WARREN CONTROLS

Language of the

"Science of Control Valves"

Tips and Hints

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Control Valves, the use of, function and selection rely on a vocabulary of terms and expressions specific to the art. Some of these are explained here for a more comprehensive understanding and to further enhance the dialog. Bold texted words within each definition are further explained within the selection.

VOCABULARY

ANSI
American National Standards Institute – a body of engineering professionals who set industry standards for pressure vessels, Leakage – essentially every facet of engineering definitions.

ATTENUATION
Loss of signal strength due to absorption as a Signal passes through a medium of substance.

AUTHORITY / VALVE
Ratio of the specific **Pressure Drop** across a valve, due to the constriction, direction changes and friction(s) to the total pressure drop across the entire loop, or circuit.

AUTHORITY / LOOP
Ratio of the loop **Pressure Drop** to the overall pressure drop throughout the entire system initiated by the initial pump pressure and piping with manifolds, elbows, elevations, and frictions throughout.

AUTO / MANUAL STATION
A device used in a larger DCS System, typically on the factory floor near the process and allows this station to override the control system and manually control the control vavle or pump with a 4-20 mA signal on a specific 0% - 100% basis. This station usually also provides feedback to the DCS that it has taken control.

BACKLASH
Mechanical movement/looseness when connected parts are direction reversed.

BACKPRESSURE
Sum total of discharge side, or "downstream" pressures created by cumulative frictions, piping restrictions and elevation impact.

BAND / PROPORTIONAL
The error required in an input signal with respect to a set point to produce a full range change in the output. Most controllers will start with a reference of the range of the input device; the thermocouple, RTD, Flow Meter, Pressure Transducer, etc. There is then a proportional band setting listed most commonly as a %. When the controller is set to 100% proportional band this means you need an error that is the full span of your input device to get a corresponding full change in 4-20 mA control signal output.

BALANCED TRIM
Any of several mechanical methods of equalizing the inlet pressures over and under a single seated Trim design, opposing double seat surfaces or cage controlled trim designs, resulting in smaller actuation force or torque requirements or Breakaway torque as might be applied for valves deployed in the Flow-to-Close direction.

BARE STEM
Control valve supplied without actuation – to be supplied by others.

BATCH
Single quantity production as in creating a "meal" from a recipe. Unlike a "continuous process."

BENCH RANGE
This is in reference to the spring range of a valve actuator tested on a bench and not connected to any piping and therefore the fluid forces as would otherwise be impacted on a valve actuator once installed. This is for determining what the air pressure points are at both open and close, on a bench.

BLOW DOWN
Cooling towers or filtration devices periodically require dumping of collected impurities.

BONNET
The very top of the valve body which fastens (bolts) onto the body, thereby retaining the internals of the valve, providing support and stability for the actuation and accessories.

BONNET / EXTENDED
As above, and raises the upper actuation components away from what may be excessive and otherwise destructive heat, as well as providing access to the stem packing adjustment parts.

BREAKAWAY TORQUE
Force required to open a valve (plug) against pressures acting to keep a valve closed.

BTU
British Thermal Unit – heat to rise temperature of one pound of water by one degree Fahrenheit, near 60 degrees.

BTU DEMAND
Heating any medium with hot water or steam requires (demands) a specific number of BTU's in order to increase temperature of the medium to a new or desired temperature. Time is also an important factor for both the heating, as well as simultaneous heat loses.

CAGE / VALVE
Inside the valve is components that contain the primary valve trim components that appear as a basket-like structure of various designs and functions. It might "brace" internal components in place or influence flow patterns while providing "guiding surfaces" for the plug in high velocity, normally destructive conditions.

CAGE / RETAINED
As above, functions continued - a cage might also "retain" the Seat orientation without threads for greater ease of removal of the seat during inspection or replacement.

CALIBRATE / CALIBRATION CYCLE
A procedure, by which defined inputs or outputs of an instrument, valve actuator or positioner are verified and as necessary, brought into specification. The procedure is unique to each instrument as defined by the manufacturer. Some procedures are self-contained and automated while other require meters, simulators or references and steps for the user to cycle through.

CALIBRATION CYCLE
Measured outputs based on known input values in full ascending and descending directions.

CAPACITANCE
Coulombs of charge stored to raise potential across an element 1 volt (SI)

CERAMIC / TRIM
TTZ ceramics are used both for erosive materials control and for harsh chemical compatibility applications. It is an extremely hard material similar to space shuttle heat shield material, highly resistant to particulates and temperature changes. Results are immunity to high flowing pressure differentials and erosion from slurries of many specifics.

CF8M
Refer to Materials Section

CHATTER
Rapid, abnormal vibrations between the plug and seat or plug and cage in a control valve usually due high flowing differential pressures or unacceptable levels of extreme turbulence.

