EnTech

Control Valve Dynamic Specification

(Summary - Version 3.0, 11/98)

Competitive Marketplace

The global market's continuing demand for quality and uniformity in manufactured products means there is even greater focus being given to process control equipment and its performance. EnTech Control Engineering Inc. has specialized in the optimization of process performance, particularly in pulp and paper manufacturing where product uniformity specifications are now approaching 1%. Plant process variability audits frequently find that product variability is increased by individual control loops that *limit cycle* because their control valves are unable to track their controller output signals closely enough (Figure 1). ***This undesirable behaviour of control valves is the biggest single contributor to poor control loop performance and the destabilization of process operation.***

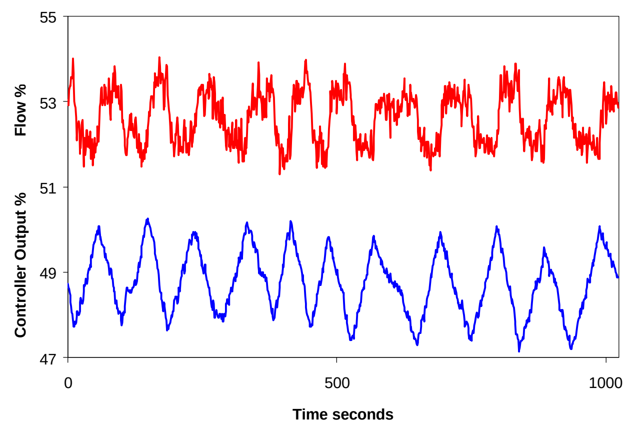

Figure 1 – Typical Control Valve Induced *Limit Cycle*

Purpose: to define the degree to which control valves can be nonlinear and still allow acceptable process control performance.

About Version 3.0: The original EnTech Control Valve Dynamic Specification was issued in 1992. Version 3.0 replaces all previous versions. It uses ISA terminology, considers end user needs, defines a valve step response performance index, and is applicable to all process industries. All words in *italics* are defined in the ***definitions section*:** see full text of the specification.

Control Valve System: The Specification considers the control valve as a dynamic system, from input signal through to the *flow coefficient* that determines the fluid flow in the pipe. The key is that a measured change in a *process variable* is expected in response to small input step-changes (1% and less). Valve *stem* movement is not an adequate indication, but is considered to be a good measure of the *speed of response* of the valve system.

SPECIFICATION

There are three sections: Nonlinear, Dynamic Step Response and Valve Sizing. Each has a number of recommendations, a default value, and an extra space for a user-specified selection. **If no control loop application knowledge is available, the default values should be used**. **The performance of a *control valve system* shipped as a package should be documented in a specification sheet, including the parameters called out in this specification.**

1. NONLINEAR SPECIFICATION

The nonlinear specification sets the maximum allowed *dead band, step resolution* and *total hysteresis*. The *total hysteresis* influences the potential *minimum step size*, which in turn determines the amplitude of the potential controller output *limit cycle*. The *minimum step size* together with the *flow gain* determines the amplitude of the potential *PV limit cycle*. Three classes are given: nominal, fine and very fine*.* Default values are provided for both rotary valves and sliding *stem* valves.

Valve Tracking Nonlinearities (% input signal)

Class	**Nominal - 1%**	**Fine - 0.5%**	**V Fine – 0.1%**	**DEFAULT Rotary Valves**	**DEFAULT Sliding *Stem***	**User**
***Dead Band* (%)**	0.6	0.3	0.06	**0.6**	**0.3**	
***Step Resolution* (%)**	0.4	0.2	0.04	**0.4**	**0.2**	
***Total Hysteresis* (%)**	1.0	0.5	0.1	**1.0**	**0.5**	

2. DYNAMIC STEP RESPONSE SPECIFICATION - STEP SIZE RANGE – *REGION C*

The dynamic response specification sets the ranges over which consistent dynamics are to be achieved (*Region C*). The step size range is set from minimum to maximum. *Minimum step size* depends on the *total hysteresis*, as well as the magnitude of *Region B*. It is valve design dependent and is likely to be about double the *total hysteresis*. Values are given for nominal, fine, and very fine. The finer, the more capable the valve design. Default values are given for rotary and sliding *stem* valves.

***Minimum Step Size* (%)**

Nominal	Fine	Very Fine		DEFAULT Rotary Valves	DEFAULT Sliding *Stem*	User
2.0	1.0	0.2		**2.0**	**1.0**	

The *Maximum step size* determines the upper range over which the valve is nearly linear and depends on the size of *Region D*. Values are given for nominal, wide and very wide. The wider, the more capable the valve design.

***Maximum Step Size* (%)**

Nominal	Wide	Very Wide		DEFAULT	User
10	50	100		**10**	

STEP RESPONSE - *REGION C* – Consistent Dynamics

The step response specification sets *T86*, *% Overshoot, Travel Gain*, *Tss.* Each class is based on the fastest control loop *speed of response* (l) available, given the valve ***T86*** and ***Tss*** as specified. The four classes include: Very Fast (1 second), Fast (5 seconds), Nominal (10 seconds), Slow (1 minute). The default is set for 5 sec.

***T86 Step Response Time (*seconds**) by Fastest Loop *Speed of Response* Class (Function of *Td / T86 Ratio*)

Class	1 second	5 seconds	10 seconds	1 minute	DEFAULT	User
Td / T86 < 0.5	0.4	2	4	24	**2**	
Td / T86 $\geq$ 0.5	0.25	1.25	2.5	15	**1.25**	

***Tss* Steady State Time *(*seconds)** by Fastest Loop *Speed of Response* Class (Function of *Td / T86 Ratio*)

Class	1 second	5 seconds	10 seconds	1 minute	DEFAULT	User
Td / T86 < 0.5	1	5	10	60	**5**	
Td / T86 $\geq$ 0.5	0.63	3.1	6.3	38	**3.2**	

Travel gain

Nominal	DEFAULT	User
0.8 to 1.2	**0.8 to 1.2**	

%*Overshoot* (% of step change)

Nominal	DEFAULT	User
20	**20**	

***Valve Performance Index W* - Weighting Factor -** (Based on Equations 1 and 2) 0=perfect, 100=poor

***W(T86)* Equation 1 =**			***W(Lambda)* Equation 2 =**	

3. VALVE SIZING SPECIFICATION

Flow Characteristic Nonlinearities:

This section of the specification is intended as a guideline for control valve sizing calculations. The flow *limit cycle* amplitude can be predicted as one half of the *minimum step size* times the flow gain. It can best be expressed as potential process variability on a percentage basis, by calculating the *limit cycle* amplitude as a percentage of the nominal flow. The *flow gain %* is the *flow gain* in flow units / valve travel %, divided by the flow at the operating point and expressed as a percent. The designer should consider the worst case in the process design (highest or lowest flow).

Maximum Allowed Flow *Limit Cycle* Amplitude (% of Nominal Flow)

	Nominal	Fine	Very Fine	DEFAULT Rotary Valves	DEFAULT Sliding *Stem*	User
***Minimum Step Size* (%)**	2.0	1	0.2	**2.0**	**1**	
***Flow Gain* %**	1.0	1.0	1.0	**1.0**	**1.0**	
Flow *Limit Cycle* (%)	1.0	0. 5	0.1	**1.0**	**0. 5**	

The control loop *process gain* is a function of the *flow gain*, the relationship of the flow in the pipe to the measured process variable, and the span of the transmitter used to make the process measurement. Ideally, the *process gain* should be approximately equal to unity (% *PV* / % valve travel) for good design. The amount by which the *process gain* varies over the operating range of the process, determines the degree to which the control loop will be difficult to tune. Poor tuning leads to control loop cycling and higher process variability. Ideally the *process gain* range should be limited to plus and minus a factor of two.

Variation in *Process Gain* (*Kp*),

	Nominal	High	Low	DEFAULT High	DEFAULT Low	User
Nominal *Kp* (%/%)	1.0	2.0	0.5	**2.0**	**0.5**	

A full copy of the specification is available via the EnTech home page at: http://www.entechcontrol.com/, or by calling EnTech.

For more information:

For more information on Variability Management please visit our website www.EmersonProcess.com/solutions/VariabilityManagement , or

Contact us at:

email: AAT@emersonprocess.com
phone: +1 512-832-3575

Emerson Process Management
12301 Research Blvd.
Research Park Plaza, Building III
Austin, Texas 78759 USA

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