COPES-VULCAN
AN SPX BRAND

# Direct Steam Converting Valves
## Model DSCV-SA

**<u>Introduction</u>**

The Copes Vulcan large capacity combined pressure reducing and desuperheating valve, which is known as the DSCV, is of angle style construction with the steam inlet through the branch connection and the steam outlet through the in-line connection. The connections can either be flanged or butt-welded depending upon customer preference. The units are manufactured in 2 parts to allow for greater customer flexibility. The High-pressure side of the unit is of cast construction with the lower pressure outlet connection being of fabricated construction.

The valve is provided with a bolted bonnet closure for pressure ratings up to and including ANSI 900# and either a pressure seal closure pressure ratings ANSI 1500# upto and including ANSI 4500# rating. The valve can be fitted with single stage Hush, Multi stage Hush or Copes-Vulcan RAVEN trim technology depending upon the pressure drop required in the steam to be desuperheated, and the requirements to meet specific noise levels. The valve is provided with balanced single seat trim construction utilising a tandem trim pilot operated concept allowing class V leakage rates per ANSI/FCI 70-2 to be achieved.

**Brief History**

The requirements dictated by the increasing use of turbine bypass systems is creating greater demand on the suppliers of the basic hardware making up the system, particularly the valves and desuperheaters used for this application. The use of turbine By-pass systems is increasing as plant operators seek to gain more flexibility in their operating practices and to reduce the times between shutdowns.
There is an increasing requirement for this type of equipment which involves the use of large and small combined pressure reducing and desuperheating valves, after coolers, fast acting dual speed valve actuators and fairly complex control schemes. Originally, turbine by-pass systems were provided as a means of disposing of steam produced by the boiler in the event of a turbine trip. A simple system would monitor the boiler pressure and when this rose above a predetermined level, the control loop would cause the by-pass system to open dumping steam produced by the boiler straight into the condenser. An alternative control philosophy would be to tie this into the turbine trip signal such that when the signal was given to trip

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the turbine, an initiating signal would be passed to the bypass system, which would open and dump the steam. In Industrial plants the pass out steam from turbines was a convenient means of producing process steam at varying conditions. The use of this approach meant the steam could be generated at one pressure and temperature in a plant and the requirements for differing pressures and temperatures for process could be met by various pass out stages from the turbine. This requirement imposed an additional demand on the system in that the supply of process steam became the main concern and continuity of supply was all-important.

The job of the turbine by-pass system in this set up is to supplement and maintain the pass out steam from the turbine at all times and to ensure the continuation of supply under all conditions whether the turbine is in operation or not.

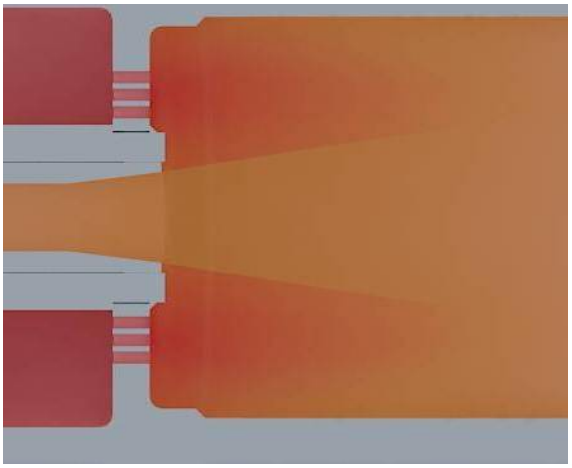
The basic function of a turbine bypass system, regardless of what method of control is used, is to reduce the pressure of steam to a level acceptable by the downstream system and to reduce the temperature of the steam to an equally acceptable level.

## Description

Operating within the balancing cylinder and cage assembly is the main plug, which incorporates a tandem pilot plug that is connected to the valve stem. The main plug is provided with a single seat that contacts the seat in the cage when in the closed position shutting off all flow into the bore. When the pilot valve is closed, the build up of pressure on top of the plug, up to the inlet pressure conditions, will provide additional seating force thus assisting the actuator to achieve class V shutoff.

The balancing cylinder is provided with large capacity ports or similar capacity ports are provided in the main plug immediately below the seating surface. These ports are provided to feed steam into the bore of the cage and are not intended to be throttling ports. Control of the flow through the valve is through drilled holes in the cage, in the case of single stage hush trim; through the overlap of drilled holes in successive sleeves in the case of multi-stage hush trims or through the tortuous flow paths of the RAVEN trim design. These flow paths are uncovered by movement of the main plug which allows steam to pass from the inlet to the outlet side of the valve which allows a pressure drop to be taken across these holes. Movement of the main plug is initiated by the valve actuator responding to a signal from the control instrumentation.

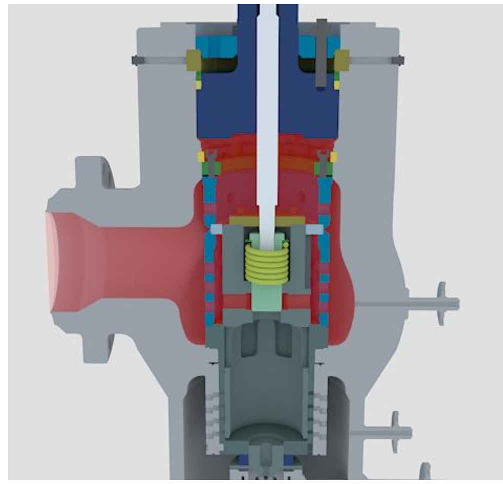
Water is introduced via a side branch on the DSCV-SA body directly into the steam atomising head. HP Steam at P1 conditions is fed into the atomising head via a converging nozzle once the main valve plug lifts off its seat. Water is introduced via a combining tube directly after the nozzle where it is atomised and then passed through a converging – diverging venturi throat section. The hot atomised water exits the atomising head and is rapidly evaporated, cooling the main steam flow. This method of water introduction does not rely on surrounding steam velocity or turbulence for effective mixing and thus gives very high turndowns, generally in excess of 100:1.



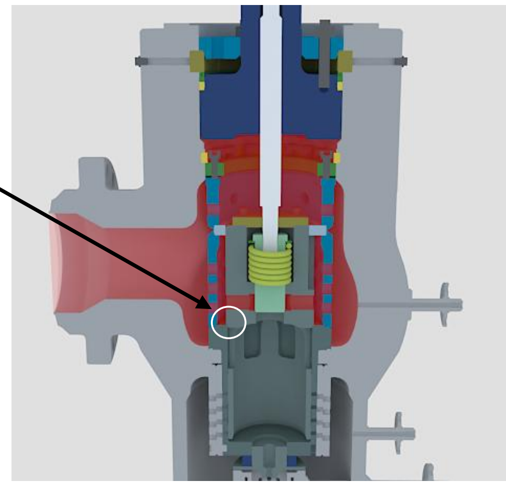
In the valve outlet, a diffuser plate or multiple diffuser plates are provided. The purpose of diffuser plates is two-fold; firstly, they take some of the pressure drop away from the trim; secondly, they create a back pressure in the valve outlet which reduces the volume of steam and enables the velocity to be maintained at an acceptable level in order to control the noise generated within the valve.

