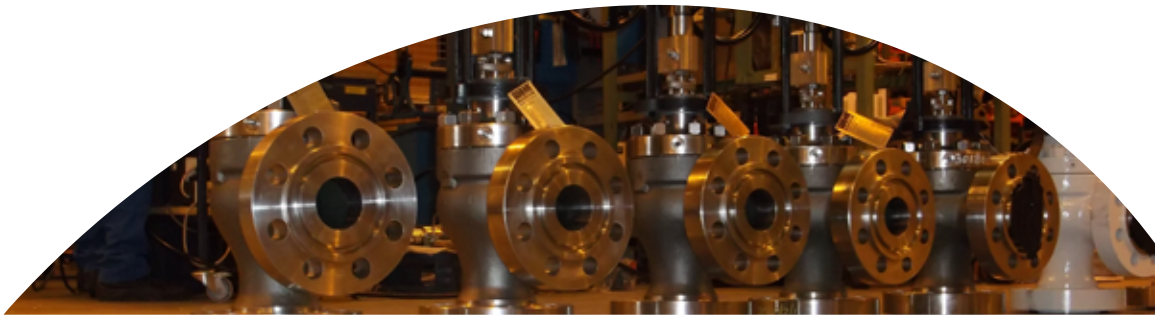
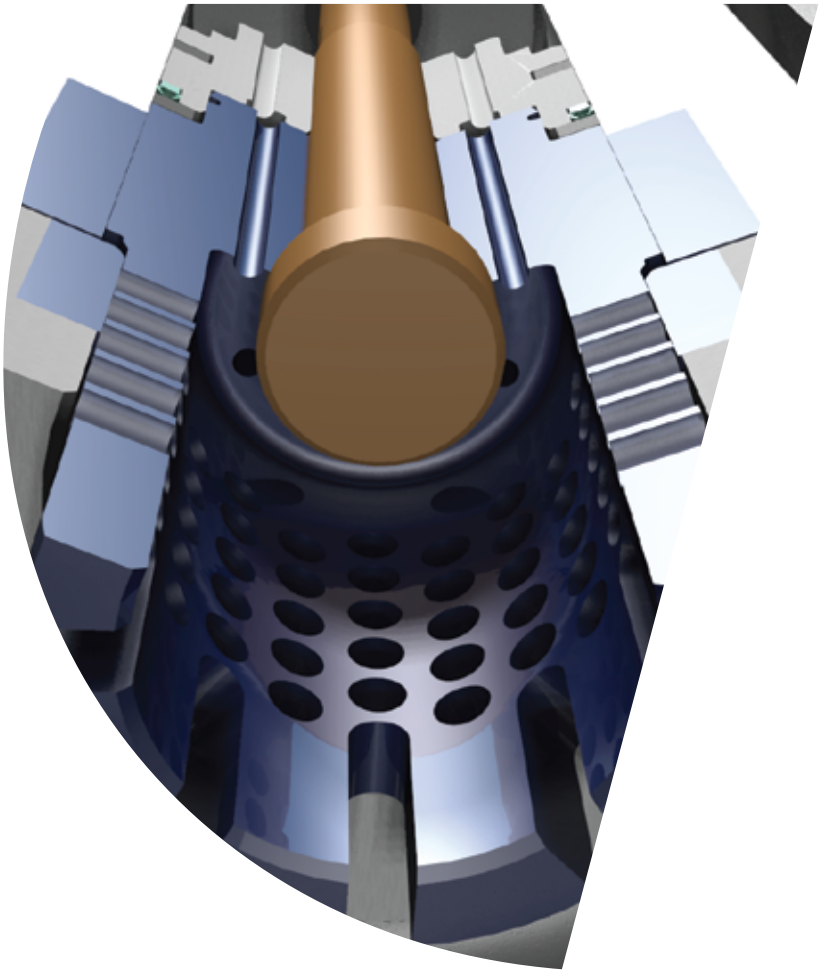
CONTROL CHOKE VALVES





TRILLIUM FLOW TECHNOLOGIES™

TRILLIUMFLOW.COM

A PROVEN TRACK RECORD

We 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.Trillium Control & Choke Valves provides a wide range of control valves for the process industry. These include severe service, choke, desuperheating and turbine bypass applications.

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

Trillium Fundamentals

- Health & Safety First
- Integrity & Customer Care
- Success Through Collaboration
- Embedded Quality
- Environmentally Responsible
- Focused on Your Profitability

ATWOOD & MORRILL®
Engineered Isolation & Check Valves

BATLEY VALVE®
Butterfly Valves

BLAKEBOROUGH®
Control, Choke & Steam Conditioning Valves

HOPKINSONS®
Isolation Valves

REDPOINT®
Specialised Isolation Valves

SARASIN-RSBD®
Safety & Safety Relief Valves

SEBIM®
Nuclear Pilot Operated Safety Valves

TRICENTRIC®
Triple Offset Butterfly Valves

FPAL empowered by Achilles

BVAA

Portfolio of engineered service solutions and aftermarket support

INTRODUCTION

Traditionally the choke valve was the first valve on the well head that would be used to reduce the pressure of the oil and gas as it was extracted from the ground. Historically all choke valves would be manufactured to American Petroleum Institute (API) - standard API 6A, but now the majority of control choke valves are specified to ASME design requirements. Occasionally choke valves have been specified as the point of conversion between the upstream API pipework, and the downstream ASME pipework.

