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Standard

# Inherent Flow Characteristic and Rangeability of Control Valves

ISA-S75.11 — Inherent Flow Characteristic and Rangeability of Control Valves

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## Preface

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The ISA Standards and Practices Department is aware of the growing need for attention to the metric system of units in general, and the International System of Units (SI) in particular, in the preparation of instrumentation standards. The Department is further aware of the benefits to U.S.A. users of ISA standards of incorporating suitable references to the SI (and the metric system) in their business and professional dealings with other countries. Toward this end, this Department will endeavor to introduce SI-acceptable metric units in all new and revised standards to the greatest extent possible. *The Metric Practice Guide,* which has been published by the Institute of Electrical and Electronic Engineers as ANSI/IEEE Std. 268-1982, and future revisions will be the reference guide for definitions, symbols, abbreviations, and conversion factors.

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Prior to the issuance of this standard, there had been no standard which provided allowable deviations for control valve flow characteristics and which established criteria for rangeability of control valves.

In contrast to conventional globe valves, most rotary motion control valve types such as ball valves, butterfly valves, or plug valves do not have a mathematically definable flow characteristic. The users of control valves, therefore, have to depend on the manufacturer to state the specific flow characteristic for a given style or size of valve either in graphic or tabular form. For sake of consistency, this method of presentation was also adapted for generic flow characteristics such as "equal-percentage" or "linear."

This standard states the limits within which a stated flow characteristic can be expected to be reproducible. Knowledge of specific flow coefficients (within allowable deviations) at stated travel positions will enable the user to calculate the installed flow characteristic for a specific control system.

The stated inherent rangeability of a specific control valve is related solely to the interaction between the closure member and the flow control orifice of a valve. This given value may not be applicable when the control valve is installed. Other factors such as the positioning accuracy of the actuator or the effects of hydraulic, flow resistance of associated piping have to be considered when deriving the installed rangeability for a specific application.

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## Contents

# 1 Scope

The scope of this standard is to define the statement of typical control valve inherent flow characteristics and inherent rangeabilities, and to establish criteria for adherence to manufacturer-specified flow characteristics.

# 2 Basic definitions

## 2.1 Terminology

Basic terminology used herein is based on definitions stated in "Control Valve Terminology" ISA Standard S75.05.

## 2.2 Flow coefficient

A constant ($C_v$), related to the geometry of a valve, for a given valve opening, that can be used to predict flow rate. See ANSI/ISA S75.01 "Control Valve Sizing Equations" and ANSI/ISA S75.02 "Control Valve Capacity Test Procedure."

## 2.3 Inherent flow characteristic

The relationship between the flow rate through a valve and the travel of the closure member as the closure member is moved from the closed position to rated travel with constant pressure drop across the valve.

## 2.4 Inherent rangeability

The ratio of the largest flow coefficient ($C_v$) to the smallest flow coefficient ($C_v$) within which the deviation from the specified inherent flow characteristic does not exceed the limits stated in Section 4.

## 2.5 Relative flow coefficient ($\phi$)

The ratio of the flow coefficient ($C_v$) at a stated travel to the flow coefficient ($C_v$) at rated travel.

## 2.6 Relative travel (h)

The ratio of the travel at a given opening to the rated travel.

## 3 Typical inherent flow characteristics

**3.1** The typical inherent flow characteristic for a specific size, type, and trim configuration of a control valve shall be specified by the manufacturers either graphically or in tabular form.

**3.2** When tabulated, specific flow coefficients shall be stated for the following travel positions: at 5%, 10%, 20%, and every subsequent 10% of rated travel up to and including 100%.

**3.3** The manufacturer may publish flow coefficients in addition to those at the above-stated travel positions.

**3.4** In addition, the manufacturer is encouraged to specify the generic name of a specific flow characteristic such as "Linear," "Equal-Percentage," etc., if applicable, following the definitions in ISA Standard S75.05.

**3.5** The manufacturer shall state the largest flow coefficient that meets the criteria of Section 4 if it is less than the rated flow coefficient. (See Figure 2.)

## 4 Permissible deviations between actual and manufacturer-stated inherent flow characteristics

**4.1** When subjected to a flow test per ANSI/ISA S75.02, the individual test $C_v$ values may not deviate by more than $\pm 10 \{1/\phi\}^{0.2}$ percent from those values specified in the flow characteristic published by the manufacturer. Exceptions of this are $C_v$s at given travel positions falling below a $C_v$ value of 5, or above a $C_v$ value of $30d^2$. In the above relationships, d is the nominal valve size in inches, and $\phi$ is the relative flow coefficient based on published $C_v$s. Allowable deviations calculated by the above equation are listed in Table 1.

