

SEMI E69-0298

TEST METHOD FOR DETERMINING REPRODUCIBILITY AND ZERO DRIFT FOR THERMAL MASS FLOW CONTROLLERS

1 Purpose

1.1 The purpose of this document is to provide a standardized method to quantify the reproducibility and zero drift of a thermal mass flow controller.

1.2 The intent of this document is not to suggest any specific testing program but to specify the test method to be used when testing for parameters that are covered by this method. The user might use this document to check significant performance characteristics, such as reproducibility and zero drift, under a set of closely controlled test conditions.

1.3 The significance of the accuracy calculations in this method is to allow an MFC user to transfer a process from one manufacturing tool to another and to exchange MFCs within a single manufacturing tool while maintaining process control.

2 Scope

2.1 This document describes the conditions and procedures for testing the reproducibility and zero drift of thermal mass flow controllers (MFCs). Because of the generic nature of this document, not all test procedures apply to all types of MFCs.

2.2 This document provides a common basis for communication between manufacturers and users.

3 Limitations

3.1 It is not practical to evaluate performance under all possible combinations of operating conditions. This test procedure should be applied under laboratory conditions; its intent is to collect sufficient data to form a judgement of the field performance of the MFC being tested.

4 Referenced Documents

4.1 SEMI Document

SEMI E28 — Guideline for Pressure Specifications of the Mass Flow Controller

4.2 ANSI Documents¹

ANSI C39.5 — Safety Requirements for Electrical and Electronic Measuring and Controlling Instrumentation

¹ American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018

ANSI C42.100 — Dictionary of Electrical and Electronics Terms

ANSI MC4.1 — Dynamic Response Testing of Process Control Instrumentation

4.3 ASME Document²

ASME MFC-1M — Glossary of Terms Used in the Measurement of Fluid Flow in Pipes

4.4 IEC Documents³

IEC 160 — Standard Atmospheric Conditions for Test Purposes

IEC 546 — Methods of Evaluating the Performance of Controllers with Analogue [sic] Signals for Use in Industrial Process Control

4.5 ISA Documents⁴

ISA S7.3 — Quality Standards for Instrument Air

ISA S51.1 — Process Instrumentation Terminology
ANSI/ISA-1 979 (reaffirmed 1993)

5 Terminology

5.1 Acronyms

5.1.1 *FS* — Full scale

5.1.2 *kPa* — Kilopascal

5.1.3 *MFC* — Mass flow controller

5.1.4 *NC* — Normally closed

5.1.5 *NO* — Normally open

5.1.6 *psia* — Pounds per square inch absolute

5.1.7 *sccm* — Standard cubic centimeters per minute

5.1.8 *slm* — Standard liters per minute

5.2 Definitions

5.2.1 *accuracy* — The closeness of agreement between an observed value and the true value; the total

² American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017

³ International Electrochemical Commission, 3, rue de Varembe, CH-1211 Geneva 20 Switzerland

⁴ Instrument Society of America, 67 Alexander Drive, Research Triangle Park, NC 27709

uncertainty of an observed value, including both precision and bias.

5.2.2 accuracy curve — The curve fitted through the average measured values over the specified range of the device under test (DUT).

5.2.3 accuracy, device — The total uncertainty over a specified range of the device. Device accuracy over a range is stated as the worst case accuracy taken over all tested setpoints in this range.

5.2.4 bias — The difference, at a setpoint, between the measured value and the sum of the setpoint value and the zero offset. The measured values of a flow standard include its total uncertainty.

5.2.5 cardinal setpoint — A specific setpoint to assess the accuracy of the device under test. For this test method, the cardinal setpoints are 10%, 50%, and 100% of full scale.

5.2.6 deadband — The range through which a setpoint may be varied, upon reversal of direction, without initiating an observable change in output signal.

5.2.7 downscale reading — A reading approached from a setpoint greater than the current setpoint and beyond the deadband.

5.2.8 downscale value, average — The sum of all downscale readings, in one cycle, at a single setpoint, divided by the number of these values.

5.2.9 flow standard — A device used to measure the actual mass flow through the DUT.

5.2.10 linearity — The closeness to which a curve approximates a straight line. It is measured as a non-linearity and expressed as a linearity.

5.2.11 linearity, terminal-based — The maximum absolute value of the deviation of the accuracy curve (average of upscale and downscale values) from a straight line through the upper and lower setpoint limits of the accuracy curve (see Figure 1).