CLASS / LEAKAGE
Control valves are specified with a required maximum "allowable" seat area leakage when in a closed orientation. These are specifications verified with water as a controlled medium in a pressurized condition. ***See Charts Below.***

LEAKAGE CLASS	MAXIMUM LEAKAGE ALLOWABLE	TEST MEDIUM	TEST PRESSURE	REQUIREMENTS FOR ESTABLISHING RATING	ALSO REFERRED TO "RELATIVELY" FOR COMPARISON
Class I				Dust Tight	
Class II	0.5% of rated capacity	Air or water at 50 - 125°F (10 - 52°C)	45 - 60 psig or maximum operating differential whichever is lower	45 - 60 psig or maximum operating differential whichever is lower	1.0
Class III	0.1% of rated capacity	As above	As above	As above	5.0
Class IV	0.01% of rated capacity	As above	As above	As above	50.0
Class IV+ **(*)** ***5800 Only***	0.02 ml /min/inch of trim size/ ΔP(PSI)	As above	Max Operating ΔP	As above	6,000 **(*)**
Class IV+ **(*)** ***3800 Only***	0.005 ml /min/inch of trim size/ ΔP(PSI)	As above	Max Operating ΔP	As above	30,000 **(*)**
Class V	0.0005 ml per minute of water per inch of port diameter per psi differential	Water at 50 to125°F (10 to 52°C)	Maximum service pressure drop across valve plug not to exceed ANSI body rating	Maximum service pressure drop across valve plug not to exceed ANSI body rating	300,000 (Hard Seats Only)
Class VI	Not to exceed amounts shown in the table to the right →	Air or nitrogen at 50 to 125°F (10 to 52°C)	50 psig or max rated differential pressure across valve plug whichever is lower	Actuator should be adjusted to operating conditions specified with full normal closing thrust applied to valve plug seat	600,000 (Soft Seats Only, with exceptions)

Class VI Leakage Table

PORT DIAMETER		BUBBLES PER MIN.	mL PER MIN.
INCHES	MM		
1	25	1	0.15
1-1/2	38	2	0.30
2	51	3	0.45
2-1/2	64	4	0.60
3	76	6	0.90
4	102	11	1.70
6	152	27	4.00
8	203	45	6.75
10	254	63	9
12	305	81	11.5

(*) Unique to Warren Controls - 3800 w/Ceramic Trim in Flow-To-Close Only - 5800, Special Trim Option

CONTROL ACTION

Method and Nature of change in controller output affected by controller's input with respect to a set point. Two common methods are ON / OFF Control and PID Control. Within PID control one can implement single elements or combinations of P-Only, PI Control, PD Control, etc. Each element of PID provides its contribution in a unique mathematical way.

P: The proportional term produces an output value that is proportional to the current error value.

I: The contribution from the Integral term, also referred to as "RESET", is proportional to both the magnitude of the error and the duration of the error. This is the sum of the instantaneous error over time and gives the accumulated offset that should have been corrected previously. The accumulated error is then multiplied by the integral gain () and added to the controller output.

D: The derivative of the process error is calculated by determining the slope of the error over time and multiplying this rate of change by the derivative gain. The magnitude of the contribution of the derivative term to the overall control action is termed the derivative gain, .control with output proportional and relative to "RATE" of change of input.

Feedback: Control measurement compared to set point producing an error measurement requiring action (from a PID or ON / OFF control algorithm)

Feedforward: Feedforward control reacts the moment a disturbance occurs, without having to wait for a deviation in process variable. If any process control loop is subject to large, measurable disturbances, it can benefit greatly from feedforward control. Sometimes pure feed-forward control without feedback is called 'ballistic', because once a control signal has been sent, it cannot be further adjusted; any corrective adjustment must be by way of a new control signal.

Time proportional: Control output are periodic pulses used with relays, typically on heating elements with duration varied to influence rate of change.

Velocity limit: Limiting "rate of change" within preset limits

COMMON PORT

Applies to three way or three "ported" valves. In a mixing function, two inlets, each feed some or all flowing medium to a single "common" outlet port, while in a diverting valve, the single "common" inlet port follows varying stroke influences to "divert" flow from the common port to either or both outlet ports.

CONDUCTIVITY

The reciprocal of "resistivity" or the ability to pass current.

CONFORMITY

Closeness of one curve to match another curve

CONSISTENCY

Viscosity as it resists deformation

CONTROL SIGNAL

Pneumatic signals such as 3-15 psi, or electrical signals such as 4-20 mA, or 2-10 Volt. See also Pneumatic signals.

CONTROLLED VARIABLE

Variable being measured to provide feedback to controller such as temperature, pressure, level or flow, whose final control element is influencing this measurement.

Direct acting: Increasing output results from increasing input signa

Reverse acting: Increasing output results from decreasing input signal

On / Off : Two position controller with discrete outputs – one being zero

CORKING

Tendency for a valve plug to remain in the closed orientation during an initial opening control signal due to plug and seat friction, also aggravated when installed in a flow to closed orientation or with higher pressures on the back side of the plug forcing the plug tightly into the seat ring surface.

CV
A dimensionless flow capacity unit defined whereas a Cv of 1.0 = Water flowing through an orifice @ 1 GPM, when the Specific Gravity is 1.0 (at 60°F) and with a pressure differential between inlet and outlet of 1 PSI.

dB / NOISE
Decibels – a measurement unit of sound intensity. Noise level measurements focus on dB intensity / per unit of time. Standards are in place to define relative noise levels for occupational regulations. OSHA and other safety organizations devise the safe level of constant dB noise emitted by equipment in a work environment as a function of time. Control valves have programs that will calculate the theoretical noise as if it were measured at a distance one meter downstream of the valve and one meter away from that pipeline – deemed to be the highest intensity point for the noise.

Example: ***70 dB results from a propeller driven airplane overhead at 1,000 feet elevation***

80 dB from a garbage disposal unit
110 dB from a Rock Band

Note: Inverse square law applies: Double the distance from source and the intensity reduces to 1/4th the original measured intensity.