**Table 1 — Permissible deviations between actual and manufacturer-stated inherent flow characteristics**

| % $C_v$ Rated | $\phi$ | Permitted +/- Deviation (%) | $\phi$ Range High | $\phi$ Range Low |
|---|---|---|---|---|
| 5 | 0.05 | 18.2 | 0.0591 | 0.0409 |
| 10 | 0.1 | 15.8 | 0.116 | 0.0842 |
| 20 | 0.2 | 13.8 | 0.227 | 0.172 |
| 30 | 0.3 | 12.7 | 0.338 | 0.262 |
| 40 | 0.4 | 12.0 | 0.448 | 0.352 |
| 50 | 0.5 | 11.5 | 0.557 | 0.443 |
| 60 | 0.6 | 11.1 | 0.667 | 0.533 |
| 70 | 0.7 | 10.7 | 0.775 | 0.625 |
| 80 | 0.8 | 10.4 | 0.883 | 0.717 |
| 90 | 0.9 | 10.2 | 0.992 | 0.808 |
| 100 | 1.0 | 10.0 | 1.100 | 0.900 |

**4.2** The inherent flow characteristic of a control valve, when plotted from test data at the stated increments of travel, shall show no major deviations in slope. By definition, a major deviation is when the slope of the line connecting two adjacent test points varies by more than 2 to 1 or 0.5 to 1 from the slope of a line drawn between flow coefficients specified by the manufacturer for the same travel positions. (See Figure 1.)

