

SEMI E17-1011

GUIDE FOR MASS FLOW CONTROLLER TRANSIENT CHARACTERISTICS TESTS

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1 Purpose

1.1 The purpose of this Guide is to provide mass flow controller (MFC) transient characteristics tests.

2 Scope

2.1 This Guide is intended to establish a common basis for communication between users and suppliers of semiconductor equipment. It provides terminology and methodology aimed at eliminating confusion regarding what previously has been referred to as MFC 'response time.' The conditions and procedures are given for determining and expressing the transient characteristics of a MFC to a step change in set point. This Guide applies to mass flow controllers for gases used in semiconductor fabrication equipment.

NOTICE: SEMI Standards and Safety Guidelines do not purport to address all safety issues associated with their use. It is the responsibility of the users of the Documents to establish appropriate safety and health practices, and determine the applicability of regulatory or other limitations prior to use.

3 Referenced Standards and Documents

3.1 None.

4 Terminology

4.1 *Definitions* (see Figures 1 and 2)

4.1.1 *actual flow* — for the purpose of this Standard, the output value of the master reference standard.

4.1.2 *dead time* — the interval of time between the set point step change and the start of the resulting observable response.

4.1.3 *final steady state value* — the average value of the actual flow, after the effects of the input transient have expired to a value equal to or below the intrinsic drift and noise.

4.1.4 *settling time* — the time between the set point step change and when the actual flow remains within the specified band.

4.1.5 *step response time* — the time between the setpoint step change and when the actual flow first enters the specified band.

4.1.6 *transient overshoot* — the maximum change in actual flow minus the steady state change in actual flow, expressed as a percentage of the set point step change.

4.1.7 *transient undershoot* — the maximum amount that the actual flow passes the final steady state value, in the opposite direction of overshoot, expressed as a percentage of the set point step change.

4.1.8 *set point* — the electrical input signal to the MFC which sets the desired value of the controlled flow.

4.1.9 *specified band* — the region between $\pm 2\%$ of the final steady state value or $\pm 0.5\%$ of full scale, whichever is greater.

5 Test Setup

5.1 The purpose of the flow system is to furnish the MFC under test with a constant pressure supply of suitable gas. It must also provide a means of determining the gas flow rate through the MFC that responds to changes in gas flow

significantly faster than the device under test. The recommended flow system for testing the speed of response of MFCs is shown in Figure 3.

5.2 The flow system shall have straight tubing or pipe connecting the MFC to the master reference standard. The inside diameter of the interconnecting tubing or pipe shall be of sufficient size to preclude any pressure drop that would effect the performance of the MFC.

5.3 The pneumatic time constant, τ , should be minimized (see ¶ 5.7).

$$\tau = V \times \Delta P_m / (Q_m \times P_a) \quad (1)$$

where:

V = Internal volume of the flow system between the MFC under test and the master reference standard, including tubing, fittings and the side of the master reference standard that is connected to the MFC under test.

Q_m = Maximum volumetric flow expected during the test.

ΔP_m = Pressure drop of the master reference standard at flow Q_m .

P_a = The absolute pressure present at the outlet of the master reference standard at final steady state value.

5.4 The source of the test gas shall be capable of delivering an essentially constant upstream pressure to the MFC under test during the transient characterization. A maximum variation of $\pm 2\%$ from the median absolute pressure is considered adequate for most MFCs.

5.5 Nitrogen is the recommended gas for the standard test shown in Figure 3. The inlet pressure is 273 kPa (25 psig). Outlet pressure is the prevailing atmospheric pressure. The temperature of the gas entering the flow controller and the temperature surrounding the flow controller shall be the same. Neither shall vary during the test so as to have a significant effect.

5.5.1 The preceding conditions are recommendations. Deviations may be made to more accurately reproduce the conditions that the MFC will experience in use, such as the variation shown in Figure 4. Any deviation from the above gas and pressure conditions and/or test setup must be noted with the test results.

5.6 The master reference standard is used to provide a representation of the instantaneous actual flow. It is customary to refer to the output of the master reference standard as the actual flow. It shall have an accuracy of $\pm 5\%$ of reading (including linearity), or better, over the flow range for which results will be reported. The pressure drop across the master reference standard at the test flow shall be small enough to not affect the response of the MFC under test.

5.6.1 Typical master reference standards are hot-wire flow meters (or similar immersible thermal flow sensors), laminar flow elements with a differential pressure transducer, and Rate of Rise (RoR) systems.

5.7 The measuring system response time is the sum of the pneumatic time constant, master reference response time and the recording system response time. The measuring system response time shall be less than 1/5 of any reported transient characteristic. If the measuring system response time is greater than 1/5 of a specific transient characteristic, that characteristic may be reported if the measuring system response time is also reported.

5.8 The test setup shall provide a step change in the setpoint to the mass flow controller, along with a time-zero cue to the data acquisition system. The step change transient time shall be less than 1% of the step response time of the MFC under test.

5.9 The test setup is recommended for MFC full scale flow rates above 10 sccm. In those cases where the flow rate is below 10 sccm and the pneumatic time constant is not less than 1/5 of the step response time of the MFC the pneumatic time constant shall be reported.

5.10 The MFC shall be electrically energized for the supplier recommended 'warm up' time prior to the start of the test.