DCS
Distributed Control System. Computer based instrumentation with multiple inputs and outputs for dynamic process based on operator input requirements for batch or continuous processes.

DEAD-BAND
Range an input can be varied without a change in output. Example: How much of an input signal change is required before the AmurAct will move to a new position (stroke)?

DIRECT-ACTING
Increasing input signal creates an increasing output result (from natural resting spot)

DIRECT-MOUNT
In Warren Controls parlance this is in direct reference to our actuator mounting method for our 3800 series rotary control valve. The Direct-Mount uses a short valve shaft that allows the valve-actuator flange to mount directly and close to the actuator. This makes the assembly compact but can only be used with self adjusting PTFE packing and is generally reserved for lower temperature applications. Also see… Indirect-Mount

DITHER
Small oscillations to overcome Stiction, Friction, or Hysteresis.

DIVERTING FLOW
See Flow/Diverting, below

DROOP
Term applies mainly to Pressure Reducing Regulators which experience a difference in measured downstream pressure (P2) at low flow rates, compared to the P2 at maximum flow rates.

DUTY CYCLE
Percentage of real time that a motor or component is in "powered" motion state as compared to "idle." A motor on for 15 seconds and idle for 45 seconds is in a 25% duty cycle. This is important to note as some actuators are not capable of operating above say 80% or 90% duty cycle for very long. All of Warren Controls actuators are capable of 100% duty cycle. In the real world is your actuator is always on the move your loop is not properly tuned and deserves some attention.

ECCENTRIC
In the "eccentric" or "E" Ball valve, the double offset geometry provides the pattern for opening and closing without "wiping" or physically scraping across the face of the seat ring as is continuous through the entire 90° of rotation with "concentric" geometry versions. The only time and eccentric plug valve has its plug in contact with the seat is when the valve is closed. In a modulating environment this allows for better trim wear than a comparable concentric designed valve.

EQUAL PERCENTAGE FLOW
See FLOW / equal percentage

ERROR
Difference between measurement signal and ideal value.

EXPLOSION PROOF
Also refer to "Intrinsic Safety"
Enclosure for electrical components or devices which is strong enough to contain internal sparks or resulting ignition of gases present internally. Also must have the ability to effectively cool the escaping hot vapors from such an internal explosion sufficiently to render the gases too cool to ignite external hazardous vapors.

FEEDBACK of FEEDBACK CONTROL
Also see "Control action" Refers to information as a part of a chain of cause & effect reactions or corrections. The information feeds back into a control algorithm for continued modifications.

FIELDBUS
All digital, bidirectional, multi drop communications system.

FINAL CONTROL ELEMENT
The element that influences change on the measured variable – flow, pressure, etc. Usually the control valve.

FLASH POINT
Lowest temperature where a flammable liquid can produce explosive vapors with air.

FLOW / EQUAL PERCENTAGE
The flow rate is related to the percent the valve opening changed in an incremental manner. For example, if the valve changed from 20% open to 30% open and produced a 70% change in flow rate, changing the valve from 30% to 40% open would increase the flow rate another 70%. Equal percentage valves are best used for throttling applications since the flow rate is small at the beginning of the stroke and increases at the end of the stroke. This provides exact control of the closure element in the first part of the stroke where the closure element is more easily affected by the process forces. The equal percentage characteristic also provides increased capacity in the second half of the stroke so the valve can pass the required flow.

Advantage- Increase in rangeability, better repeatability and resolution in first half of stroke.

FLOW / LINEAR
The flow rate is directly proportional to the amount the disc travels. Linear flow characteristics produce equal change in flow per unit of valve stroke. If the disc is open 50%, the flow rate is at 50% of maximum flow. This provides better flow capacity throughout the entire stroke. Linear valves are best used for 15 PSI Steam, Level Control Systems and processes that are continuously integrating.

FLOW-TO-CLOSE
Flow inlet is directed in harmony with a closing valve orientation. Flow tends to keep valve closed therefore the breakaway torque (corking) tendency is highest until plug breaks away from the seat. Downstream pressure "close to inlet" is beneficial.

FLOW / DIVERTING
In bypass loops or to control excessive flowing medium, it may be controlled with a "diverting" valve upstream of the load to accept all inlet supply, sharing the flow proportionately between two outlet ports (pipes), one being the bypass line itself. Another approach that is often preferred is to use a 'Mixing' valve downstream of the load where the outlet of the load is one inlet and the other inlet is the bypass line. See also "Common Port" above

FLOW / INHERENT
Flow rates follow an "off the shelf" stroke to flow volume rate change whether in an on/off or a modulating function with a constant pressure drop. This will change based on the impact of installed pressure conditions in any flowing situation. Inherent is a designed characteristic totally dependent and modified by installed conditions.

FLOW / MIXING
Converse to "diverting" explained above, the operation in a mixing valve is to accept two differing flowing input sources and mix them proportionately according to a control signal from 100% of one (upper port) and 0% of another (lower port) changing gradually with stroke based on signal, changing gradually to the opposite extreme – 0% upper and 100% lower. ***Note: Also see "common port" above***

FLOW-TO-OPEN
Flow inlet is directed in harmony with an opening valve orientation. Upstream pressure therefore tends to try to open the valve, so shutoff is challenged. Downstream pressure if significantly lower, as in "dumping" to atmosphere can be a critical problem. This is the most common flow orientation on control valves as it provides the best control.

