

SEMI F56-0600

TEST METHOD FOR DETERMINING STEADY-STATE SUPPLY VOLTAGE EFFECTS FOR MASS FLOW CONTROLLERS

This test method was technically approved by the Global Facilities Committee and is the direct responsibility of the North American Facilities Committee. Current edition approved by the North American Regional Standards Committee on April 10, 2000. Initially available on www.semi.org May 2000; to be published June 2000.

1 Purpose

1.1 The purpose of this document is to define a method for characterizing mass flow controllers (MFCs) being considered for installation into a high-purity gas distribution system. This method will quantify the steady-state supply voltage effects on the MFC's ability to accurately deliver set point flow values.

2 Scope

2.1 This procedure applies to thermal mass flow controllers. It is intended to measure the delivered mass flow rate variation as a function of deviation from the reference steady-state supply voltage. The test method is designed for DC-powered MFCs. The supply voltage effects include voltage depression and over-voltage variations in the DC supply.

2.2 This standard does not purport to address safety issues, if any, associated with its use. It is the responsibility of the users of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

3 Limitations

3.1 This test method is not designed for AC-powered MFCs. This test method addresses steady-state effects and does not address any effects caused by transient power supply behavior.

4 Referenced Standards

4.1 None.

5 Terminology

5.1 Acronyms and Abbreviations

5.1.1 *DUT* — device under test

5.1.2 *MFC* — mass flow controller

5.1.3 *NIST* — National Institute of Standards and Technology

5.1.4 *psia* — pounds per square inch absolute

5.1.5 *psig* — pounds per square inch gauge

5.2 Definitions

5.2.1 *actual flow* — flow value measured by the flow standard.

5.2.2 *indicated flow* — flow value derived from the MFC.

5.2.3 *Reference voltage(s)* — manufacturer's recommended power supply voltage(s).

5.2.4 *stable* — the state a signal level obtains when its magnitude varies by less than or equal to $\pm 2.0\%$ of full scale over a one-minute period.

6 Summary of Method

6.1 This test method consists of varying the steady-state supply voltage to an MFC in $\pm 1\%$ (of rated supply) increments from the reference voltage span. Both the positive and negative supply voltages will be varied independently and together in 1% increments. The MFC flow output is monitored at 0% and 100% of its operating range (see Table 1). At each incremental change as well as at the reference supply voltage, the MFC flow and flow standard outputs are recorded at 0% and 100% of its operating range. The test shall end when a $\pm 3\%$ of full-scale output flow change is noted between the flow at the reference voltage and at an incremental change point. A flow chart outlines the procedure (see Figure 1).

7 Interference's

7.1 Because of fluctuations in ambient temperature or a changing load on the power supply, the reference steady-state supply voltages may change. These changes in supply voltages may adversely effect the MFC's ability to deliver setpoint flow. The magnitude of this effect can be measured by this test method.

7.2 The user of an MFC can use the data generated by this method to evaluate the impact of steady-state supply voltage variations on the MFC's ability to deliver setpoint flow values. Knowing the magnitude of this effect and the power level variations, allows the user to decide on what measures to take to reduce this effect, if necessary.

8 Apparatus

8.1 The equipment and instrumentation required to complete this test method are shown in Figure 2.

8.2 *DC Power Supply*, to provide the required voltage to the MFC under test, with the capability to vary its output over the range of ± 30 VDC at 500 mA, and with ripple less than 0.1% rms.

8.3 *DC Power Supply Monitor/Recorder*, placed in parallel with the DC power supply, and capable of measuring the DC voltage to within ± 5 mV over the entire operating range of the supply.

8.4 *Flow Output Monitor*, connected to the MFC output and signal common/ground points. The monitor/recorder shall be capable of measuring over a range of 0–10 VDC to within ± 5 mV.

8.5 *Flow Standard*, installed downstream and in series with the flow through the MFC. The flow standard shall be capable of measuring flow changes within $\pm 0.3\%$ of full scale.

8.6 *Current Meter*, connected in series in the power common line of the DC power supply, capable of measuring over a range of 0–200 mA to within ± 1 mA.

9 Reagents and Materials

9.1 *Test Gas*, nitrogen

10 Safety Precautions

10.1 The user must know the respective instrumentation, practice proper handling of test components, and understand good laboratory practices.

10.2 The user should not exceed the ratings (such as pressure, temperature, flow, and voltage) of the components.

11 Preparation of Apparatus

11.1 *Setup and Schematic* — See Figures 2 and 3.

11.2 The test gas source and delivery system must be capable of satisfying the test volume flow rate at a constant pressure, ± 0.1 psia.

11.3 The test gas source and delivery system must be capable of delivering a gas at ambient temperature $\pm 2^\circ\text{C}$ for the duration of each analysis. The ambient temperature shall be held to $22 \pm 1^\circ\text{C}$.

12 Calibration and Standardization

12.1 All instrumentation shall be calibrated with NIST traceable standards and shall be under current calibration.

13 Procedure

13.1 Install the MFC into the test setup per manufacturer's recommendations.

13.2 Apply power to all devices shown in Figure 2 per manufacturer's specifications. Allow the devices to warm up for the duration specified by the equipment manufacturer.

13.3 Set the DC power supply to the manufacturers recommended reference voltage. Verify the voltage magnitude using the power supply monitor.

13.4 Purge the system with nitrogen for a length of time equal to ten times the amount of time it takes to replace the system volume with the test MFC at its full-scale rated flow rate.