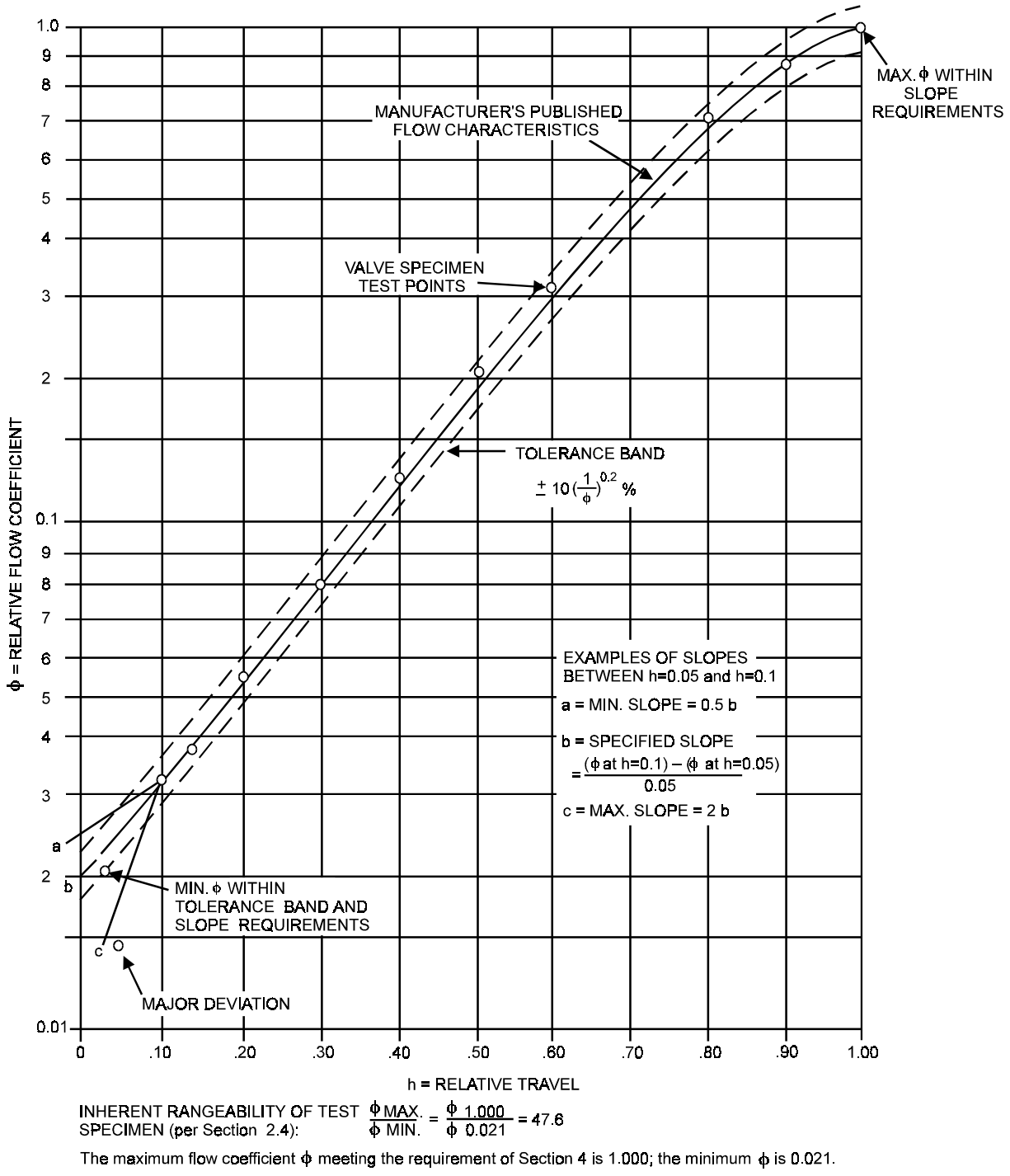
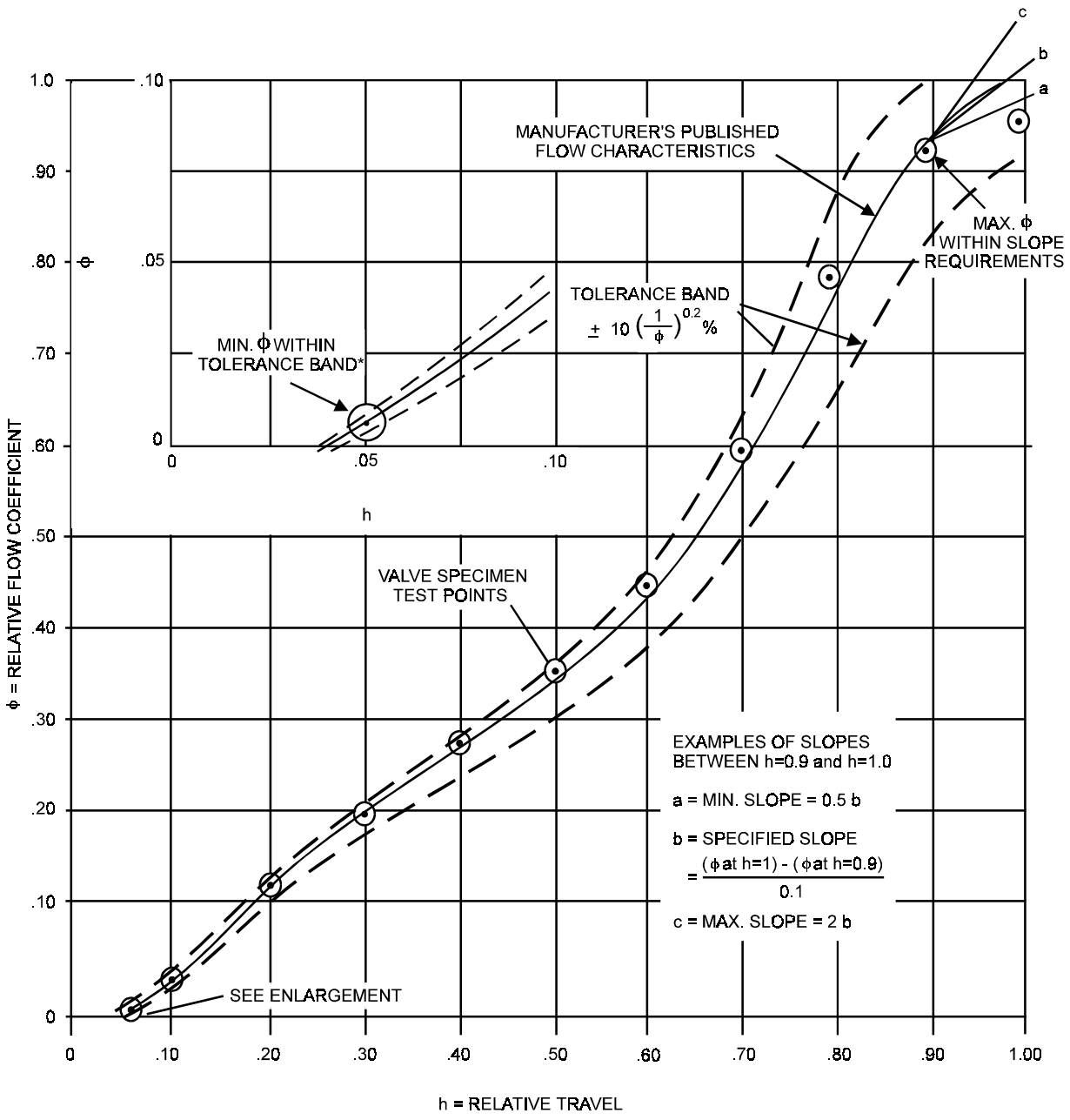



**Figure 1 — Example of globe valve specimen compared to manufacturer-specified flow characteristic**




INHERENT RANGEABILITY OF TEST SPECIMEN (per Section 2.4): $\frac{\phi \text{ MAX.}}{\phi \text{ MIN.}} = \frac{\phi\ 0.91}{\phi\ 0.01} = 91$

The maximum flow coefficient $\phi$ meeting the requirements of Section 4 is 0.91; the minimum $\phi$ is 0.01.

*Tolerance band for $\phi = 0.01$ is $10 \left\{\frac{1}{0.01}\right\}^{0.2} = \pm 25\%$ of $\phi = 0.01$.

**Figure 2 — Example of butterfly valve specimen compared to manufacturer-specified flow characteristic**

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