FUZZY LOGIC
Algorithm modeling requiring a language to explain, not strictly mathematical (calculus) supported.

Example: Traffic lights can be on/off with time as a basis, but with fuzzy logic, timing can be influenced by fuzzy terms such as "more" or "less" or "some".

GAIN
Ratio of changes in output versus input.

GUIDED / TOP AND BOTTOM

Typically refers to the internal support provided for the plug and stem. With an upper and a lower stem extension, each end is supported firmly within and guided by a corresponding receptacle and sealed to prevent dirt buildup or accumulation. Especially valuable in cases of high flow velocities and resulting extreme vibration.

HANDWHEEL

External handle, wheel or means of manually adjusting the valve position in cases where signals and/or power is lost.

HYSTERESIS

Also see **Deadband:** The lag in response exhibited by a body reacting to changes in the forces. In a control valve this lag can be observed when changing direction and back again. It may be slightly different in each direction and also different in different points of the valve stroke.

HUNTING

With either continuous process upset conditions or with improper PID settings, a control valve can exhibit a constant increasing and decreasing stroke – as if "hunting" for the sweet spot. Never settling into a constant stroke (flow). This occurs when the process experiences continuous overshooting and undershooting of the desired set point.

INDIRECT-MOUNT

In Warren Controls parlance this is in direct reference to our actuator mounting method for our 3800 series rotary control valve. The Indirect-Mount uses a long valve shaft and mounting bracket that allows the actuator to sit atop this bracket. This makes the assembly a bit larger than the Direct-Mount counterpart but is required for when adjustable packing is used or when elevated temperatures may adversely affect the actuator or instrumentation mounted to the actuator.

Also see… Indirect-Mount

INTRINSIC SAFETY

Also refer to "Explosion Proof."

Electrical power signals are sufficiently low so as to not be able to ignite a hazardous atmosphere. Usually requires Intrinsic barrier components.

LEAKAGE

See also "Class/Leakage"

Term often used to describe either stem leakage in case of compromised packing, or as seat leakage. In cases when high velocity flow of controlled medium has resulted in "wire drawing" or erosion of the seating surfaces the ability to "seal off" or tightly close will be severely compromised, and therefore will leak significantly. This can be a safety situation as well as poor control resulting from casually selected materials of construction without considering severe operating conditions. Short stroking can also be a cause.

LEAKAGE CLASS

Also see Class/Leakage.

ANSI and FCI bodies have defined a leakage in units and created a standard 70.2 for Class I through VI leakage reference.

LINEAR / FLOW

See Flow/Linear above.

LOAD

Related to BTU demand, or required energy to raise temperature from some initial temperature to a desired temperature for a specific mass, within a referenced time frame.

MATERIALS of CONSTRUCTION

Refer to separate section at end.

MEASURAND

Physical parameter to be measured (Current, Pressure, Temperature, Level, Flow)

MIXING FLOW

See Flow / Mixing above

OFFSET

Controller with steady state "deviation" and a fixed set point

PEEK

"Polyether ether keytone" – a class of thermo-plastic organic polymer with superior mechanical strength and temperature reliance up to 450°F and melts around 662 °F. Used for its superior "soft seat" capability for Class VI "bubble tight" close-off – also very reliable for internal bearings due to the resistance to chemical and thermal degradation.

PID Control

PID (Proportional, Integral, Derivative) control is used when processes changes due to energy or inertia. (A car's cruise control is a PID controller.) Many real world processes build up over time. When you step on the accelerator of your car, your car moves slowly, then faster, and faster still, until you let off the gas pedal. As you speed up, you press the gas pedal less, then a little less, then even less, until you reach the speed limit. Unlike the digital world where things are either "on" (1) or "off" (0), real processes have varying degrees of "on". In the driving example, how much the accelerator is turned "on" depends on the car's current inertia and how different the car's speed is from the speed limit. Controlling such a process with inertia can be done with only five lines of code. But, just like learning to drive, it takes practice to know if you are starting too quickly, or if you'll overshoot the speed limit.

Cruise control is one example of a PID control loop. To calculate the output, it needs three factors. The first, (P), is the difference between the current speed and the desired speed. The second, (I), is the sum of the differences over time. And, the third, (D), is the rate of change between sampled differences. Each factor is scaled by a gain constant; they are referred to as Kp, Ki, and Kd. The value of these gain constants determines how responsive the output will be. If the Kp, Ki, and Kd values are too high, the output (car's speed) will far exceed the set point (speed limit). Set too low, the output may never reach the set point (like driving 40mph on the highway).
Also see "Control Action"

Process controller of DCS, PLC, or SLC style with capability of P and I and D factors in some specific harmonious combination / relationship. **Note:** similarity to following.

P&ID

Piping and Instrumentation drawings are used to display interconnection, piping patterns, distances, elevations and loop descriptions. Do NOT confuse with PID.

PLC

Programmable Logic Controller. A device which compares desired process conditions to actual state and provides output signal changes to effect a change.

PNEUMATIC

Use of air pressure as an actuating medium. In a control valve the air must be "breathable" in quality so as to avoid particulate clogging of small passages in controllers and accessory instrumentation.

PNEUMATIC SIGNALS

Standard air signals may be 3-15 psi, 1-17 psi, 0-30 psi depending on the "work" required and the instrument selected to provide the action.