13.5 Close the inlet shut-off valve and then the outlet shut-off valve located adjacent to the MFC (see Figure 3). Adjust the MFC setpoint to zero flow. Follow the manufacturer's recommendations for adjusting the MFC zero. If the MFC has an auto-zero function, leave it active and note this fact on the data sheet in Table 1. Wait for the signals to become stable. Record on the data sheet (see Table 1) three separate readings of the MFC flow output, the power supply voltages, and the current of the power supply common.

13.6 Vary the positive DC power supply voltage in $+1\%$ steps from the reference value while holding the negative supply at its reference value.

NOTE 1: If reference voltage is $+15$ V, the first step is a change in voltage of $+0.15$ V.

13.7 After the monitored signals become stable, record the MFC zero value, the current value, and the power supply voltage magnitudes. Record the measurements at each step-change of power level on the data sheet. Continue to increase the positive supply voltage span until the MFC zero point changes by $\pm 3\%$ of full scale flow, the MFC zero output point remains unstable for five minutes, or the voltage level changes to $+115\%$ of original value.

13.8 Return the power supply level to the original reference value and repeat Section 13.5.

13.9 Repeat the procedure described in Section 13.6, with the following exception: Decrease the power supply span in 1% decrements until either the MFC zero changes by $\pm 3\%$ of full scale, the zero output point remains unstable for five minutes, or 85% of the original value is reached.

13.10 Return the power supply level to the original reference value, repeat Section 13.5, and go to Section 13.10.

13.11 Repeat Sections 13.6 through 13.9, with the following exception: Vary the negative DC power supply while holding the positive power supply at its reference value.

13.12 Vary both DC power supply voltages together in +1% steps from the reference value.

NOTE 2: If the reference voltages are ± 15 V (30 V span), the first step is a change in voltage of ± 0.15 V increasing the span to ± 15.15 V (30.3 V span).

13.13 After the monitored signals become stable, record the MFC zero value, the current value, and the power supply voltage magnitudes. Record the measurements at each step change of power level on the data sheet. Continue to increase the supply voltage span until the MFC zero point changes by $\pm 3\%$ of full scale flow, the MFC zero output point remains unstable for five minutes, or the voltage level changes to $+115\%$ of original value.

13.14 Return the power supply level to the original reference value, repeat Section 13.5, and go to Section 13.13.

13.15 Repeat Section 13.11, with the following exception: Decrement the power supply voltages by 1% and go to Section 13.14.

13.16 Return the power supply level to the original reference value, repeat Section 13.5, and go to Section 13.15.

13.17 Open the inlet and outlet shut-off valves that are adjacent to the MFC (see Figure 3) and adjust the MFC set point to 100%. Insure that all reference conditions are within the specified tolerances. Once the output signals become stable, record the MFC output signal, the power supply voltage, the flow standard output, and the current value.

13.18 Vary the positive DC power supply voltage in +1% increments from the reference while holding the negative power supply at its reference value as described in Section 12.6. Record, on the data sheet, the measurements of MFC flow output, power supply voltage, flow standard output, and current meter signal after the values become stable. Continue to increase the voltage in 1% increments until the MFC or flow standard signal changes by $\pm 3\%$ of full scale, or the MFC output signal remains unstable for five minutes, or the voltage level changes to $+115\%$ of original value.

13.19 Return the power supply level to the original reference value, repeat Section 13.5, and go to Section 13.18.

13.20 Open the inlet and outlet shut-off valves that are adjacent to the MFC and adjust the MFC setpoint to

100%. Repeat the procedure described in Section 12.16, but decrease the positive supply voltage in 1% decrements until either the flow signal changes by $\pm 3\%$ of full scale, the MFC output signal remains unstable for five minutes, or 85% of the original value is reached.

13.21 Return the power supply level to the original reference value, repeat Section 13.5, and go to Section 13.20.

13.22 Repeat Sections 13.15 through 13.19, with the following exception: Vary the negative DC supply voltage level while holding the positive power supply at its reference value and go to Section 13.21.

13.23 Repeat Section 13.15 and then go to Section 13.22.

13.24 Vary both DC power supply voltages together in +1% steps from the reference value.

NOTE 3: If the reference voltages are ± 15 V (30 V span), then the first step is a change in voltage of ± 0.15 V increasing the span to ± 15.15 V.

13.25 After the monitored signals become stable, record the MFC flow and flow standard values, the current value, and the power supply voltage magnitudes. Record three measurements at each step-change of power level on the data sheet. Continue to increase the supply voltage span until either the flow changes by $\pm 3\%$ of full scale flow, the MFC zero output point remains unstable for five minutes, or the power level has been changed to $+110\%$ of span (± 16.5 V).

13.26 Return the power supply level to the original reference value, repeat Section 13.5, and go to Section 13.24.

13.27 Open the inlet and outlet shut-off valves that are adjacent to the MFC and adjust the MFC setpoint to 100%. Repeat the procedure described in Section 13.22, with the following exception: Decrease the supply voltages together in 1% decrements until either the flow signal changes by $\pm 3\%$ of full scale, the MFC output signal remains unstable for five minutes, or until the supply voltage span has changed $\pm 15\%$ (± 12.75 V). Then go to Section 13.25.

13.28 Return the power supply level to the original reference value, repeat Section 13.5, and go to Section 14.

14 Calculations or Interpretation of Results

14.1 Convert the MFC indicated flow output data and the flow standard output data to percent of full scale flow as follows: