DEFINING SEVERE SERVICE VALVES

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No clear or universal industry definition or mechanism exists to describe and accurately define severe service valves (SSVs) from general purpose valves, yet such a definition would allow clients to benefit from improved process performance, increased profitability, safety and environmental protection. This high level paper looks to offer an objective definition suggestion for better communication between users, specifiers and suppliers.

Most experts agree that SSVs are identified by applications, and that these applications are challenging to the valve's ability to provide a minimum acceptable level of performance over a minimum acceptable duration.

Severe service valves can be found in non-return, isolation and control functions, although it is recognized that Severe Service Control Valves (SSCVs) do have reasonable industry agreement on what can define severe service. Severe Service Isolation Valves (SSIVs) do not have nearly as clear agreement or understanding.

Non-return (check) valves for severe service applications should be treated as control valves and sized so that their operation is consistent with the flow-rates of the process rather than the pipe size they are typically selected for.

Control valves take energy out of a piping system; isolation valves contain the energy and non-return valves delay and reduce the energy from its full effects on the isolation and control valves. All valve design functions require basic information, but those valves destined for severe service require a deeper understanding of all of the factors that affect their in-service performance.

Figures 1 and 2 are a snapshot of the dynamic fluid state through a control valve showing the energy lost during the pressure drop. Figures 3 and 4 show various combinations of mechanisms that can effectively absorb that energy and protect the valve and downstream components from damage.

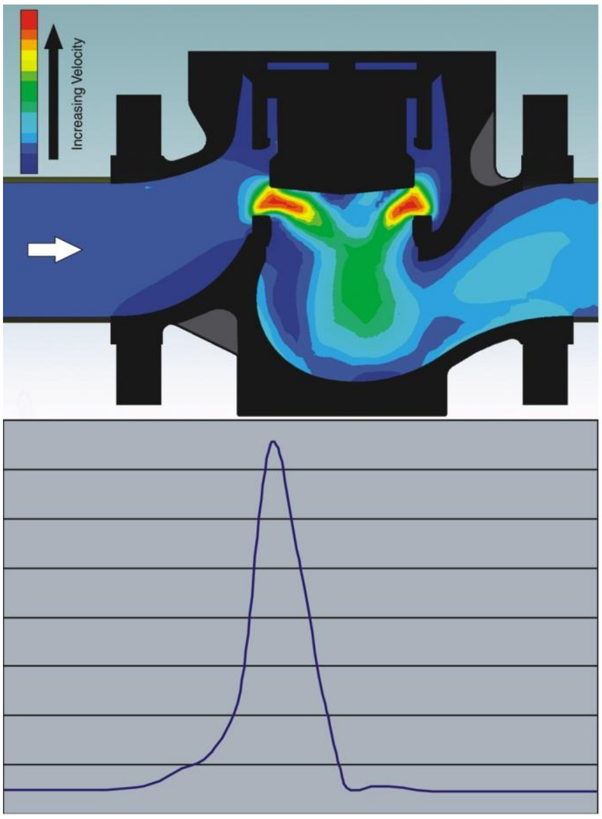

Fig. 1: Velocity Profile Through a Control Valve

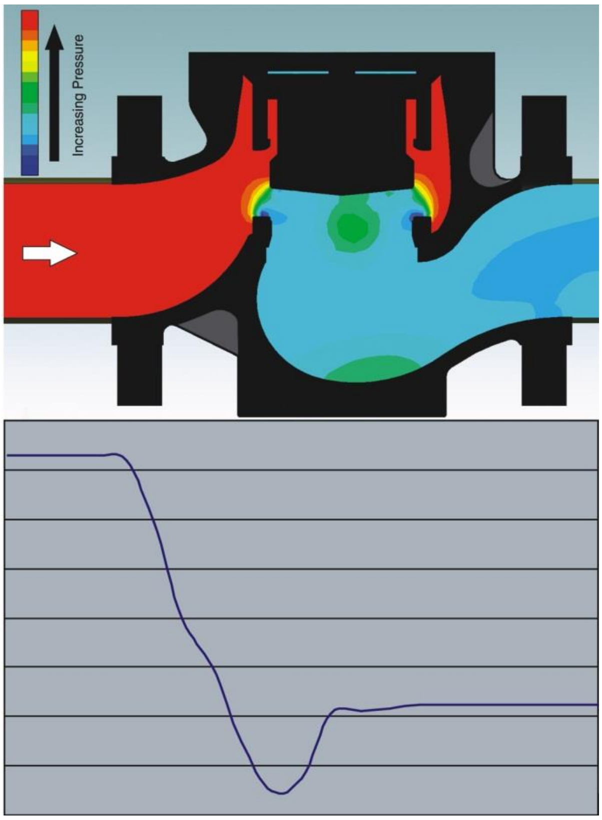

Fig. 2 Pressure Profile Through a Control Valve

Identification of severe service conditions for control valves may be determined by performing sizing calculations using IEC 60534-2-1 or ISA 75.01.01 with the following information:

- Fluid state (liquid, gas, vapour, 2-Phase, multi-phase, slurry)
- Flow rate at max, normal and min conditions (Q)
- Upstream pressure at max, normal and min conditions (P1)
- Differential pressure at max, normal and min conditions ((P1-P2) or (dP))
- Vapour pressure of liquids (Pv)
- Temperature (T1)
- Valve size

A determination of whether severe service exists for a control valve can be applied through thresholds expressed in Table 1. It should be cautioned that the potential for severe service is an indication rather than a proof and further examination and analysis should be performed. However, it is clear that the further beyond the threshold one gets, the more severe the service.

Excellent tools exist to reduce risk and time to perform the multiple calculations that are required to test for the condition thresholds; one of the best is Flowserve's Performance!, which uses a Valve Selection Guide to significantly reduce sizing and selection inaccuracies and provides clear and abundant data to assist in defining the conditions within and around the control valve.

Table 1: Determining Factors

Condition	Formula/Reference	Threshold	Notes
Cavitation	(P1-Pv)/(P1-P2)	$\sigma > \sigma i$	Cavitation index per ISA–RP75.23
Choked flow	FL	Q > Qchoked	ISA–RP75.23
Erosive flow	Velocity normal flow	>8m/s inlet	Clean liquids
Flashing	P2/Pv	≤1.0	Liquids only
High alloy metallurgy	B16.34	>Group 3.1	
High energy state	dP(Pa) x Q	>100 Kw	Q is volumetric flow
High noise	IEC 60534-8-3&4	>85 dB	
High turn down ratio	Qmax/Qmin	>10	
Scale precipitation		>1mm/year	
Slurry		>10% solids>5m/s	Suspended solids
Temperature (high normal operating)		>425°C	Or as per B16.34
Temperature (low normal operating)		<-50°C	Fluid temperatures

When any of the above conditions violate the thresholds in Table 1, the application should be considered as severe service and the selection of the SSCV should be made by suppliers who specialize in control applications using valves designed with severe service trims and features. Additional process information should also be reviewed.

Severe service conditions always apply to the following:

- Autoclave let-down
- Boiler Feedwater
- Choke valves
- Coal gasification
- Compressor anti-surge
- Engine test stands
- Fluids with high out-gassing potential
- HP separator drains
- Minimum flow recycle
- Solar power molten salt
- Slurry control
- Toxic/Lethal Service
- Turbine by-pass

Control valves that do not violate any of the conditions in Table 1 or are not identified in the above list of severe service applications can be identified as general purpose control valves.