POSITIONER

A device which accepts a remote signal as an input and compares it to the feedback indication it collects from the valve (usually stem) and adjusts the output – either pneumatic or electrical to further "position" the stem to the desired stroke orientation.

PRESSURE DROP

A small loss of pressure due to fluid flow friction resulting from relative wall smoothness, a restriction or bend within the flow path, which alters the velocity and therefore the pressure. Some is recovered with a small unrecoverable portion having been converted to heat energy.

$$P1 - P2 = 1.25 \times (P1 - P2)$$

PRESSURE DIFFERENTIAL

Difference between inlet and outlet pressures in a given situation – flowing or closed.

RANGEABILITY

You will find slightly different representations of this whether the discussion is about flow meters or control valves. Generally speaking it is the ratio of the maximum controllable (or allowable) flow to the minimum controllable (or allowable) flow, that a control valve can accurately control or a flow meter can accurately measure. This is commonly confused with Turndown but is different (depending on the authority holding your attention).
Also see "Turndown"

RECIPROCATING

Reciprocating motion, also called reciprocation, is a rhythmic and repetitive up-and-down or back-and-forth motion. It is found in a wide range of mechanisms, including reciprocating piston engines and pumps. The two opposite motions that comprise a single reciprocation cycle are called strokes. This is different than what a globe style control valve does in that there is no rhythm or constant repetition by design. A globe style control valve should NOT be called a reciprocating style valve. Rather it should be referred to a sliding stem style valve.

REVERSE-ACTING

Increasing input signal creates a decreasing output result (from natural resting spot)

SENSOR
Input device with output in response to an input measurement influence. Thermometer, RTD, thermocouple, piezoceramics as examples.

SEGMENTED BALL
As used in our eccentric ball design, it is a segment or slice of a ball, used to act as the plug in a plug and seat trim combination for highly effective control.

SENSITIVITY
Ratio of change in output to change of input that created it after a steady state is achieved
See also "Deadband"

SETPOINT
Input setting (constant or variable) of a controller that sets the desired value of the measured variable to maintain.

SIGNAL / CONTROL
See Control Signal and Pneumatic Signal

SKIRT GUIDED
A valve plug is often designed with a "fluted" bottom in order to influence the flow to stroke curve to optimum function. The same device can be relied on to guide the plug through its stroke range without excessive vibration or destructive chatter.

SLC
Single loop controller for specific loop control of P, PI, or PID factors

SPRING LOADED
Refers to packing gland designs. Different styles are used but the most common is a TFE or Teflon® "stack" or gaskets. These are molded to maximize sealing qualities within the valve body and to prevent the internal flowing medium from escaping past the packing and creating a leaking situation. Springs are usually incorporated to maintain a constant and uniform pressure on the packing to maximize the sealing effect.

SPLIT-RANGING
With single input, 2 or more signals for 2 or more final control elements (valves) with or without overlap. Often used for greater rangeability requirements or for extreme differences between seasonal demands such as very little chilled water need for winter season but enormous volumes for air conditioning in summer. One valve may be challenged whereas a small and a larger in parallel can provide better control. Strategies include 1/3 and 2/3 or even 1/5 and 4/5 designs as the latter can yield the wide rangeability.

STEADY STATE
Variable showing no change over long periods of time.

STICTION
Resistance to start of motion – in valves, its friction and slippage factors.

TEFLON
DuPont trade name for fluorocarbon polymer. TFE, FEP, and PFA are such examples.

TRANSDUCER
Converts one quantity of information to that of different information and quantity, I/P (current to pneumatic), pressure or temperature to ratiometric voltage, etc. These are usually 2-wire devices that are loop powered or 3-wire devices that may require excitation.

TRANSMITTER
Uses a transducer responding to measured variable to a transmission signal based on variable. Outputs are typically 4-20 mA and these generally require a dedicated power supply.

TRIM
In a control valve, trim refers to the internal parts that create a change in flow velocity and pressure energies – often referred to as the "wetted surfaces, or parts" Usually the plug, seat, stem and cage if present.

TURNDOWN
Turndown is commonly confused with **Rangeability**. The Warren Controls definition of 'Turndown' is the ratio of the MAX flow to the MIN flow that is required in the plant by the application. This would then be the 'Turndown Requirement'. Conversely, we are uniquely using the term 'Rangeability' to be with respect to what the control valve or flow meter is capable of accurately achieving.
Also see… Rangeability

UNBALANCED TRIM
Single seat designs with no means to reduce or eliminate the pressure differential across a valve inlet and outlet ports. This is logarithmically influential in larger sized valves (4") or larger differential pressures and can greatly impact the smooth operation and/or shutoff capabilities.

SPECIAL SECTION FOR MATERIALS OF CONSTRUCTION

Bronze	Casting available in small sizes 2" or less, most cost conscious work horse for steam and water
Stainless Steel CF8M	castable definition **316** lowest cost most common – sometimes referred to as **316L** which is European for "Low" carbon levels **400 series** – higher temperature and durability rating **17-4** special "hardened" version used often for stems and trim variations
Stellite	Very costly but very hard version for resistance to abrasives or high velocity flow. Also referred to as **Alloy 6**
Cast Steel	**WCB** slight difference in composition as compared to **WCC**, such as .05% nominal Carbon content
Cast Steel	**WCC**
Ceramic	**TTZ** – special trim combination for abrasive and particulate laden mediums. **Y-TZP** – includes an exit port lining – hardest of the ceramic capabilities.

