modelling, various flow paths were tested using Scherlieren optical techniques to visualise the light intensity of the shock cells, jet formations and vortices.

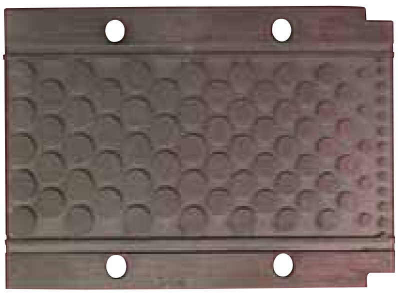
To establish a datum measurement a blank disc was tested to simulate a single stage trim and the Scherlieren visual image was produced as below. The shock cell formation can clearly be seen and it is these pulses that would be responsible for high noise levels if this type of disc was used in a working control valve.

Blank disc simulates single stage trim

It can be seen from the image below that shock cells were created in the gas. The shock cells would generate high noise levels in the downstream pipe.

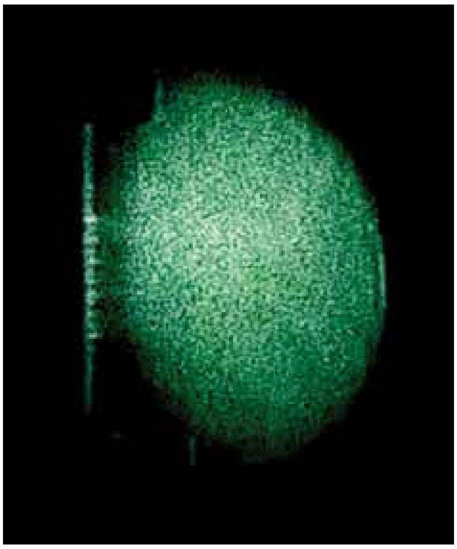


Disc with outlet mesh to prevent shock cell formation

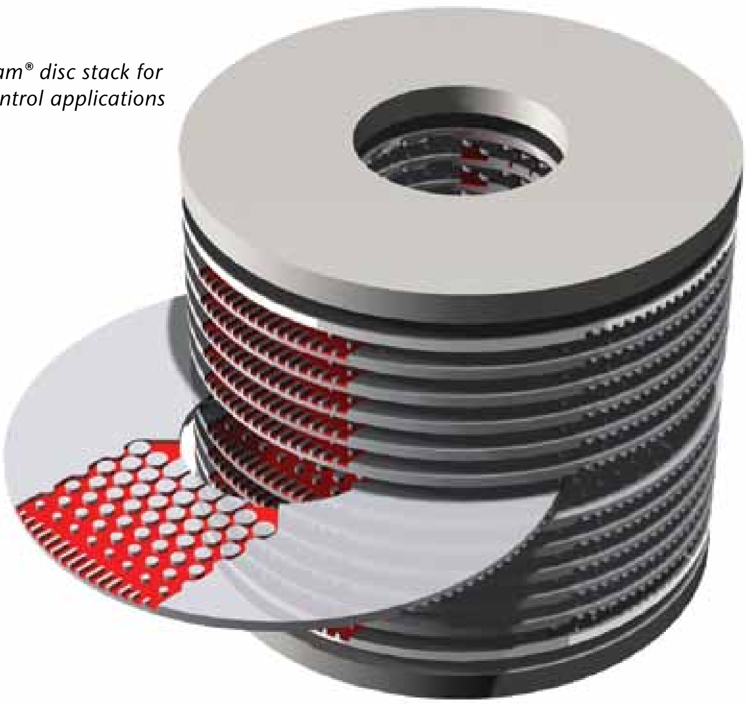


Disc with jet control row

The disc is designed so that the gas pressure is reduced gradually over many cylinder arrays. Higher pressure drops are controlled as the gas enters the disc where the cylinders are tightly packed. As the gas flow passes towards the outlet of the disc the cylinder size is reduced giving reduced pressure drops. The final row of cylinders controls the gas jets, it is this row that prevents shock cell coalescence as the flow exits the trim. The Scherlieren visualisation for the above disc is shown below, it can clearly be seen that shock cells have been totally eliminated at the exit of the trim.



X-Stream® disc stack for gas control applications



Severe Service Applications

Severe service applications are very difficult to define and are normally specified through experience, as problematic, rather than applications above a certain level of pressure drop. For example, a valve with 100 bar pressure drop across it would not necessarily be classed as high pressure, but could still be considered severe service if the outlet pressure was only slightly above fluid vapour pressure. However, applications with pressure drops higher than around 300 bar would normally be classed as problematic and therefore severe service. This is because of the potential of fluid velocities within the valve and the greater probability for cavitation/ flow erosion to occur. These applications can be handled by carefully controlling the energy dissipation within the valve. It is this process which gives the high-energy loss trims their name.

In an attempt to give a clearer understanding of the types of applications which can be considered severe service some examples from the power and oil and gas industries are listed below.

Power Industry

The type of valve used in the power industry depends on the types of station. The following examples are based on a modern combined cycle power plant.

The Condensate System

This covers the process from the condenser to the deareator and essentially acts as a heat exchanger by condensing the steam from the turbine so that it can be recycled through the system. A partial vacuum in the condenser helps to lower the output pressure for the turbine therefore increasing its efficiency. The output from the condenser is then passed through a series of low-pressure heaters, which will be used to increase the temperature of the fluid still further, before it is passed into the deaerator. Because of the low pressure in the system there is only one valve, which could potentially be considered as severe service, this is the condensate Re-circulation valve.

Condensate Re-circulation Valve

To protect the condensate pump from overheating and cavitating, it is necessary to ensure there is a minimum amount of fluid flowing through it. When re-circulation is necessary the condensate re-circulation valve is used to dump the condensate into the condenser, which is either at atmospheric pressure or even a partial vacuum. Although typical pressure drops would only likely to be in the region of 30-40 bar (400-600 psig) because of the low outlet pressures there is a high potential for cavitation.

The Feedwater system

This system, encompasses the portion of the steam cycle that takes the feedwater from the deaerator and passes it through the boiler feedwater pumps, high-pressure heaters, the economiser and into the boiler. During this process the feedwater is heated to the temperature of the boiler and raised to its full outlet pressure. This system is regarded as the most severe environment in the plant and the severe service valves are normally located around the boiler.

Boiler Feedwater Re-circulation Valve

This controls the re-circulation system used to protect the boiler feedpump from its severe service environment. As the differential pressure between the boiler and the deaerator is relatively high, the valve is likely to see high pressure drops across it. Because of its usage levels this is probably one of the most severe applications within the plant and typical conditions depend very much on the size of the plant. For example these may be as high as inlet pressures of 380 bar (5500 psig) with outlet pressures of 0-10 bar (0 – 150 psig).

Boiler Feed System

For start up, the boiler feed system must cope with the full pressure of the feedpumps at the inlet and the unpressurised boiler at the outlet, with relatively small flow rates. However as the boiler drum comes up to pressure, the pressure drop across the system reduces and the flow rate increases. With the two very different sets of process conditions, two valves are normally used in parallel with each other to achieve this large rangeability. These are unique to drum style boilers and, dependant on the boiler manufacturer, may not be control valves. It is the start-up valve which is likely to see severe service process conditions.

Boiler Feedwater Start-up Valve

During start-up the flows are usually very small with the high pressure drops and hence the potential for cavitation is high, however, its severity is not as great as that seen by the boiler re-circulation valve. Inlet pressures are likely to be in the region of 200-220 bar (2800-3200 psig) with outlet pressures near atmospheric.

The Main Steam System

This takes the high pressure steam from the boiler and sends it through the superheaters into the high-pressure turbines. The steam is then bled off, pumped through a reheater and passed into the low pressure turbine, before finally being dumped into the condenser after all its potential has been extracted. Because of the high pressure steam in this system, several of the valves can be classed as severe service.