The majority of choke valves are specified as angle valves to minimise erosion in the valve outlet, but occasionally, especially on gas to flare applications a choke valve can be specified as a globe valve.

In broad terms Trillium apply the following model numbers to choke valve designs:

- ASME rated choke valve – globe design – BV990
- ASME rated choke valve – angle design - BV992
- API rated choke valve – globe design – BV993G
- API rated choke valve – angle design – BV993
- API (Inlet) and ASME (outlet) choke valve – BV992

FEATURES

- Standard and bespoke designs
- None collapsible trim
- Bolted, clamped or screwed bonnet
- Streamline flow passages
- Stable, internally guided trim
- Low shear
- Low pressure recovery
- Total velocity control
- Natural anti-clogging
- High flow capacity
- Cavitation control
- Noise control
- Erosion control

CUSTOMER ADVANTAGES

- Easy service valve
- Custom solutions
- Reduced downtime
- Extended intervals between service
- Double the service life through trim reversal on specific trims
- Reduced maintenance costs
- Reduced cost of ownership

CHOKE VALVE APPLICATIONS

Choke valves are specified for many applications, but most valves fall into the following general categories:

PRODUCTION CHOKE VALVES

The production choke valve is normally used to reduce the pressure of the oil and gas as it is extracted from the ground. It is normally located on or close to the well head. Depending on the valves location it can either be specified in ASME, API or API/ ASME designs.

The production choke valve is exposed to some of the worst process conditions including:

- Oil
- Gas
- Water
- H2S
- Co2
- Methanol
- Sand

Material selection in a production choke valve is based on customer design conditions, but often these valves are subject to low temperatures on start-up due to a low temperature gas cap.

The highly erosive process conditions mostly dictate that the valve trim should be manufactured with solid tungsten carbide inserts to ensure maximum resistance to the impingement of the erosive sand particles.

WATER INJECTION CHOKE VALVES

As the name suggests, water injection choke valves are used to inject water into the well. In most cases the water is clean so there are no concerns about fluid contamination.

Water injection valves are often subject to very high inlet pressures and low outlet pressures. It is important that the right process conditions are given so that Trillium can select the appropriate number of pressure reduction stages to avoid cavitation.

In water injection applications it is important to select a 'low pressure recovery' trim. By definition this will be a cage trim valve design with fluid impingement in the centre of the valve cage.

Water injection valves are mostly specified with either the Cascade (2 or 3 stages of pressure reduction) or the X-Stream™ trim where the number of pressure reduction stages is selected according the specific pressure drop.

GAS LIFT CHOKE VALVES

Gas lift choke valves are used to inject gas into the well. In the well, gas is injected into well tubing. It is used to reduce the fluid density in the well proportional to the flowrate. The gas that is typically used on gas lift systems is normally taken from the reservoir and has been cleaned to remove impurities. Valves on a gas lift system are normally relatively small (up to 3") and depending on the amount of gas, are either spline or cage designs. Valves are usually manufactured in carbon steel.

FLARE SYSTEMS

Valves associated with the gas to flare system are often specified as choke valves. Some common specifications call for both API and ASME design valves. A number of choke valves on the flare systems tend to be larger than conventional production choke valves due to both the volume of gas and the associated pressure drop across the valves. Flare system valves can sometimes be globe valves.

When associated with well depressurisation the choke valves are mostly manually operated but can be specified for control purposes with the correct actuator selection.

Often outlet pressures can be near to atmospheric pressure which can lead to high outlet Mach numbers meaning that the valve and outlet pipe size needs to be specifically considered.

CHEMICAL INJECTION

Chemical injection valves are used to inject specific chemicals into the well to enhance oil and gas recovery. A common chemical is Methanol. Chemicals are injected at very high pressures and therefore the valves normally have a high pressure rating. Most chemical injection valves are relatively small, typically 25mm (1") but trims are designed with high grade materials to prevent erosion during the injection process.

GENERAL CONSTRUCTION

Valves are manufactured from forged or cast bodies and bonnets according to the project specification and the applicable API or ASME specification. In the case of API materials, the material grades are selected according to the particular strength requirements stated in API 6A. ASME materials are specified according the ASME B16.34.

The bonnet is usually a bolted, however clamped or special bonnets can be applied according to customer specifications.

RATINGS

- ASME Pressure Ratings – ASME 150 – ASME 4500
- API Pressure Ratings – API 2000 to API 15000

VALVE SIZES

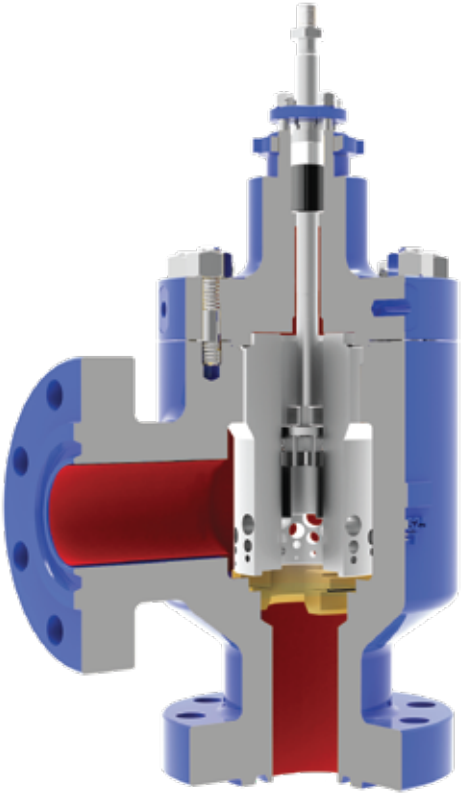
- ASME 1” -36”
- API 1” – 16”

ACTUATION

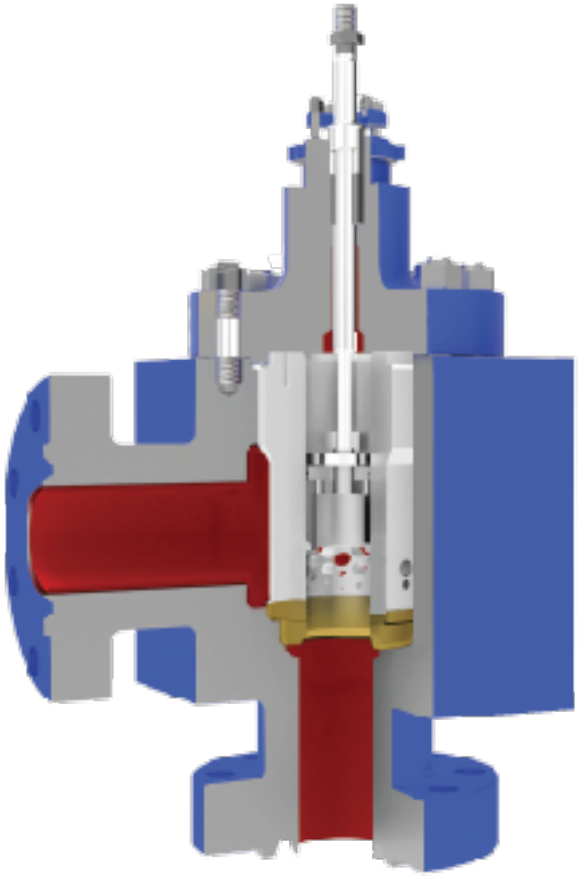
- Linear pneumatic
- Linear hydraulic
- Hydraulic stepping
- Manual
- Electric

COMPLIANCE

- API 6A
- ASME B16.34
- NORSOK
- NACE



Typical Cast Choke Valve



Typical Forged Choke Valve

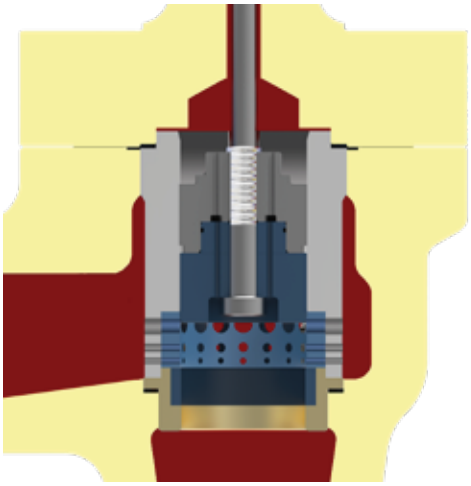
SINGLE STAGE (MULTI-FLOW) VALVE TRIM

The valve trim is the most important aspect of a choke valve. It is often subjected to the highest pressure drops under highly erosive conditions due to fluid contamination. It must be designed to withstand erosion while maintaining control of the valve.

Trillium has extensive experience in designing valves for high pressure drop applications coupled with the potential for erosion due to fluid contamination such as sand.