**Principle of Operation**

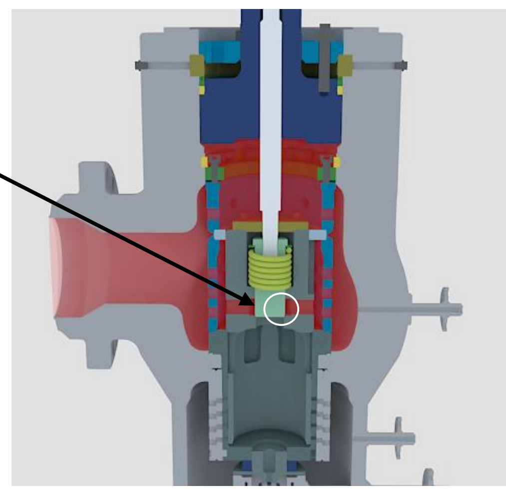
The DSCV-SA valve here is in the closed position.



The main plug is fully seated

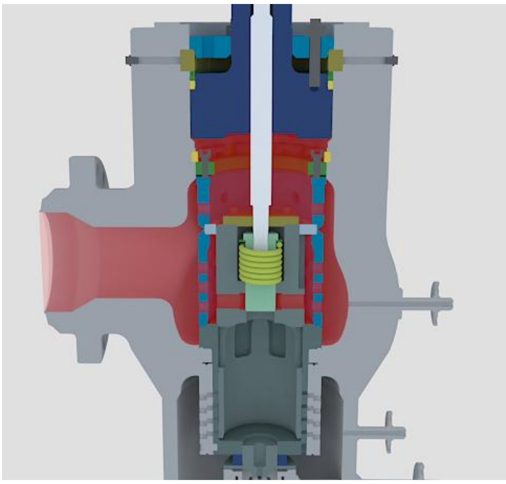


and the pilot tandem plug is closed

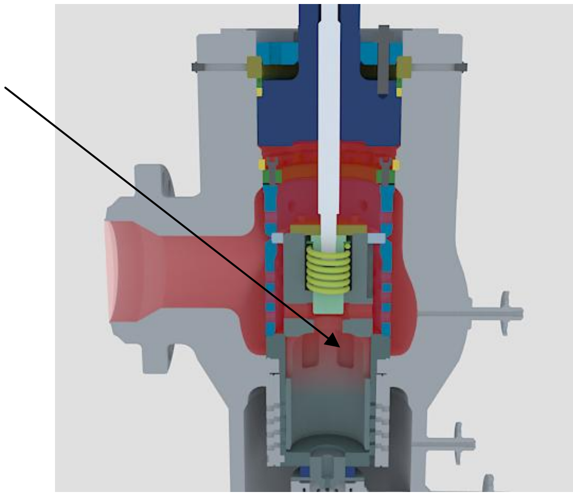


The DSCV-SA valve has a very tight shut off in the closed position, as a minimum ANSI FCI 70-2 class V. It achieves this tight shut off by utilising a pilot plug design so that in the closed position the main plug is unbalanced with the full steam pressure acting on the top of the plug, this load combined with the actuator thrust resulting in very high seat contact loads, which ensures a very tight shut off.

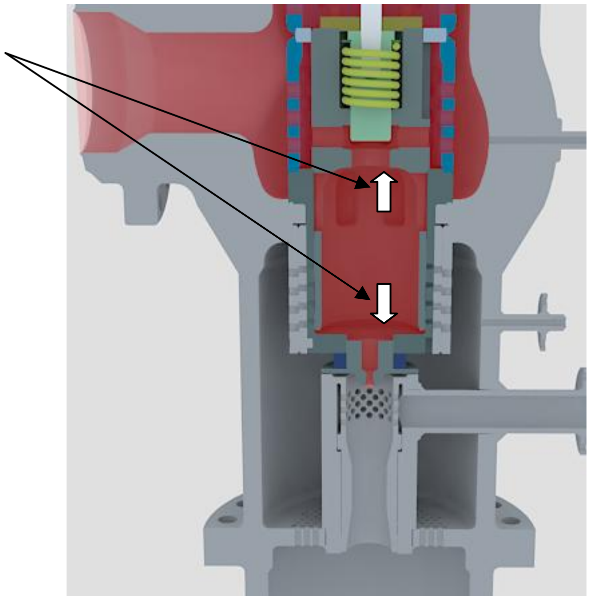
Not only is tight shut off required for plant thermal efficiency it also prevents leak induced 'wire drawing' damage across the seat which would otherwise result in frequent maintenance to repair or replace the seat.



When an open command signal is received, the actuator retracts and the pilot plug is the first to open. This allows P1 steam to flood through the large pilot plug port to the underside of the main plug. The main plug is now balanced reducing the actuation thrusts required.

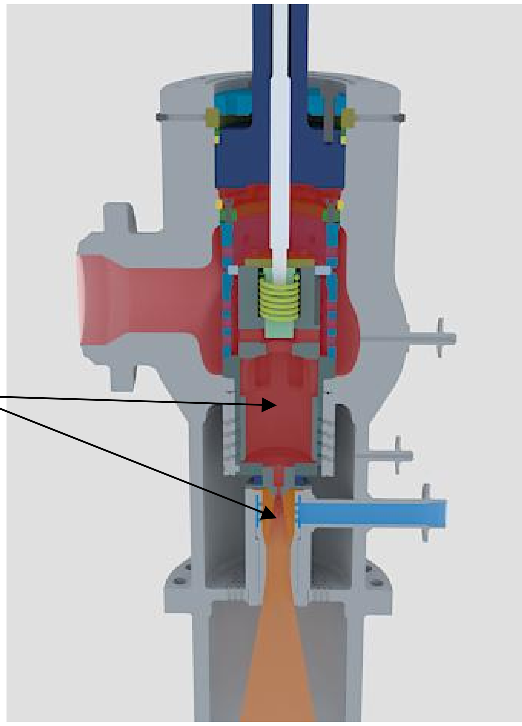


As can be seen, the CV or capacity of the pilot port is several times greater than the atomising nozzle and designed leak paths of the cage guiding system ensuring equal inlet pressure on the underside and top side of the main plug

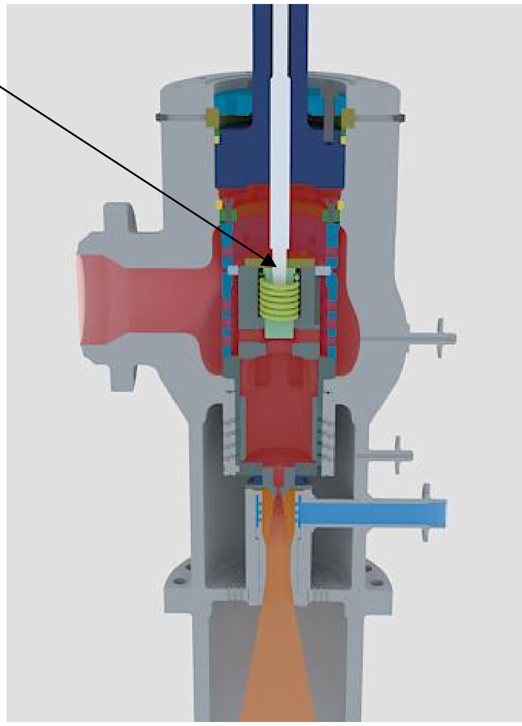


High pressure balancing or P1 balancing is a key design feature of the DSCV-SA for reliable smooth operation. Some other designs employ low pressure or P2 balancing however these low pressure balancing systems rely on auxiliary balancing seals such as piston rings and close tolerance sealing surfaces to prevent the high pressure steam unbalancing the trim. In operation if these seals or surfaces ware or become damaged the trim quickly becomes unbalanced stem loads dramatically increase and fluctuate which can result in the valve oscillating violently or even unable to open on command.