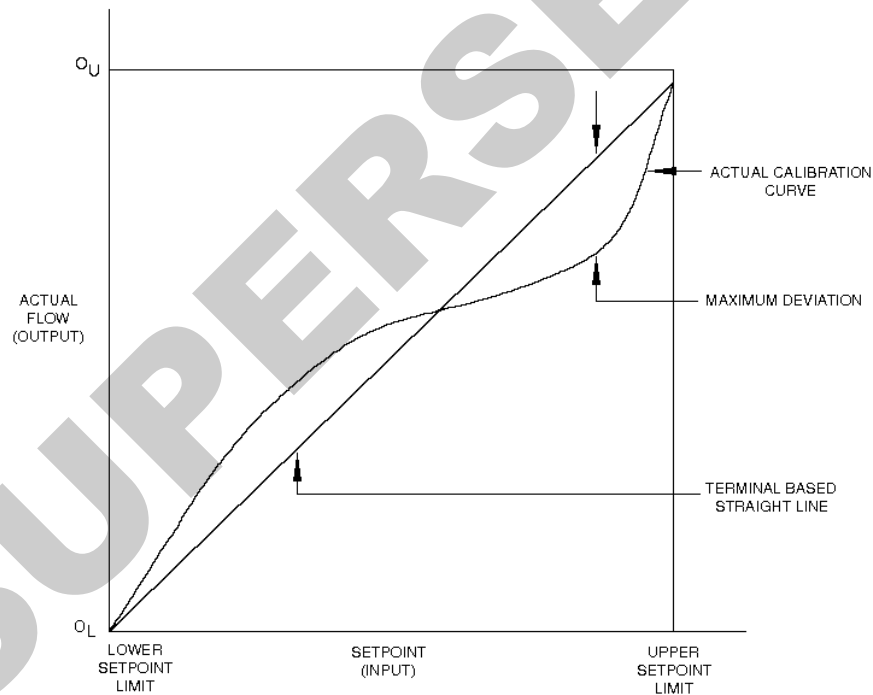


Figure 1
Terminal-Based Linearity for Mass Flow Controller

5.2.12 *measured value* — The actual flow through a device under test, expressed in sccm or slm, as measured by a standard, preferably primary.

5.2.13 *measured value, average* — The sum of all readings (both upscale and downscale) for all cycles, at a single setpoint, divided by the number of these readings.

5.2.14 *operating conditions, normal* — The range of operating conditions within which a device is designed to operate and for which operating influences are stated [ISA S51.1].

5.2.15 *operating conditions, reference* — The range of operating conditions of a device within which operating influences are negligible [ISA S51.1].

5.2.16 *operating influence* — The change in a performance characteristic caused by a change in a specified operating condition from reference operating conditions, all other conditions being held within the limits of reference operating conditions [ISA S51.1].

5.2.17 *precision* — The closeness of agreement among the measured values at a setpoint. It is often expressed as a standard deviation.

5.2.18 *repeatability* — The closeness of agreement among a number of measured values at a setpoint, under the same operating conditions, operator, apparatus, laboratory, and short intervals of time. It is usually measured as a nonrepeatability and expressed as a repeatability in percent of reading [ISA S51.1].

5.2.19 *reproducibility* — The closeness of agreement among repeated measured values at a setpoint, within the specified reference operating conditions, made over a specified period of time, approached from both directions. It is usually measured as a nonreproducibility and expressed as a reproducibility in percent of average reading. Reproducibility includes hysteresis, deadband, long-term drift, and short-term reproducibility [ISA S51.1].

NOTE: Between repeated measurements, the input may vary over the range, and operating conditions may vary within normal operating conditions.

5.2.20 *reproducibility, short-term* — The closeness of agreement among a number of measured values at a setpoint, under the same operating conditions, operator, apparatus, laboratory, and short intervals of time,

approached from both directions. The approach must be from beyond the deadband. It is usually measured as a nonreproducibility and expressed as a reproducibility in percent of reading. Short-term reproducibility includes repeatability, hysteresis, deadband, and shortterm drift.

5.2.21 *setpoint* — The input signal provided to achieve a desired flow, reported as sccm, slm, or percent-full scale.

5.2.22 *setpoint limit, lower* — The lowest setpoint at which the instrument is specified to operate.

5.2.23 *setpoint limit, upper* — The highest setpoint at which the instrument is specified to operate, usually full scale.

5.2.24 *span* — The full-scale range of the DUT.

5.2.25 *stability* — The ability of a condition to exhibit only natural, random variation in the absence of unnatural, assignable-cause variation.

5.2.26 *standard conditions* — 101.32 kPa, 0.0°C (14.7 psia, 32°F)

5.2.27 *uncertainty, total* — The range within which the true value of the measured quantity can be expected to fit; an indication of the variability associated with a measured value that takes into account the two major components of error — bias and the random error attributed to the imprecision of the measurement process.

5.2.28 *upscale reading* — A reading approached from a setpoint less than the current setpoint and beyond the deadband.

5.2.29 *upscale value, average* — The sum of all upscale readings, in one cycle, at a single setpoint, divided by the number of these values.

5.2.30 *zero drift* — The undesired change in electrical output, at a no-flow condition, over a specified time period, reported in sccm or slm.

5.2.31 *zero offset* — The deviation from zero, at a no-flow condition, reported in sccm or slm.

6 Summary of Test Method

6.1 Specific procedures are given for characterizing MFCs discharging to atmospheric pressure or into a vacuum using accepted reference standards to determine reproducibility and zero drift (see Figure 2).