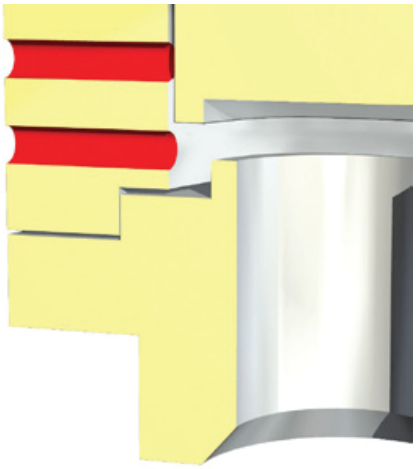
Trillium internally guide the plug. This means the valve plug runs inside the valve cage. This has a number of benefits:

- Valve is low pressure recovery design
- Fluid impingement is on the inside of the cage
- Tungsten carbide is protected by the steel outer cage
- Erosive fluid jets are directed towards the valve outlet
- Plug is fully supported through the stroke eliminating the potential for noise and vibration
- Reduced acoustic efficiency of the flow stream and changes the power spectrum which contributes to lower noise
- Trim can be balanced which in turn requires smaller actuators
- Optional protected seat design for longevity of the seating faces



PROTECTED SEAT

On flashing or contaminated fluid applications protected seat designs can be applied to extend the life of the trim seat area. The special plug head contour ensures that the seating face of the plug is protected from the flow area by an extended lip on the outside of the plug nose. Additionally the use of the protected seat design ensures a deadband before the flow starts to pass through the cage. This ensures a reduced velocity through the trim and consequently a reduced rate of erosion.

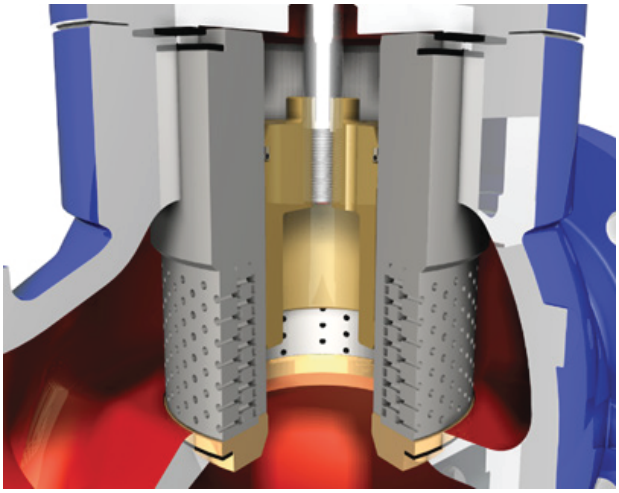


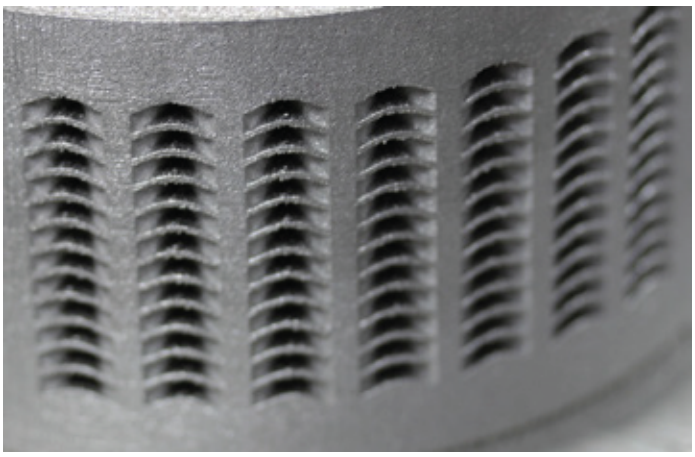
CASCADE TRIM

The Cascade trim is designed with a series of drilled hole cages when can offer 2 or 3 stages of pressure reduction.

The Cascade trim is offered when the process fluid is clean, such as water injection, but where there is a high pressure drop or the potential for cavitation.

The Cascade trim is designed with drilled cylindrical rings that when made into an assembly ensures the fluid has a tortuous flow path around multiple 90 degree turns.





SEVERE SERVICE X-STREAM™

Trillium are at the forefront of multi stage trim technology. The X-Stream™ trim when applied to choke valves gives unrivalled technological advantages over other disc style technologies. These include:

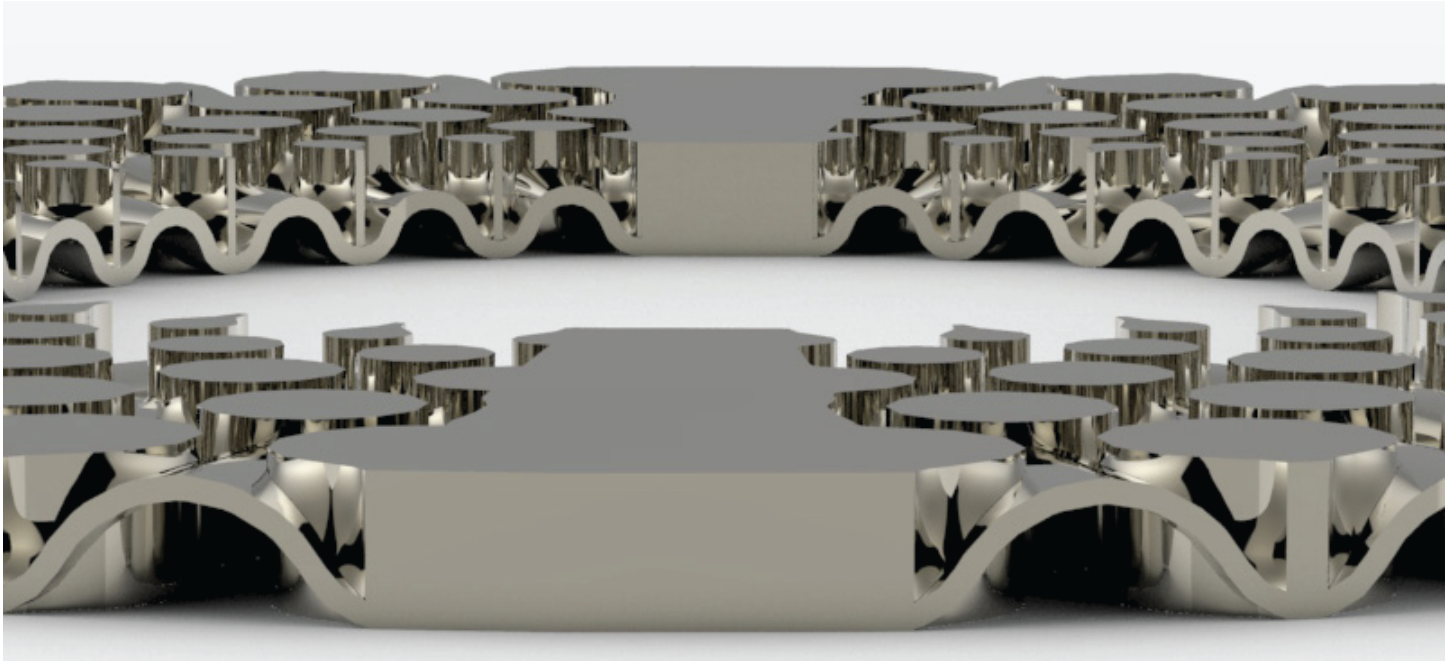
- Manufactured to suit the application
    - Spark eroded disc flow path
    - 3D printed disc stack
    - Separable disc stack
- Anti-clogging through smooth flow profile
- Low shear design
- Cavitation elimination
- Noise control
- Double the operating life (linear trims)

ELIMINATION OF CAVITATION

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.

A number of disc stack designs are too focused on limiting the trim exit velocity through turning the flow around 90 degree 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 choke 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.



NATURAL ANTI CLOGGING
NO SHARP CORNERS

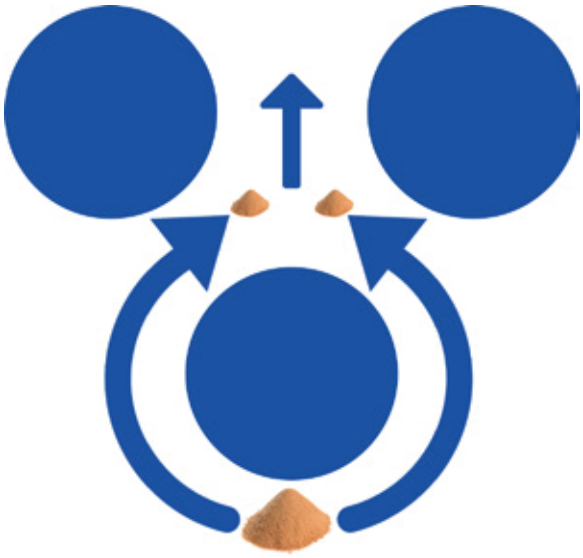
Unlike virtually all other severe service trims on the market the X-Stream™ trim has a natural flow path with no sharp corners.

IF DEBRIS CAN ENTER THE TRIM, IT WILL SIMPLY WASH THROUGH. THE TRIM WILL NOT BLOCK.

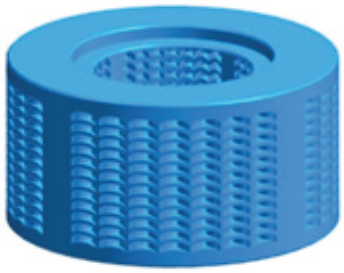
In Oil & Gas applications the trim is ideal for valves where sand is present. Sand particles are simply washed through the trim.

The streamline flow paths ensures minimum erosion of the trim due to solid particulates. In the field, the X-Stream™ has been shown to last more than 6x longer than conventional trims.

For high levels of sand contamination and/or high pressure drops the X-Stream™ can be supplied in Tungsten Carbide. This gives high levels of erosion control.



Sand passes around smooth corners with less impact erosion



LOW MAINTENANCE COSTS - DOUBLE THE LIFE

The X-Stream™ trim is usually produced as a linear stack. It is specifically designed to reduce maintenance costs as it is field reversible.

This means that one disc stack can simply be reversed giving double the trim life and exactly the same level of control performance.

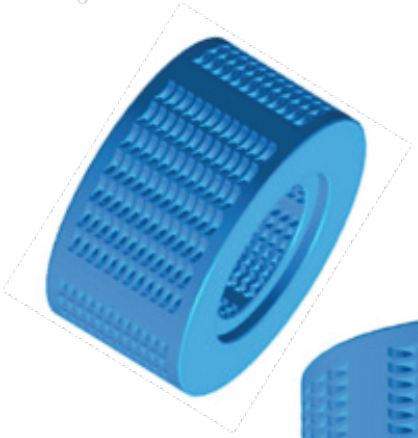
APPLICATION

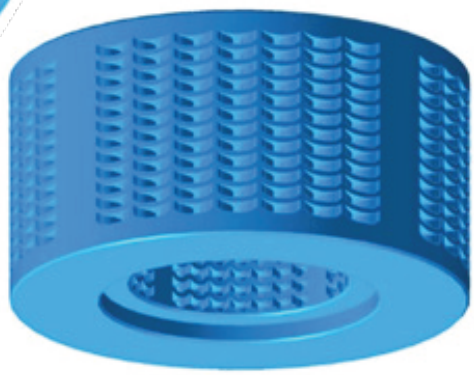
The X-Stream™ extends service life in an offshore application with sand in the fluid.

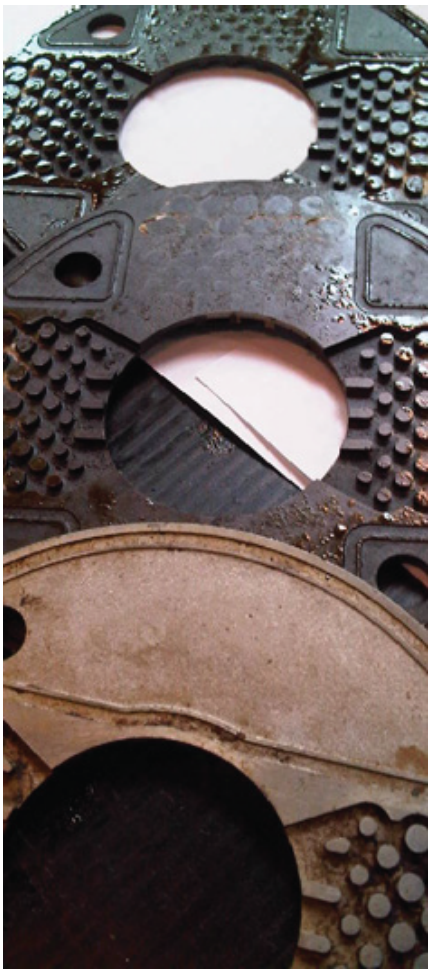
No valve lasts forever especially when sand is present. Sand impingement on material surfaces especially at high pressure drops causes erosion.

In most applications sand erosion will be confined to the lower portion of the cage where the pressure drops are the highest.

On linear trims, the disc stack can be reversed effectively doubling the life of the trim.







SEPARABLE DISC STACK LOWER COST SPARES

The X-Stream™ can be ordered and supplied with a separable disc stack in applications where there are known issues of fluid contamination and therefore the potential for erosion.

Separable discs allow for one off replacement of individual discs ensuring significantly lower maintenance costs and reduced downtime.

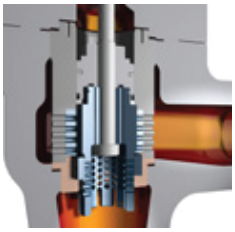
Note:
Trillium can provide upgrade solutions to existing choke valves. Consult your nearest sales office (see Trillium web site) for details.

Protection of the tungsten carbide trim by the metallic valve cage – sometimes referred to as a brick-stopper

Tungsten carbide although very hard wearing is also very brittle and in the event of large pipe debris (such as screws and welding rod) that have been left in the system, high velocity impact can result in exposed tungsten carbide components shattering, resulting in valve failure and lack of control. In cage guided valves flow is normally from outside to in and this acts as to a protection mechanism for the tungsten carbide components.

Reversible Choke used for both production and injection.

The well changes over it's lifetime usually resulting in lower pressures in the oil being extracted from the ground. One such application required Trillium to produce a choke valve that could be reversed in the field so that it could be used for both production and injection. This called for a unique trim solution to both eliminate blockage due to a high sand content and also have multiple stages of pressure reduction (without sand blockage) to eliminate cavitation.



Made to measure

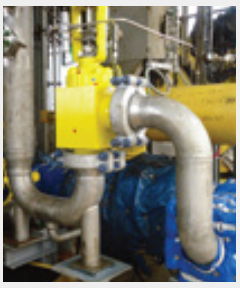
Trillium can produce custom designs if space is limited or if replacing existing valves. This example shows a valve designed with custom end connections to fit in the customer space envelope.

Erosion prediction and flow limiters

Flow erosion and trim collapse can be an issue for system safety. Trillium were commissioned to produce a choke valve safety study to predict the life of a choke valve trim under highly erosive sand impingement. A flow limiting device was installed in the valve outlet to limit the total flow through the valve should the trim fail.

Dealing with pipework constraints

Space offshore is limited and often valves are required to fit in a limited space without any operational issues. Bends directly before or after a valve can cause issues with unstable flows. Once Trillium are made aware of these constraints then a specific trim can be designed to eliminate issues caused by flow instability.



CHOKE VALVE ACTUATORS OPTIONS

Top side and land-based choke valves can be specified with a large selection of actuators options. Common actuators are shown below.

Pneumatic Diaphragm

Pneumatic actuators offer a cost-effective solution for valve control. On choke valves they are typically applied to balanced valves.

Pneumatic Piston

Where is pneumatic actuator is required, but the pneumatic diaphragm does not provide sufficient thrust then a piston actuator is specified.

Electric

Electric actuators are both relatively compact and offer high thrusts, stable control and high levels of 'stiffness'.

Electro Hydraulic

On offshore applications the electro hydraulic actuator is normally powered by a hydraulic ring main. This means that actuators can be relatively simple but yet offer high levels of thrust

Stepping

When the valves are not used for full modulating control and are typically in one position for extended periods a stepping (hydraulic or pneumatic) is used to give high levels of 'stiffness'.

Manual

The manual actuator is used where modulating or automatic control is not required.

MATERIAL AND MATERIAL SPECIFICATION

Depending on the applicable standard, customer specification materials common materials used on choke valves are either cast or forged. Forging can also include specific processes such as Hot Isostatic Pressing (HIPping). Valves manufactured from forged materials have better mechanical properties than cast materials but are generally more expensive as more material has to be machined away to produce the valve flow gallery. Common API materials and requirements are listed below.

API material selection is based on the material strength, materials with a 60K yield strength can be used for choke valves up to API 10000 rating.
API 15000 choke valves require a material strength of 75K

Carbon Steel	Material Grade	Type	Suitable for NACE	Material Yield Strength		API 6A Designation
				Up to API 10k (60K Material)	Up to API 15k (75K Material)	
Carbon Steel	ASTM A487 Gr C	Cast	√	√	x	AA,BB,DD & EE
Duplex	ASTM A995 Gr 4A (UNS J92205)	Cast	√	√	x	CC & FF
Duplex	ASTM A995 Gr 5A (UNS J93404)	Cast	√	√	√	CC & FF
Super Duplex	ASTM A995 Gr 6A (UNS J93380)	Cast	√	√	x	CC & FF
AISI 4130	AISI 4130	Forged	√	√	√	AA,BB,DD & EE (HH with Inconel cladding)
AISI 4140	AISI 4140	Forged	√	√	x	AA,BB,DD & EE
Duplex	UNS S31803 (F51)	Forged	√	√	x	CC & FF
Duplex	UNS S32760 (F55)	Forged	√	√	√	CC & FF
Super Duplex	UNS S32760 (F55)	Forged	√	√	√	CC & FF
LF6	ASTM A350 LF6 Class 2	Forged	√	√	x	AA,BB,DD & EE
660	ASTM A638 Grade 660	Forged	√	√	√	CC & FF
AISI 410	AISI 410 Condition T	Forged	x	√	x	CC & FF

API 6A PRODUCT SPECIFICATION REQUIREMENTS (PSL)

Casting					
	PSL 1	PSL 2	PSL 3	PSL 3G	PSL 4
Chemical	Required	Required	Required	Required	Required
Mechanical	Not Required	Not Required	Required	Required	Required
Impact	Dependent on Temperature		Required	Required	Required
Hardness Testing	Not Required	Not Required	Required	Required	Required
NDE	Not Required	100% MT or PT on surfaces Sample RT - casting	100% RT or UT 100% MT or PT	100% RT or UT 100% MT or PT	100% RT or UT 100% MT or PT
Welding	Allowed	Allowed	Allowed	Allowed	Not Allowed(except overlay)
Forging					
Chemical	Required	Required	Required	Required	Required
Mechanical	Required	Required	Required	Required	Required
Impact	Impact	Impact	Impact	Impact	Impact
Hardness Testing	Not Required	Not Required	Required	Required	Required
NDE	Not Required	100% MT or PT on surfaces	100% UT 100% MT or PT	100% RT or UT 100% MT or PT	100% RT or UT 100% MT or PT
Welding	Allowed	Allowed	Allowed	Allowed	Not Allowed(except overlay)

Note: The tables shown are for guidance. Consult either API 6A or ASME B16.34 for details.