Now with the pilot plug open, high pressure inlet steam has flooded the underside of the main plug and the steam atomising unit is now operating in preparation to receive the incoming cooling water from the water control valve

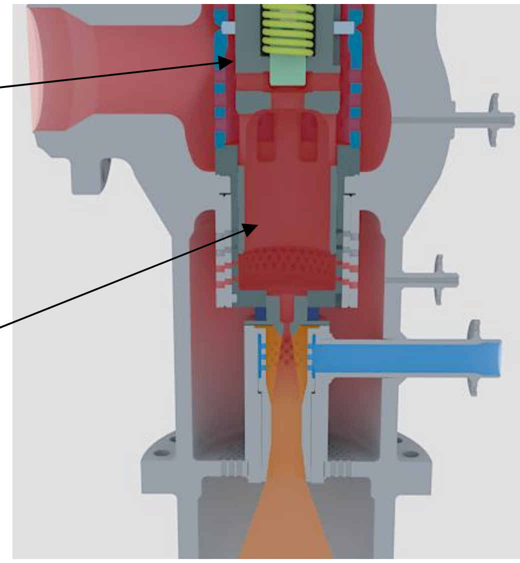


The pilot plug shoulder has now engaged with the underside of the tandem cap of the main plug. The main plug now starts to lift and the main seat opens



This heavy duty distribution spacer has been specifically designed to negate any upstream pipework induced flow disturbance being communicated to the main plug. Therefore long radius bends or isolation valves can be fitted directly to the valve inlet to minimise installation space. The main plug is fully guided by the cage and spacer to ensure complete plug stability through full travel.

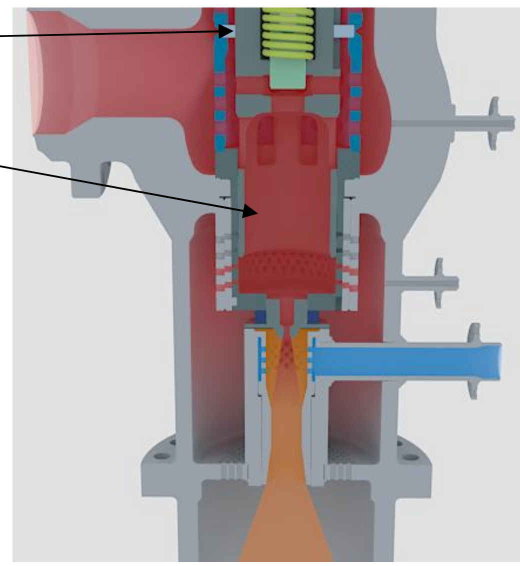
As the main plug opens, steam first enters the valve via a heavy duty distribution spacer. The steam passes through the spacer by means of numerous holes evenly positioned around the full diameter



The main plug is fully and securely guided throughout. The upper section of the main plug is guided in a specially hardened and extremely robust guide ring with an integral anti-rotation key.

The lower section is securely cage guided through its entire length.

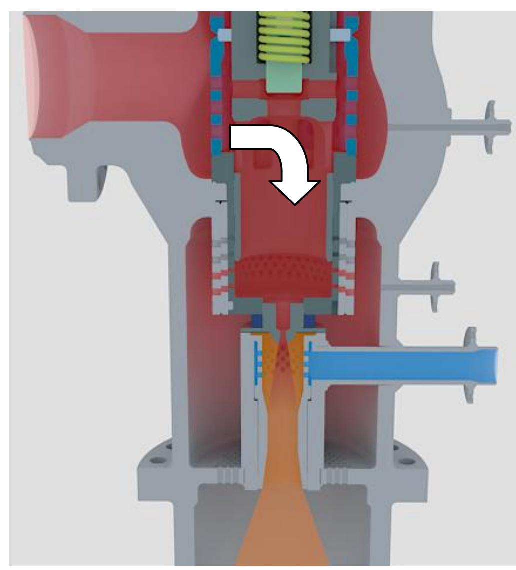
The combination of the heavy duty inlet distribution spacer and full cage guiding ensure total plug stability even in the most arduous installations.



After the inlet steam has passed through the distribution spacer it now travels through the main seat area to the underside of the main plug via large feed ports

With the main plug now lifted the pressure reducing ports of the cage are now open to allow the steam to be pressure reduced in a controlled manner. As the command signal increases and the actuator further opens the main plug further pressure reducing ports are exposed and the steam flow rate increases. Copes-Vulcan can supply the DSCV-SA steam turbine bypass valve with its industry proven active noise attenuation trim styles, Single and Multi stage HUSH or the multi labyrinth, multi disk RAVEN.





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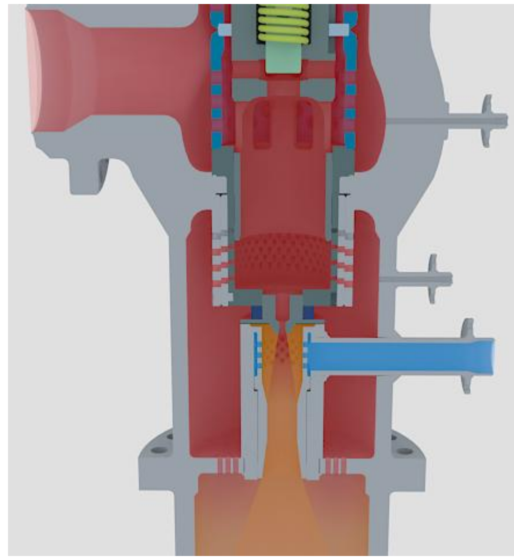
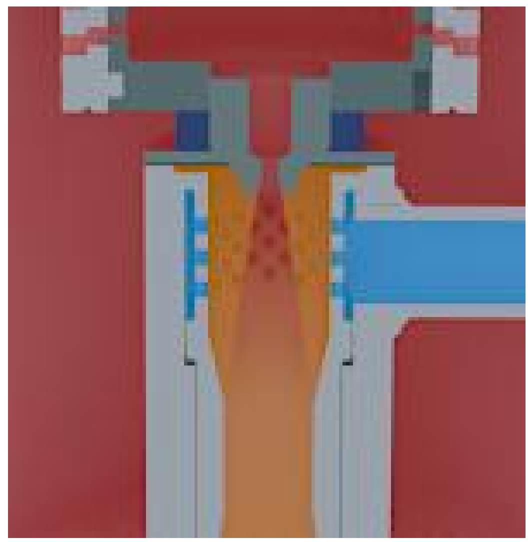
The pressure reduced steam exits the cage into the outlet section of the steam bypass valve. The steam pressure in this area is slightly higher than the final downstream pressure. This final pressure drop is taken across the outlet diffuser. The outlet diffuser has several functions; it aligns the steam that has exited the pressure reducing cage providing a perfect mixing zone for the introduction of the cooling water. It also provides a very secure anchor point for the steam atomising head. The diffuser forging can also be used as a material transition point to eliminate on-site dissimilar welding, as the bypass valve is an ideal point which piping engineers can utilise to change piping class and material.

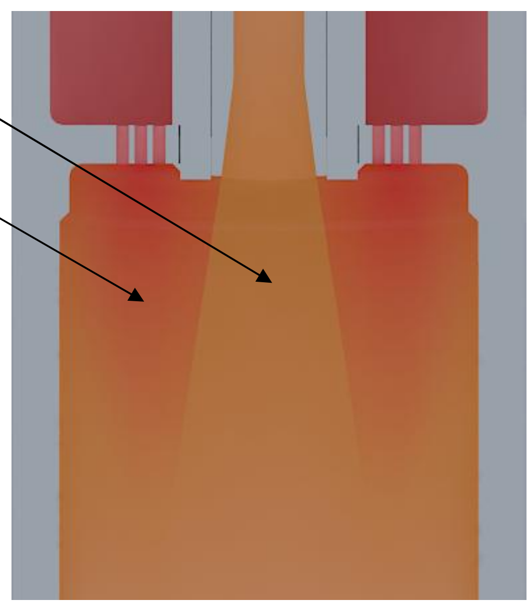


The cooling water enters the DSCV-SA directly into the steam atomising head. The cooling water is forced into an annular chamber which is created by a multi holed combining tube. The combining tube uniformly directs the cooling water into the atomising zone. The energy available in the high pressure steam is efficiently converted into a high velocity expanding jet of steam. The cooling water is instantaneously atomised and travels forward into the venturi section of the atomising head. Here the steam and finely atomised cooling water decelerate and expand as heat is transferred from the atomising steam into the cooling water.



This intimately mixed fluid exits the venturi section with the consistency of a ‘hot fog. As the cooling water is finely atomised and pre-heated the final desuperheating takes place directly after the outlet diffuser section.

With the outlet diffuser aligning the main steam flow to create an excellent mixing zone the final stage of desuperheating occurs rapidly and evenly without danger of thermal shock or water drop out in the downstream pipe work. As final evaporation occurs very quickly then the required downstream straight line lengths are kept to an absolute minimum.”



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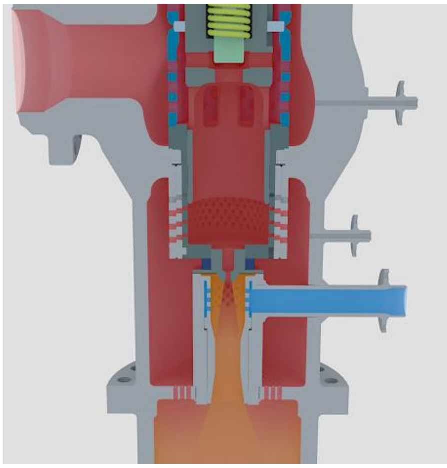
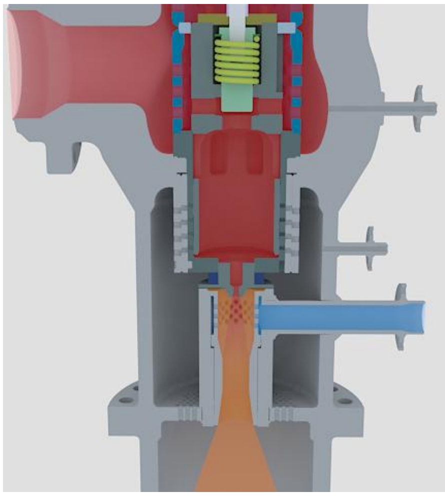
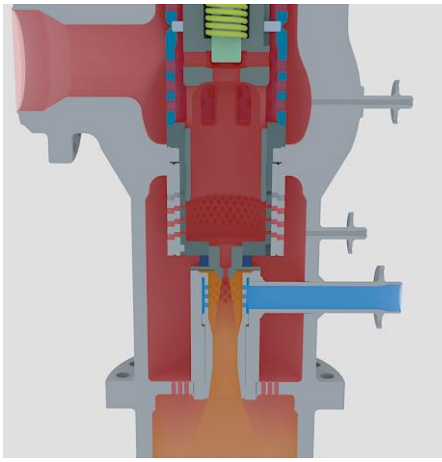
The DSCV-SA valve must be capable of controlling the maximum steam loads but equally important is accurate control and temperature stability at low loads and transition phases. Therefore Turndown or rangeability is an extremely important consideration that plant designers and power generators must consider.



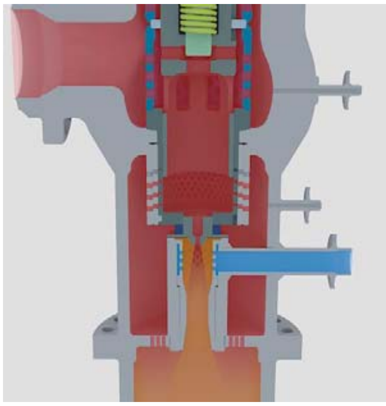
The DSCV-SA was specifically design to achieve extremely high turndowns and wide performance envelopes. This is realised by numerous trim options and the method of cooling water introduction employed, steam atomisation. The trim options of HUSH or RAVEN are characterisable and all have very low minimum controllable CVs. Steam atomisation has several benefits over mechanically spraying the cooling water via nozzles. Mechanical spray nozzles, even spring loaded types are limited in their turndown as the water atomisation and spray pattern degraded as the water flow rate and available pressure differential reduces. As the water demand reduces the spray water control valve closes and the spray valve trim absorbs the water pressure differential leaving little pressure differential for the spray nozzles. This lack of pressure differential at the spray nozzles does not allow them to atomise the spray water, leading to the water pouring into the steam rather than a fine atomised mist. Mechanical spray nozzles also rely on the surrounding steam velocity to provide adequate mixing. When the steam load reduces so does the steam velocity and the ability of mechanical spray nozzles equally reduce. This effect manifests itself with poor downstream steam temperature control and water **'drop-out'**. Water drop-out can be very damaging as cold water will track along the bottom of the inside wall of the downstream pipe whilst un-cooled superheated steam travels along the top and sides. This produces high thermal shocks which can lead to steam header fracture.

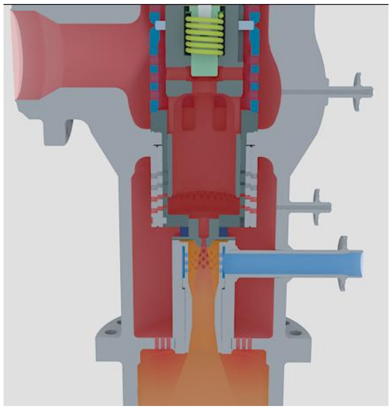


The DSCV-SA employing steam atomisation for the cooling water introduction has several major benefits. The atomising steam pre-heats the cooling water a significant accelerating the evaporation and desuperheating process. Equally important is to finely atomise the incoming cooling water. Very fine atomisation produces extremely small water droplet sizes with a massively increased surface area to promote rapid heat transfer. The atomised, pre-heated water in introduced into the centre of the steam flow with the finely atomised cooling water being carried by the atomising steam itself and therefore has no dependency on the main steam velocity. Therefore for turndown the DSCV-SA is unrivalled."

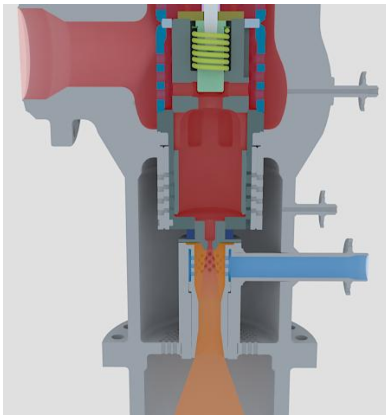


When a closing signal is received the main plug smoothly extends back into the cage which proportionately decreases the steam flow rate.

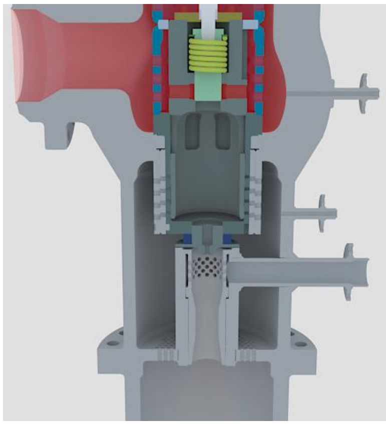




The main plug continues to close until the main seat is engaged. At this point virtually all the steam flow has ceased.

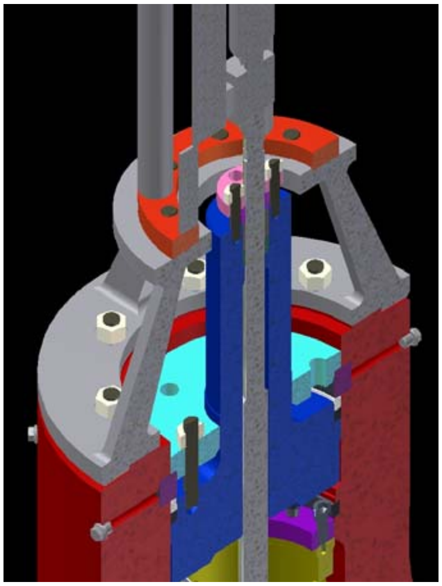


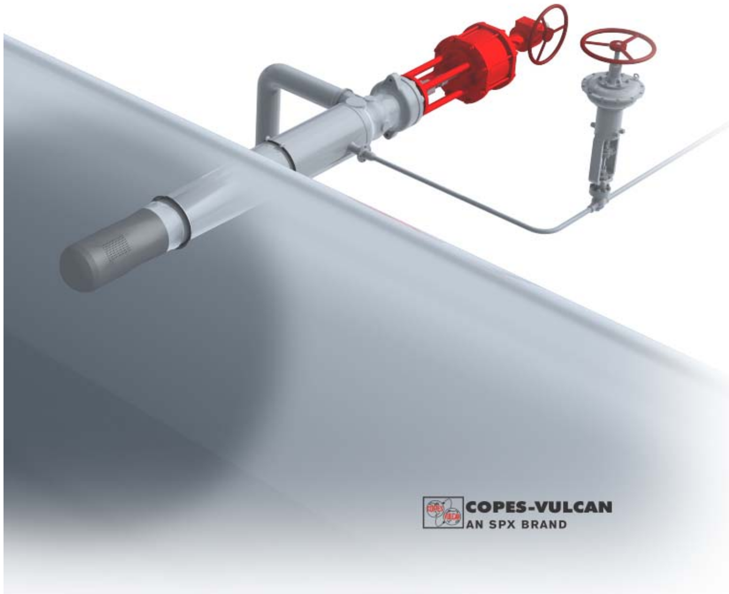
The actuator continues to extend until the pilot plug engages with its seat. At this point full inlet steam pressure is applied to the top of the main cage and the underside of the cage decays to downstream pressure. Effectively the trim is now unbalanced. This unbalanced force significantly augments the seat contact load resulting in a very tight and repeatable shut off.



Some systems such as steam turbine bypass must be able to react and modulate very quickly under emergency conditions such as a turbine trip. Stroking speeds of less than one second may be required. The DSCV-SA can be supplied with either pneumatic or hydraulic actuation to meet this critical requirement. With extremely rapid stroking speeds and large actuation forces it is vital that the actuator and its interface with the steam turbine bypass valve is sufficiently robust to handle these extreme sudden loads. The actuator is connected to the valve by a specially designed actuator load stool

The stool safely transfers and spreads the actuation loads into the heavy section body of the DSCV-SA and NOT into the valve bonnet thus not compromising the bonnet joint integrity or alignment. The stool is spigoted onto the DSCV-SA body and held in place with high tensile, high temperature bolting.

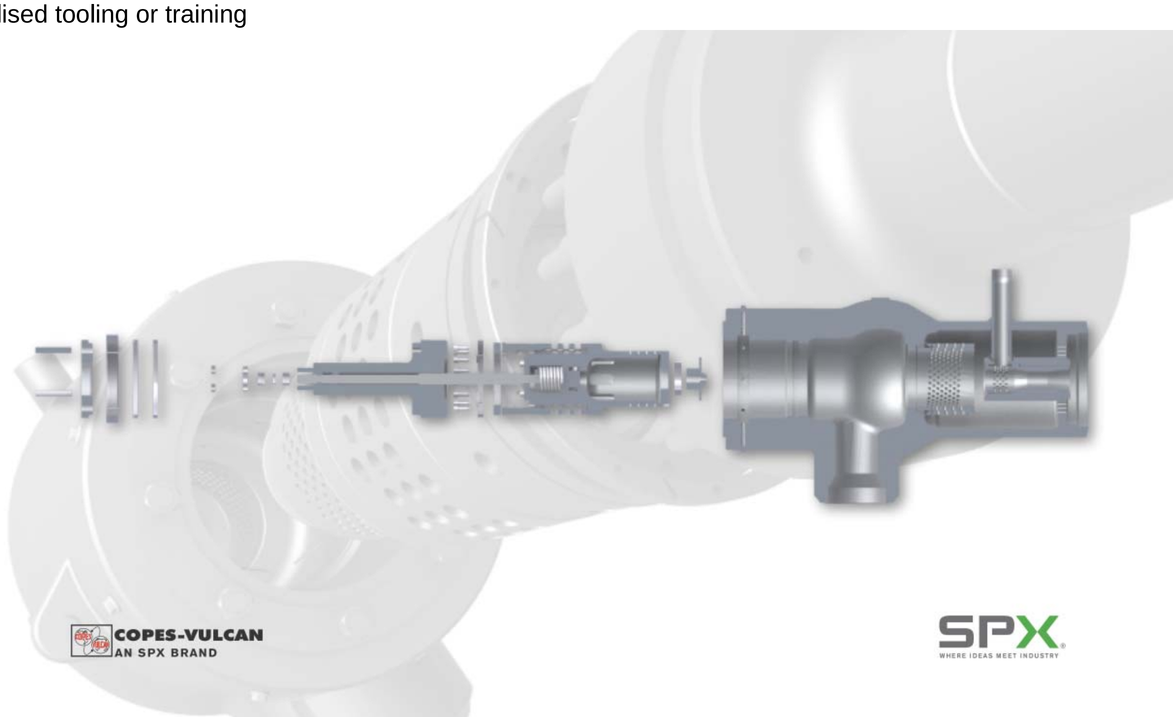





The DSCV-SA can be mounted in the steam header in any orientation allowing full flexibility to the plant piping engineers. All actuators supplied with DSCV-SA steam turbine bypass valves are designed to be self supporting in a horizontal orientation. Therefore no additional supports are required.

As demonstrated earlier upstream and downstream straight line lengths are kept to a minimum with this world leading design.

The DSCV-SA is not a high maintenance valve. However the Copes-Vulcan engineering team were tasked with 'easy maintenance' within their design brief. The complete trim is a 'Quick-Change' style with no welded in components or large internal threaded parts. The whole trim assembly is held in compression by either a compression ring or the bonnet. By simply removing the compression ring or bonnet the whole trim simply slides out of the top of the valve. Therefore in-situ maintenance, should it be required, is both expeditious and uncomplicated with no need for any specialised tooling or training

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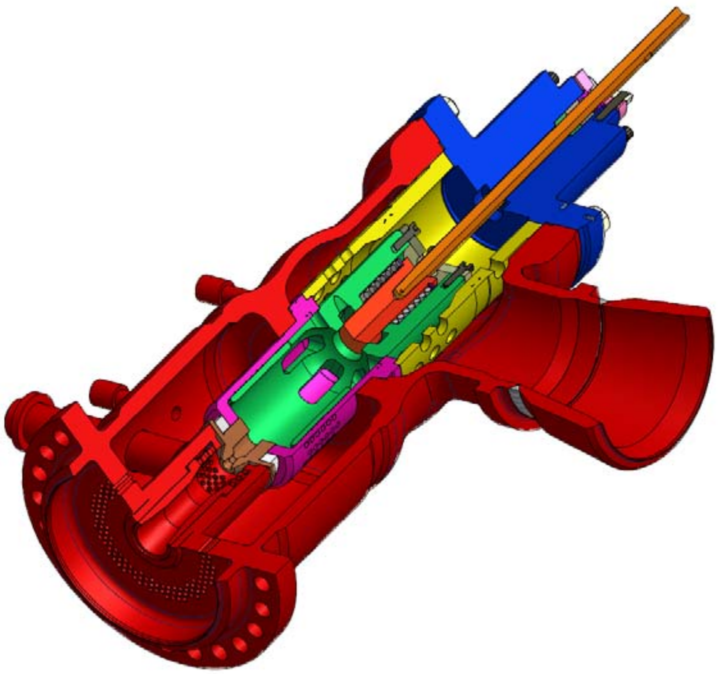
**Design**

The pressure retaining parts of the DSCV are designed in accordance with the requirements of ANSI B16.34 for cast construction and ASME Section VIII for forged fabricated construction. Other applicable standards are ANSI B16.5 and ANSI B16.25.

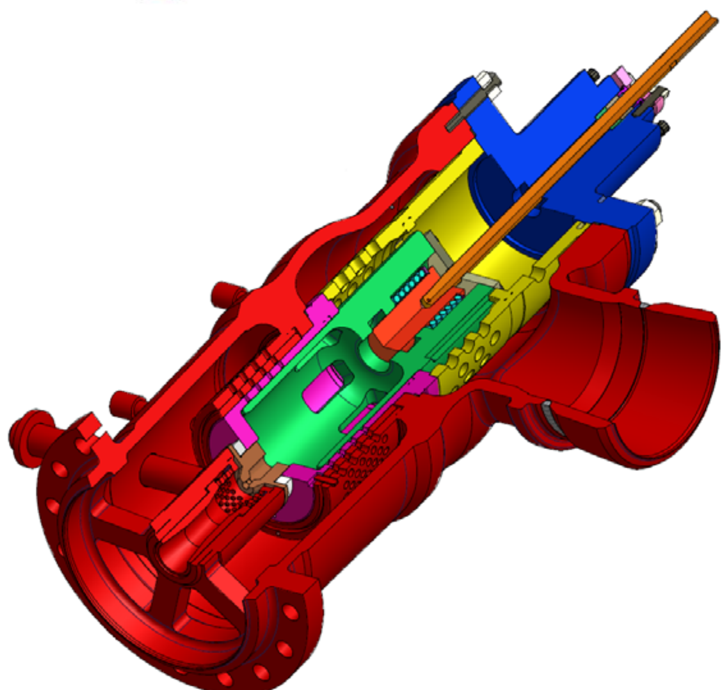
Standard body-to-bonnet joint, up to 2500# standard, is bolted and incorporates a fully enclosed spiral wound gasket made from 300 stainless steel with graphite filler. The standard body-to-bonnet joint for pressure ratings above 2500# is a pressure seal closure, which utilises a graphite-sealing ring.

**Trims**

Three types of trims are provided in this valve: Single stage Hush, Multi stage Hush and RAVEN. The selection of the appropriate trim is determined by the application and will reflect the need for single or multi step pressure reduction in order to utilise pressure profiling to achieve an acceptable noise level.



DSCV-SA fitted with Single Stage Hush Trim design. An integral exit diffuser Plate is also fitted to the valve for further noise attenuation. Valve shown incorporates a bolted bonnet design



DSCV-SA fitted with Multi-Stage Hush pressure Profiling Trim design. Valve shown incorporates a bolted bonnet design

**Pressure Ratings**

The DSCV-SA Valve is of the split rated design and available in standard and special class. Standard class in available upto and including ANSI 4500 rating, special class designs can be accommodated if required. Because the DSCV has a split rated design this provides the customer with a convenient point for pipe transition for size, rating and material. As the DSCV-SA is of 2 part construction virtually any configuration can be met to satisfy any client requirements.

**Materials of Construction**

The valve can be manufactured from any material to meet specific design requirements. Standard Materials are as shown below: -

**Body & Bonnet**

Carbon Steel to ASTM A216 WCB / ASTM A105
Alloy Steel to ASTM A217 WC6 / ASTM A182 F11
Alloy Steel to ASTM A217 WC9 / ASTM A182 F22
Alloy Steel to ASTM A217 C12A / ASTM A182 F91

**Bonnet Studs and Nuts**

The standard body-to-bonnet studs and nut materials for bolted bonnets are: -

For applications up through 454°C (850°F):

Studs: ASTM A193 Grade B7
Nuts: ASTM A194 Grade 2H

For applications over 454°C (850°F) to 565°C (1050°F) in low alloy steel:

Studs: ASTM A193 Grade B16
Nuts: ASTM A194 Grade 4

**Stem Materials**

Stems are made from 17/4 ph grade ASTM A564 GR630.

**Other Options**

**Double Packed Bonnet**

When packing leakage is to be minimised, a double packed bonnet may be used. The lower packing set provides primary sealing between the internal Valve fluid and the leak off tube while the back up prevents leakage to the atmosphere.

**Lubricator**

Stem packing lubricators can be provided on the bonnet assembly but are not considered necessary with graphoil packing.

**Sizes**

The DSCV-SA is available in an almost infinite range of sizes as each valve is tailored to suit a particular customers requests and requirements. Additional Noise Attenuation can be performed by utilising a specifically engineered RAVEN multi-labyrinth trim design utilising upon 18 stages of pressure reduction.

**End Connections**

The DSCV-SA can be provided with either flanged or butt-welded ends – or indeed any combination of the 2. Butt weld ends can be provided to match both size and material of the client's pipework to minimize on site welding and ease the fitment and commissioning of the valves.

**Packing Material**

Standard Packing is Compressed graphite die formed rings with braided graphite end rings to prevent extrusion of the packing. The packing is used in a bolted compression type gland arrangement

**Trim Material**

This will vary depending on the application for which the valve is being used, but the standard materials

Plunger – ASTM A217 WC6
Cage Assembly – ASTM A217 WC6
Distribution Spacer – ASTM A217 WC6
Pilot Plug – BS970 420 S37
Atomiser Nozzle – BS970 316 S31

The trim components are given additional heat treatment to give increased hardness at elevated temperatures. This additional treatment is also used to ensure superior performance in high-pressure drop applications.

**Live Loaded Packing**

This packing arrangement provides a more constant force on the packing, which minimises packing leakage over time. This feature is often used when the valve is to be located in an area where it is difficult to perform maintenance on the valves.

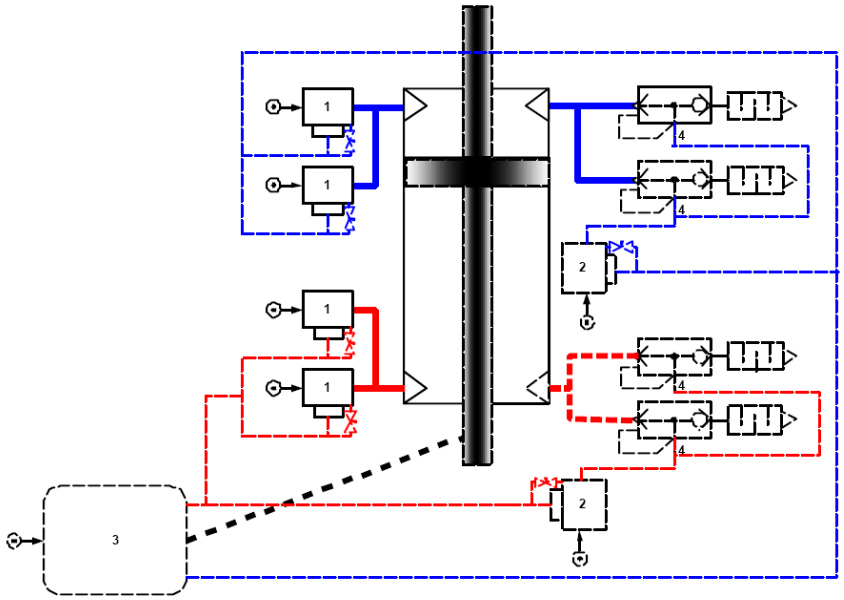
Pictures show Explosion Proof (Eex-d) HPU and control system provided by Copes Vulcan on a recent contract.

**Actuation**

Due to the flexible design of the DSCV-SA any actuation can be accommodated. The options pneumatic (either Piston or diaphragm), Hydraulic or Electric. If required Copes Vulcan can provide the valve with not only actuation, but also logical actuation via a custom designed control panel assembly – giving the customer any mode of operation required and covering every eventuality.

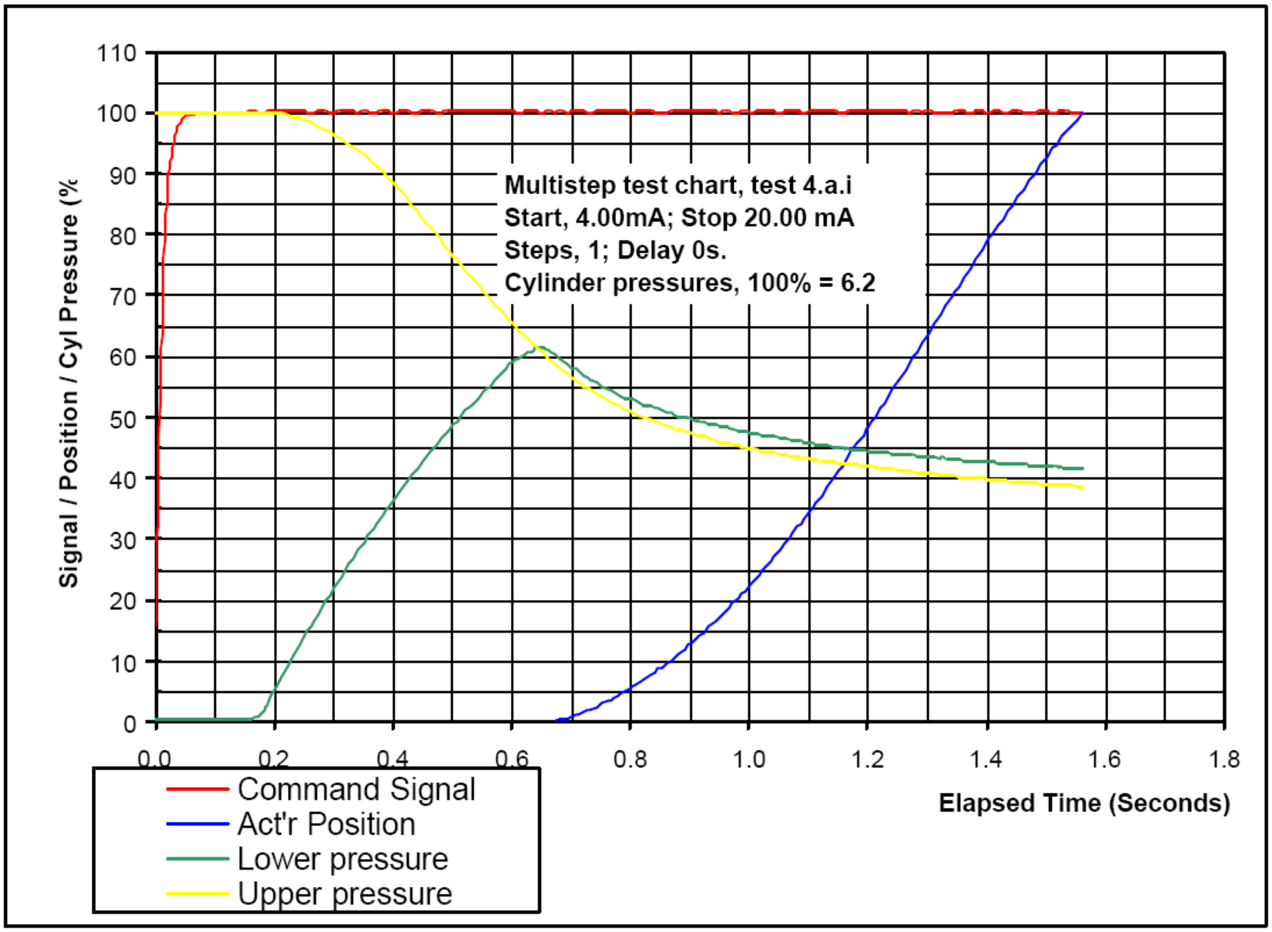
## Fast Acting Pneumatic Actuators

Recognising the need for fast and reliable pneumatic actuation solution Copes-Vulcan has developed, tested and proved that modulation of a DSCV-SA valve from fully closed to fully Open is possible within less than 2 seconds just by using the system 4-20mA command signal. The diagram below indicates a typical equipment arrangement.



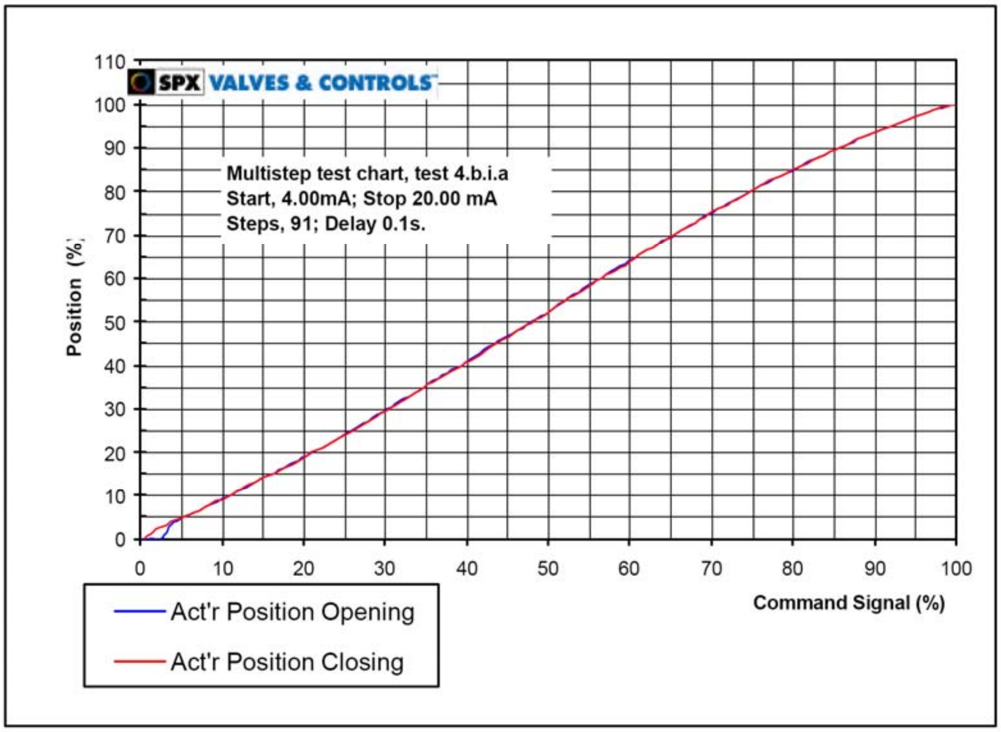

| Component Schedule | | |
|---|---|---|
| Item | | |
| | Actuator | Double acting, bore 450 mm, stroke 250 mm Rod diameter 50 mm |
| 1 | Volume booster | RK Controls ¾" |
| 2 | Volume booster | RK Controls ¼" |
| 3 | Positioner | Siemens Sipart PS2 |
| 4 | Quick exhaust valve | Schrader ¾" |

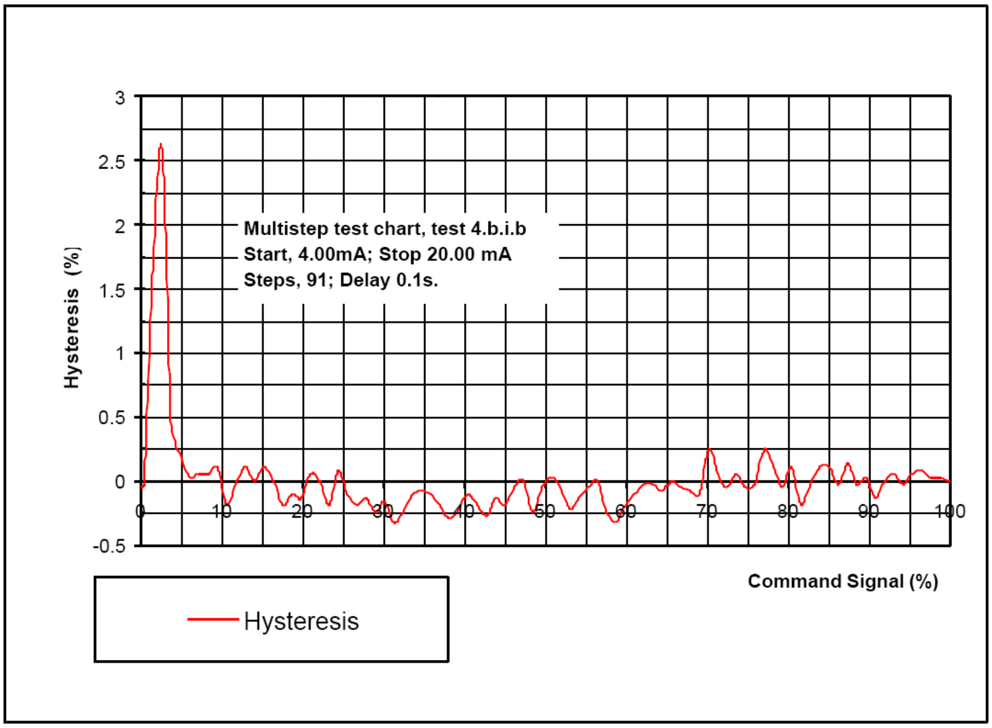
**Fast Opening Test Report**
Plot of command signal, actuator position and cylinder pressure on a time base.




The actuator test begins at rest with the lower cylinder pressure fully evacuated and the upper pressure saturated out to the supply value of 6.2 barg (100%). The command signal takes some 0.05s to ramp to 100%, the boosters become active after 0.19s and 0.21s and start to vent air from the top of the piston and supply air to the underside. Actuator movement begins at 0.66s and full stroke is achieved at 1.55s, an elapsed time of 0.89s. This compares favorably with the time indicated by the Siemens positioner during auto calibration of 0.8s up and down. When in auto stroke mode the stroke time is taken as a dynamic condition without waiting for pressure saturation to occur.

**Hysteresis Test**




The hysteresis test again begins with the actuator in a saturated condition, as the command signal starts to build the device takes some time to de-saturate before movement takes place. Once the actuator is dynamically balanced there is no further hesitation as the actuator ramps up and down scale. On the approach to the zero position the actuator is dynamically balanced and does not therefore see the saturation evident at lift off. The second chart, 4.b.i.b shows the hysteresis throughout the stroke, with the exception of the start point referred to above the unit is generally within +/- 0.25%

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