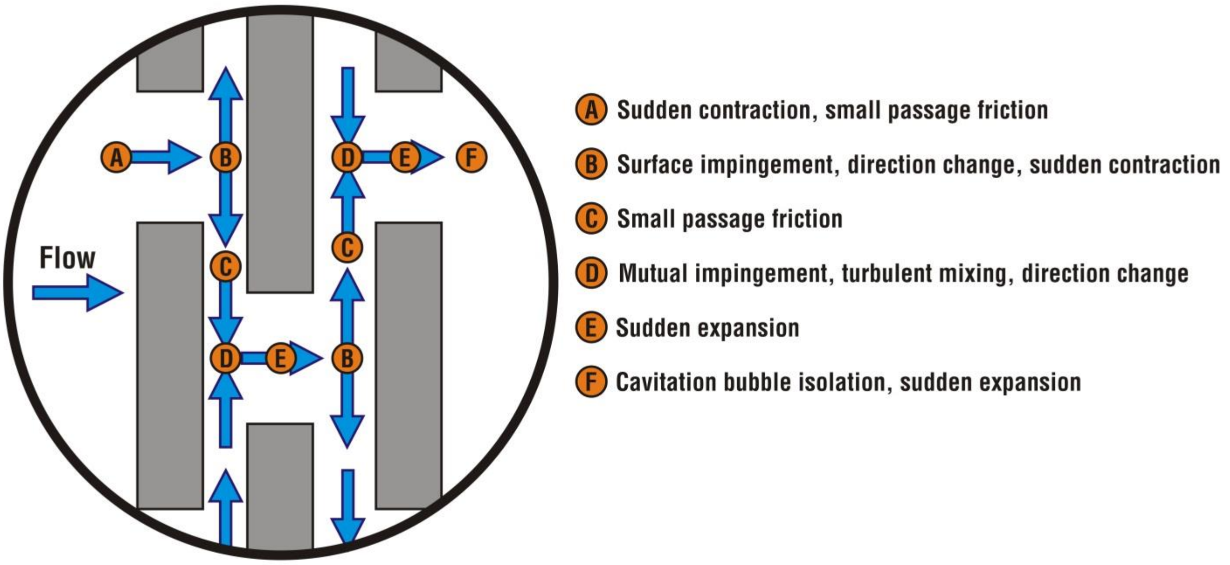

Fig. 3: Radial Flow Mechanisms for Handling Severe Fluid Conditions

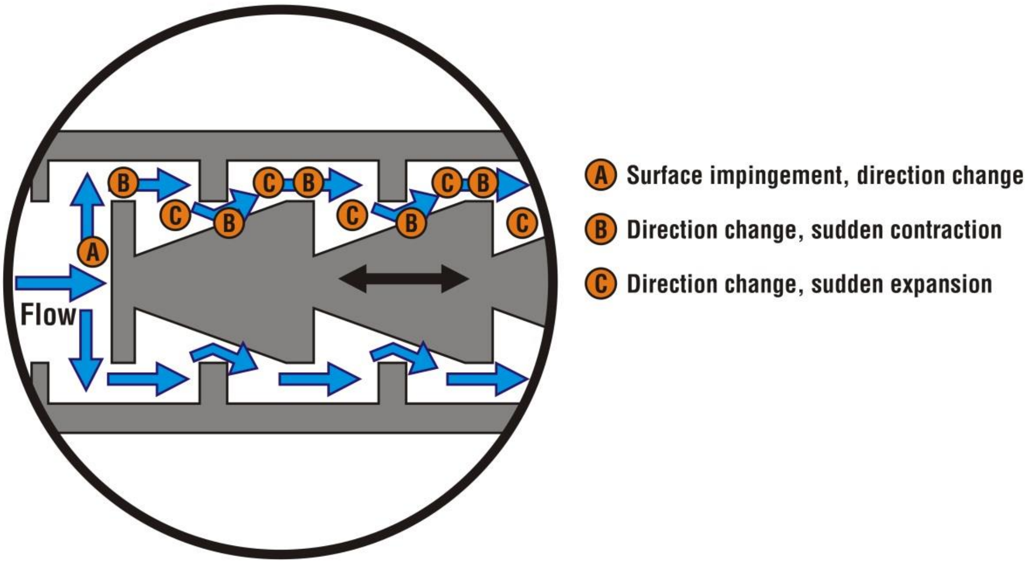

Fig. 4: Axial Flow Mechanisms for handling severe fluid conditions

High solids slurry isolation ball valve in a copper concentrate pipeline

Delta ASME Class 600 slurry knife gate on PD Pump circuit

Isolation valves perform a different function than control valves. During much of their installed life they are static, like the pipe flange they are installed within. Typically the valve datasheet provides us with adequate information for valve selection for this state. As with control valves for severe service applications, more and deeper information and consideration is required to select a Severe Service Isolation Valve (SSIV)

Industry adheres to Codes like ASME B16.34, B31.1 and B31.3 to protect for this static state, but these do not provide much guidance for when the valve is in dynamic situation. An important element in selecting SSIVs is the consideration of what can occur while the SSIV is transitioning from its static normal state to the other (Open to Closed, Closed to Open); when it is in dynamic conditions.