COMMON TESTS ON CHOKE VALVES

The following is a list of common tests carried out on choke valves. This list is by no means exhaustive and different specifications often call for different requirements.

Test	Comments	Trillium
PR2 Testing	The requirements for PR2 testing are defined in API 6A. In general, the requirements are mostly applied to API rated valves. Testing can also be carried out on ASME rated valves where the applicable requirements of the PR2 test can be applied.	Specific valve sizes and ranges have already been qualified. Should the project requirements be outside the current qualifications, Trillium can meet all the test requirements.
Fire Testing	In strict terms the choke valve is not an isolation or shut off valve so according to standards a fire test is not required on the valve. Many specifications however, call for fire testing of the choke valve. The most common standard for fire testing on a choke valve is API 6FA. This standard allows valves that are both ASME and API rated to be tested and qualified. One fire test qualifies a range of valves. According to the latest standard fire testing to older versions of the standard qualifies valves to the current version.	Specific valve sizes and ranges are already qualified. Should project requirements fall outside existing certification then a test valve can be built and fully tested
Fugitive Emission Testing	Project specifications sometimes call for emission testing. The most common standard for testing is ISO 15848. This is split into two parts, Part 1 covers prototype testing and Part 2 covers production testing. Once valves have been tested to Part 1 of the standard this qualifies a range of valves of various sizes and ratings. The specific qualification will be stated on the certificate. Production valves will then only need testing to Part 2 of the standard which only requires a limited number of test cycles.	Common stem sizes and packing designs have already been qualified according to the requirements of ISO 15848. Production testing can be carried out on production valves during assembly.
Gas Testing	All choke valves are hydrostatically tested as part of our standard test routines, however, depending on the PSL (PSL 3G or PSL 4) level or customer specification gas testing could also be required. Before gas testing a hydrostatic test is performed. Gas testing is normally performed at the rated working pressure, at ambient temperature. For testing valves are submerged. Valve seats do not require gas testing.	Gas testing is largely a function of the valve specification. Gas testing can be completed based on the requirements of API 6A. Additionally we can meet the majority of customer specifications.
NED Testing	Particular NDE requirements on choke valves can be conducted to meet API 6A as detailed for the particular PSL level. Additional NDE can also be performed according to customer requirements.	As a minimum Trillium will meet the requirements of API 6A. Additionally we can meet the majority of customer specifications.
PMI	Positive Material Identification (PMI) ensures materials are checked before and during valve assembly.	PMI testing is available where required.

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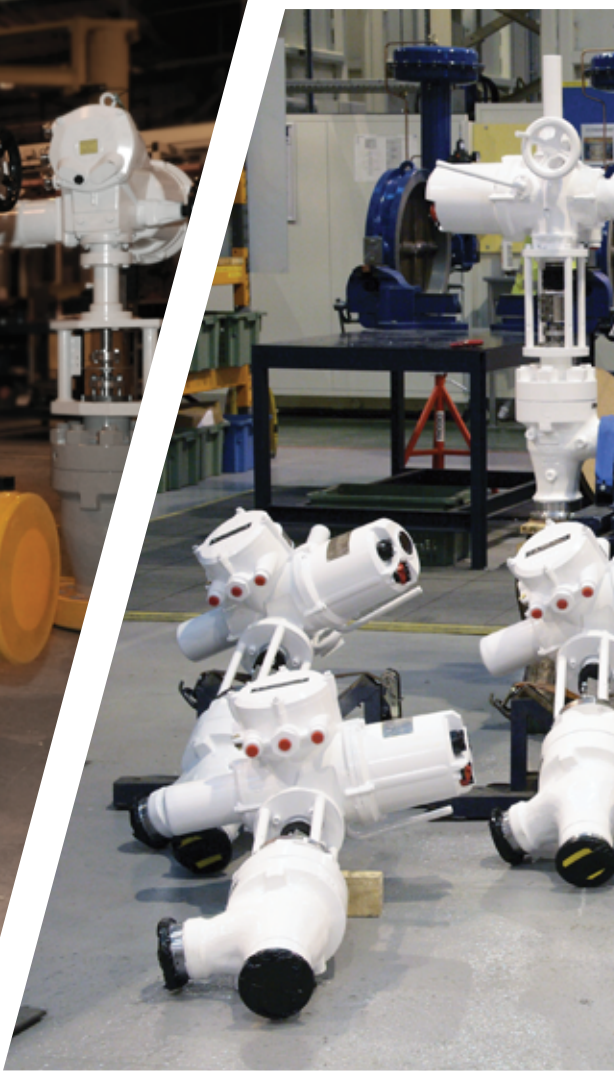

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