Foreword

This document discusses control valve stem position mechanical stability, establishes a measurement criterion for position instability and provides a bibliography of published papers.

Abstract

This document is intended to help the user recognize, measure, and diagnose the unstable stem motion of a valve.

Key Words

Control valve stem position mechanical stability, unstable motion, maximum amplitude, design of the valve closure member, pressure-balancing, deadband, hysteresis, position instability, fluid forces, actuator forces, control signal, force gradient, pressure balanced.

1 Scope

This document discusses control valve stem position mechanical stability and establishes a measurement criterion for position instability of the valve. Other forms of instability associated with control valves and control systems are not covered.

2 Purpose

This document is intended to help the user recognize, measure, and diagnose the unstable motion of a valve. A reference section (Annex A) with abstracts provides further references.

3 Definitions

3.1 position instability:
evidenced by uncontrolled fluctuating valve travel. It is caused by the fluid forces interacting with the actuator forces. It is a persistent cyclic motion inconsistent with control signal to the valve. It is not a static deviation caused by dead band or hysteresis.

3.2 control loop instability:
a regular oscillation of a feedback control system caused by excessive loop gain. It is independent of external disturbances.

3.3 flow rate instability (bistable flow):
an abrupt change in the control valve flow rate that occurs independent of changes in valve position. It may be caused by variable wall attachment of the fluid stream at the valve orifice, by flashing, or by cavitation.

3.4 hunting:
a continuing cyclic motion caused by friction, with the positioner or controller attempting to find the set position.

4 Discussion

4.1 Position instability, as defined in 3.1, may occur when the immediate force-to-travel gradient associated with the action of the flowing fluid on the moveable valve trim overcomes the stiffness of the actuator, particularly on flow-to-close valves. Electromechanical and hydraulic actuators, because they are inherently stiff, are rarely subject to position instability unless there is mechanical backlash. Pneumatic actuators that depend upon a compressible fluid are more susceptible to position instability. However, the stiffness of pneumatic actuators varies greatly according to actuator design and application. Mechanical spring rate, actuator gas density (pressure), and actuator tare (clearance) volume all contribute to pneumatic actuator stiffness.

4.2 An analysis of forces includes the following:

a) the differential fluid pressure acting across the effective unbalanced area of the valve closure member;

b) the static fluid pressure acting on the stem area of sliding-stem valves;

c) buffeting forces associated with the fluid velocity, such as vortex shedding, impact, turbulence, cavitation, and flashing;

d) the actuator spring(s), mechanical or pneumatic, and the opposing pneumatic pressure; and