THUMPS OF RULES

The following are additional acquired "generalities" or practices gained over 40 years in the practice of control valve sizing, selection and application. None are absolute, but may assist in influencing such exercises or evaluation of in situ examinations.

REQUIRED CV EQUALS ½ GPM MAXIMUM REQUIRED FLOW

Or, therefore - Required Cv for 60 gpm maximum flow specification may be at or close to **Cv=30**. Siemens and similar HVAC suppliers often use a "**Rule of 5**", so 500 gpm, with a 5 psi Delta P, required a 5 inch valve which, coincidentally, has a Cv of 250 (1/2 the gpm)

Acoustic absorption insulation can result in a reduction of 10 dBA per inch thickness.

One pound of water, (2 cups) or 0.016 ft3 at 14.7 psi atmospheric pressure will produce 26.8 ft3 of steam

3 KEY STEAM VALUES - EASY TO MEMORIZE:

0 gauge pressure = 212F,
15 psi (**low** pressure standard) = 250F,
150 psi (**High** pressure) = 365 F (days in a year)

3 GOALS OF A STEAM TRAP: TRAP CONDENSATE, VENT AIR, AND SAVE STEAM

- Visible Steam is RECONDENSED WATER VAPOR
- Control Valves for steam benefit from drain on bottom
- Linear versus equal percentage inherent characteristics result in higher rated Cv, but lower rangeability (50:1 / 30:1)

LINEAR VERSUS EQUAL PERCENTAGE INHERENT CHARACTERISTICS RESULT IN HIGHER RATED CV, BUT LOWER RANGEABILITY (50:1 / 30:1)

- Selecting trim for control valves – 17-4 is preferred for hot water systems.
- Steam GENERATOR systems are typically 125 lb steam.
- Maximum Saturated Steam pressure differential that Teflon trim is good for is **50 PSID**

ENGINEERING PREFERENCES FOR SIZING

Such standards are somewhat different, exhibiting more or less of a preffered "safety margin" which can be a market driven or conservative preference. Below are several, which are similar, yet slightly different. Either may be appreciated depending on how accurate the real process conditions are known. Guesses are not allowed.

Some "schools of thought maintain that Control valves should be sized such that:

MAXIMUM FLOW	is achieved with valve at less than 90% stroke
NORMAL FLOW	is 60%-90% for equal percentage 50%-70% for linear
MINIMUM FLOW	20%

Another popular engineered standard may hold that: (Different engineers hold somewhat differing standards)

ANOTHER POPULAR ENGINEERED STANDARD MAY HOLD THAT:

A control valve that is sized to operate around 60 percent to 80 percent open at maximum required flow and not much less than 20% open at the minimum required flow will give the best control overall.

A properly sized segmented ball valve is usually 2 sizes smaller than the line size.
A properly sized sliding stem Globe valve is usually one size smaller than the line size.

Additional practice for split range selection allows for **MAX FLOW** at 85% **MIN FLOW** at greater than 7%. **Pressure Valve** is miss-leading. Pressure **Reducing** Valve, or a PRV is not a Pressure **Relief** Valve, and neither is a "Control" valve. Be aware

Thumps of rule are applied more often today in selecting the correct "inherent flow characteristic" for a particular application and selecting the correct valve size.

If a system has a lot of piping (common) use an equal percentage valve trim.
If a system has very little piping, use a linear valve trim design.
If a set of loop tuning characteristics only works well at one end of the control range and not the other, the valve's flow characteristic is most likely the wrong one.

CAVITATING FLOW: is destructive and difficult to manage, although several methods are often applied.

METHODS OF ELIMINATING CAVITATION DAMAGE INCLUDE BOTH VALVE STYLE SELECTION AND PROCESS MODIFICATIONS.

FLOW DIVISION
PRESSURE DROP STAGING, OR COMBINED

Flow division divides one large flow into a number of smaller flows be designing the flow path in the valve so that the flow passes through a number of small parallel openings. Desired results are achieved since the size of the cavitating "bubbles" is partly a function of the size of the opening the flow is traveling through. Smaller openings allow smaller bubbles which results in less noise and less damage when they collapse.

Pressure drop "staging" means that the valve is designed to have two or more throttling points in series so that the entire pressure drop in=s not taken across a single valve but is taken in several small steps or stages. Smaller individual pressure drops can prevent the pressure at the vena contracta (point where velocity is highest and pressure is lowest) from dropping to or below the liquid's vapor pressure. Both flow division and pressure drop staging can be combined for most effective preventative designs.
Predicting cavitation damage is complex but may be somewhat predictive. This method is based on the fact that vapor bubble collapse is what causes the cavitation damage as well as associated noise levels. Noise levels below the following usually assures a cavitation free experience:

Up to 3" valve	**<80 dBA**
4" to 6"	**<85 dBA**
8" to 14"	**<90 dbA**
16" and larger	**<95 dBA**

SHORT STROKE VALVES (typically ¾" stroke) can exhibit inaccuracies, or "stiction," from Graphite packing choices, compounded with poor resolution when using analog positioners.

PREFERRED "THUMP OF RULE" suggests that a digital. High resolution positioner will provide enhanced resolution as one improvement, and use of TFE packing, when temperature limits allow, will produce a smoother stroking result. Graphite packing is more "sticky" than TFE, resulting in uncontrollable stick/slip movement (steps) when changing control points. i.e. several control signal changes may be necessary before a change in stroke is observed – this may be result in an "overshoot / undershoot" result.

EXAMPLE RESOLUTION / ACCURACY:

Analog Positioners:	~3% to 4%	
Digital Positioners	~ 0.5%	(such as an ABB)

AMURACT TROUBLESHOOTING PROCEDURES MAY INCLUDE, make sure the RTD is programmed correctly as a 2 wire OR a 3 wire improper selection in the controller can result in wide swings open / closed.

PRESSURE VALVE is miss-leading. Pressure **Reducing** Valve, or a PRV is not a Pressure **Relief** Valve, and neither is a "Control" valve

3800 TRIM CHOICES: ***Several combinations are offered in trim combinations which needs an explanation:***
Trim, as explained in the "Vocabulary" section, consists of the plug, the mating seat ring, and this is held in place by a retainer, as in a sandwich arrangement. These components are selected based on several criteria such as temperature, differential pressure and erosive materials being controlled.

"S"	is 316 SS plug & seat with 316 SS retainer (Class IV)
"T"	is Teflon seat with 316 SS plug and 316 SS retainer (Class VI rated to 100 PSID)
"P"	is PEEK seat with 316 SS plug and 316 SS retainer (Class VI rated to 200 PSID)
"6"	is Alloy 6 plug & seat with 316 SS retainer (Class IV)
"H"	is Alloy 6 plug & seat with hardened 17-4 retainer (Class IV)
"Z"	is Ceramic seat and plug face with 316 SS retainer (Class IV+)
"R"	is Ceramic seat and plug face with hardened 17-4 retainer (Class IV+)
"Y"	is Ceramic seat and plug face with ceramic sleeve (Class IV+)

H, R & Y are for erosive applications depending on the degree of possible erosion.

SIZING & SELECTION

In any given situation, many questions need related information, to guarantee the correct and optimum solution for control, reliability, cost of ownership, maintenance requirements and can also be impacted by customer's preferences – right or wrong. The following is an offering of some of the more important and practical considerations worth evaluation in a professional selection process for such an ***engineered product***.

SIZING AND SELECTION OF CONTROL VALVES SHOULD RELY ON LAWS OF PHYSICS – AND LESS ON PREFERENCE OF A "COLOR."

Situation:

Is this a new or an existing application with a previous "solution"?
If New, proceed to next sections.

If existing, what is the history?
Include Good, bad and the ugly. Define the picture as to what's installed, what happened, what make and model or at least what is the face to face dimension, for a "drop and play" possibility? What is material and size(s) of inlet and outlet piping? Take a picture for reference.

Operating Conditions:

Is it a modulating or control application?
2way or 3 way (mixing or diverting)?
Single valve or staged requirement?

What is the piping detail? Horizontal? Size? Material of construction?
What is the Inlet pressure (P1) and Outlet pressure (P2) – measure if possible in closed and in flowing conditions.
What is the temperature, if other than steam?
Pressure codes or hazardous restrictions in place?

Fluid Properties:

Water, hot or cold - using chemical additives?

Undefined liquid – if so, is Vapor Pressure, critical pressure, and specific gravity information known?

Gas - defined
Steam, saturated or superheated
Clean, single phase, corrosive, abrasive, or flammable?

Slurry – define concentration and specific process dynamics requiring control

Flowing Conditions:

Lb.hr, GPM, BTU or other definition during maximum, Normal or start up conditions
Leakage allowed – Class pertaining to seat leakage.
Rangeability and/or turndown required

Sizing methods used:

Computer based, with printed results, formula based, with results, pure line size, or a guess.

Installation:

Location – Is the installation in an occupied area? Is it to be installed at an elevated location? Would maintenance be routine?

Might moving vehicles impact the installation? Any related seismic influences to be considered? Fire safety considerations? Might a worker use it as a step ladder? (happens every day)

Function:

Failsafe mode required?
In such case, is a manual over ride going to be necessary?
Flanged, threaded ends, or other specific mounting required?
Materials of construction?

Trim and packing choices – supported by engineering considerations?

Actuation preferred – pneumatic or electric – speed of stroke impact?

Accessories required – Positioner, I/P, air set, thermal or acoustic insulating blanket?

Documentation:

IO&M documentation is to be stored where?
Original paperwork? Warranty?

Additional points of impact:

Control source – PLC, DCS, PID, Other

Signal quality – is 4.0 mA as an example, accurate?
Advanced design Including features such as "ramp to set point" or other high end capabilities?

CONTROL VALVE DESIGNATIONS

Type	Style	Definition	Further Qualification	
20	Two way single seat	Unbalanced	Stem "in" to close	(norm open)
22	Two way double seat	Balanced	Stem "in" to close	(norm open)
23	Two way single seat	Cylinder balanced	Stem "in" to close	(norm open)
28	Two way	"Low Flow"series S	tem "in" to close	2800 only
30	Three way	Mix only	Side "Common"	2800, 2900 series
32	Three way	Divert only *	Bottom "Common"	2800, 2900 series
40	Two way single seat	Unbalanced	Stem "in" to close	
43	Two way single seat	Cage balanced	Stem "in" to close	
48	Two way single seat	"Low Flow" series	Stem in to close	Flanged 5800
50	Three way	Mix only *	Side "Common"	1800 series
52	Three way	Divert only *	Bottom "Common"	1800 series
70	Two way single seat	Unbalanced	Stem out (up) to close	(norm closed)
72	Double seat	Balanced	Stem "out" to close	(norm closed)
73	Two way single seat	Cylinder balanced	Stem "out" to close	(norm closed)