During this dynamic state, conditions can be vastly different than when static. For example, closing a valve against a normal flow rate from its fully opened position will accelerate the fluid up and until it is stopped by the closed valve, while at the same time decrease its pressure (Bernoulli's Principle) to a point where it may flash or choke.

It is important to have a firm idea of the number of cycles from one starting position to another and the normal position for each application. There are several typical scenarios: low frequency normally closed (NC), low frequency normally open (NO), frequent NC and NO and equal NC/NO. The frequency of cycling isn't in itself the challenge, its knowing what happens on each cycle to affect the valve's health and ability to retain the minimal performance required by the application.

If a valve has an allowable leakage rate (see FCI 70.2-2013) like most metal seated valves have, then the fluid can become erosive if the energy level (differential pressure) is high enough to propel the fluid past the closure element, and severe degradation of the sealing elements can occur.

This might seem to indicate that a higher number of closed cycles are likely to produce valve health issues than less cycles, but each application has its unique needs, and a valve that only cycles once per year may be as difficult to perform as one cycling once every six hours.

Isolation valve datasheets also often fail to provide a goal or target for installed performance during the valve's useful life other than the risky assumption that the required valve closure test from API 598, ISO 5208 or MSS-SP-61 can translate a similar quality into the valve's actual duty and performance in service.

Therefore more attention should be focused upon arriving at a reasonable Severe Service Isolation Valve (SSIV) definition, as it is in our opinion, the more difficult task.

A severe service isolation valve data sheet lists the key elements that should be identified in order to properly select the type, materials and options of the SSIV, including the information required to determine the effects of the dynamic status like cycle rate and media affects.

SSIVs should

- Isolate over a minimum installed period of time to a minimum quality of isolation (leak-tightness) required by the process
- Be available when required to deliver the minimum isolation performance regardless of dynamic changes in the application
- Operate in hostile environments, in upsets, and with changes in the effects of the media
- Protect the environment and worker safety
- Perform significantly better and longer than non-SSIVs
- Be used where the lack of adequate isolation has a substantial negative affect to facility profitability
- Be used where a single isolation valve requires a second valve in series to isolate

Table 2:Determining Factors			
Condition	Formula/Reference	Threshold	Notes
Available on demand	IEC 61508 &61511	100%	
Category M fluids	B31.3	All	
Cryogenic fluids		<-150°C	
Fugitive emissions	ISO 15848-1 &2	<500ppm	VOCs
High alloy metallurgy	B16.34	>Group 2.4	Also all unlisted high alloys
High dP	dP/P1	>0.8	
Solids deposition		>1mm/year	
Slurry >10% solids		>20 barG	
Tightness of closure	FCI 70.2	>Class V	
Temperature	>260°C	>260°C	

In addition to Table 2, severe service conditions always apply to the following isolation applications:

- Autoclave Block
- Boiler ERV, Drains, Vents
- Catalyst
- Delayed Coking
- Emergency Shut-Off Valves (ESDs)
- Ethylene Furnace Isolation
- FCCU
- Fire Isolation Valves
- H-Oil
- High Cycle Switching/PSA
- High Pressure Slurry Block
- HIPPS
- Hydrocracking
- Hydrogen
- Molecular Sieve/Dehydration
- Reactor Isolation
- SIL Rated Service
- TEOR Steam
- Toxic/Lethal Service

By using suppliers who specialize in severe service valves, applying a series of steps in qualifying them and separating general purpose from the more challenging applications, greater and longer success for a facility's valve population is achievable.

Severe service valves will be objectively defined in the next few years. We will all benefit.

[1] *Diagrams courtesy of Flowserve; photographs courtesy of ValvTechnologies and CGIS.*

[2] *This technical article was originally published in IPP&T Magazine in September of 2014.*