Reheater Atterperator Spray Valve

Used to control the temperature of the steam before it enters the low pressure turbine, which is critical to protect the delicate turbine blades from being damaged. In this case the reheater is maintained at a relatively low pressure and the relatively high pressure drops combined with low flow rates give a high potential for cavitation. Inlet pressures can be as high as 270 bar (3900 psig) with an outlet pressure of 2 bar (290 psig)

Deaerator Pegging Steam Valve

The deaerator pegging steam valve is used to supply the deaerator with the water it requires, which means a high-pressure drop with the potential for severe noise generation. Similar to the turbine bypass valve, typical conditions include inlet pressure of up to 310 bar (4500 psig) and outlet pressures close to or at atmospheric pressure.

Soot Blower Valve

Used to control the sootblowers, which are used to keep the boiler tubes clean. This application experiences high pressures and pressure drops, which are likely to cause a noise problem. Typical conditions include inlet pressures of up to 310 bar (4500 psig) and outlet pressures close to or at atmospheric pressure.

Oil & Gas Applications

Oil and gas refinery/processing is a notoriously arduous service for any of the major process components therein. This is due to the environments in which the valves are situated and the type of services which they are likely to see. Oil and gas will normally occur in the same place and therefore, when trying to extract it, it is likely that on occasion both fluid and gasses will be captured together creating what can be a highly erosive two-phase flow. When this is combined with the extremely high pressures at the well head and entrained particles of sand, it can prove to be one of the most arduous process conditions ever seen by control valves. Another highly corrosive service is sour gas, where the gas is polluted with hydrogen sulphide, which is highly corrosive. Also, sub-sea valves must be able to withstand corrosion from the salty seawater and hot services are becoming more of a problem, particularly in the area of the well head. Unlike applications in the Power industry, valves for oil and gas applications can vary extensively between sites, which make them very difficult to standardise.

Re-circulation Valves & Overboard Dump Valves

Similar to the minimum flow re-circulation valves in power applications, these valves re-circulate fluid through the pumps, as it is impractical to have the pumps running at low levels. The excess fluid is then dumped overboard. Because of this, the valves will be seeing high pressures from the pump at the inlet and outlet pressures at atmospheric vent. With such a combination of high pressure drops and low outlet pressures the potential for cavitation is high.

Separator Level Controls

This is the second valve seen by the excavated fluid, the first being the choke valve. It is therefore likely to see relatively high pressure drops with multi-phase flow, which is a mixture of gas, oil and water. Entrained sand can also be present in the mixture on some old services.

Flare Valves

These valves are used to control the venting of the excess hydrocarbon gas and will therefore experience high pressure drops as the gas is taken from a high pressure system and vented into atmosphere. However, because the fluid is hydrocarbon gas the service a relatively clean.

Anti-surge Valves

The anti-surge valves are attached to both the high and low pressure systems and are used to protect the gas compressors from unwanted surges. Like the pump re-circulation valves, these valves are likely to see high pressure drops with outlet pressures at near atmospheric conditions. In this case the valves operate on gas services and therefore noise and vibration are the main problems.

Glycol & Methanol Systems

Glycol and Methanol are used in the system to clean out the water from the pipework and piping components to prevent them from icing up in cold conditions. Because this is a flushing process over a large length of pipework the fluid must be pumped at high pressures but will be reducing to low pressures at outlet, therefore cavitation potential is high.

Oil Export Pump Valves

These valves are used to control the pumps which are used to export the oil down the piping system and to shore, where it can be processed. This service is problematic because it is likely to see high pressures with high flow rates, therefore the potential for cavitation is high. However a common problem with this type of service is vibration.

Valve Services

Site Service	Workshop Services	Service Plans
Outage, shutdown and turnaround management	Mechanical valve overhaul and refurbishment	24hr Customer Service Number
Overhaul and refurbishment	Valve pressure testing	48hr Service Response Engineer
Installation and commissioning	Upgrades and modifications	LTSA (Long Term Service Agreement)
In-situ valve seat replacement	Control valve service, maintenance and monitoring	Embedded engineering programmes
In-situ testing and monitoring	Actuator servicing and torque testing	Asset management
Turnkey project management	Service exchange programmes for valves and actuators	Bespoke service management

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