** There can be situations, with sufficient information to satisfy, where these might be reversed. Consult Factory*

BAC Series

Example: VA 12 3456 - X 789 ***Note:*** VA = Valve Assembly

VA digits 1 and 2 = "type" as listed above; 3 & 4 = size; 5 = Type and Rating; and 6 = Trim

Final chain " X" = Actuator "D" for Diaphragm / "E" for Electronic; followed by 7,8,9 for specific version; fail safe mode; size; spring range; speed; and/or accessory;

SIZE(IN INCHES)

04 = 1/2"	11 = 3"
05 = 3/4"	13 = 4"
06 = 1"	14 = 5"
07 = 1 1/4"	15 = 6"
08 = 1 1/2"	17 = 8"
09 = 2"	19 = 10"
10 = 2 1/2"	

TYPE AND RATING ANSI

A = 250# threaded bronze
B = 250# threaded iron
C = 125# flanged iron
D = 250# flanged iron
E = 300# threaded stainless steel

TRIM (PLUG AND SEAT)

A = Bronze
C = Stainless Steel
D = SS larger bonnet
(115 actuator)

Note: "Designations" (above) apply to BOTH Industrial and BAC (HVAC) series valves.
*For Industrial valves this becomes part of a 26 - 28 (model number+ letter) "chain"
*For BAC valves, a condensed number / letter combo of 11 units is used for selection due to fewer combinations

Sliding Stem Globe Style Control Valves

Model	Type	Size	Body	Ends	Trim	Trim	Cv	Packing	Bonnet
1800 **18H** 2 ½" – 4" 84" or 115" Diaphragm 6"/8" Cylinder **18J** 6" – 12" 115 Diaphragm 8" or 12" Cylinder **18K** ½" – 2" **Low Flow** 84" Diaphragm	**40** 2 way Single Seat **43** 2 Way Cage Balanced **50** 3 Way Mixing **52** 3 Way Diverting	**050** ½" **075** ¾" **100** 1" **150** 1 ½" **200** 2 **250** 2 ½" **300** 3" **400** 4" **600** 6" **800** 8" **010** 10" **012** 12"	**W** WCB **F** CF8M SS **R** Cast Iron	**F**125/250# Flanged **G** 250/300# Flanged	**E** =% **L** Linear	**S** 316SS **6** Alloy6	**F** Full **1** 1stSR **2or3SR**	**T** Teflon **G** Graphite	**S** 450 **X** 800
Model 2800 **28N**	**20** 2 Way Single Seat **28** 2 Way Low Flow **30** 3 Way Mixing **32** 3 Way Diverting	**050** ½" **075** ¾" **100** 1" **125** 1 ¼" **150** 1 ½" **200** 2"	**B** Bronze **F** CF8M	**S** Screwed **B** Buttweld	**E S**316SS **L** Linear **M** ModLin	**B** Bronze **6** Alloy 6 **H** 17-4 ph **T** Teflon **P** PEEK	**1** 1stSR **2 – 4 SR**	**G** Graphite **V** Vacuum	
Model 2900 **29N** 49" or 84" Diaphragm **291** 115" Diaphragm Cylinder Balanced	**20** 2 Way Single Seat **22** 2 Way Single Seat **23** 2 Way **30** 3 Way Mixing **32** 3 Way Diverting	**250** 2 ½" **300** 3" **400** 4" **500** 5" **600** 6" **800** 8" **010** 10"	**R** Cast Iron	**F** 125# Flanged **G** 250# Flanged	**E** =% **L** Linear	**B** Bronze **S** 300 SS **H** 17-4 ph **6** Alloy 6	**F** Full	**T** Teflon **G** Graphite **V** Vacuum	
Model 5800 **58N** 49" or 84" Diaphragm 4" or 6" cylinder **58H** 84" or 115" 6"/8" Cylinder	**40** 2 Way Single Seat Cage Retained **43** 2 Way Single Seat Cage Balanced	**100** 1" **150** 1 ½" **200** 2" **250** 2 ½" **300** 3" **400** 4"	**W** WCB **F** CF8M	**F** 150# Flanged **G** 300# Flanged **S** NPT Thread W Socket Weld	**E** =% **L** Linear	**S** 316SS **T** Teflon **P** PEEK **6** Alloy 6 Over 316 **7** 400SS **8** Alloy6	**F** Full **1** 1stSR **2-4 SR**	**T** Teflon **G** Graphite **V** Vacuum	**S** PEEK **N** Nitronic **H** Alloy6 **X** Alloy 6

Rotary Globe 90 Degree Control Valves

Model	Type	Size	Body	Ends	Trim	Trim	Cv	Packing	Bonnet
Model 3800	**385 1", 2"** **386** **387** **388** 6" or 8" **F10** **389** 6" or 8" **F12**	**100** 1" **150** 1 ½" **200** 2" **300** 3" **400** 4" **600** 6" **800** 8"	**W** WCB **F** CF8M	**F** 150# Flanged **G** 300# Flanged		**S** 316 SS **Z** TTZ Ceramic **T** TFE Soft **P** PEEK Soft **6** Alloy 6	**F** Full **1** 1stSR **2-3 SR**	**S** PEEK **G** Graphite	**C** Thru D **D** Thru I **E** Split D **F** Split I

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