

SEMI E17-0318

TEST METHOD FOR MEASUREMENT OF MASS FLOW CONTROLLER TRANSIENT CHARACTERISTICS

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NOTICE: The section symbol (§) is used to reference a numbered section, paragraph, or header and all subordinate paragraphs, headers, and embedded material (i.e., EXCEPTIONs, lists) therein. The paragraph symbol (§) is used to reference a particular numbered paragraph and embedded material therein. When duplicated (i.e., §§ and §§) the symbols are used to reference more than one section or paragraph, respectively.

1 Purpose

1.1 The purpose of this Standard is to provide a test method for measurement of mass flow controller (MFC) transient characteristics.

2 Scope

2.1 This Standard 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 Standard 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 Limitations

3.1 This Test Method does not address any operational influences outside of the manufacturer's published limitations.

4 Referenced Standards and Documents

4.1 None.

5 Terminology

5.1 Definitions

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

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

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

5.1.4 *set point* — the input signal provided to achieve a desired flow, reported as sccm, slm, or percent-full scale.

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

5.1.6 *step response time* — the time between the set point step change and when the actual flow enters the specified band for the first time.

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

5.1.8 *transient overshoot* — the maximum deviation from the actual flow to the set point, expressed as a percentage of the set point.

5.1.9 *transient undershoot* — the maximum deviation from the actual flow to the set point in the opposite direction of overshoot, expressed as a percentage of the set point.

6 Summary of Test Method

6.1 Transient characteristic from an OFF position to a final set point is evaluated (refer to § 8.2).

6.2 Transient characteristics between two non-zero controlled set points is evaluated (refer to § 8.3).

6.3 Parameters such as dead time, step response time, settling time, overshoot and undershoot are recorded.

7 Test Setup

7.1 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.

7.2 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 affect the performance of the MFC.

7.3 The pneumatic time constant, τ , should be minimized (refer to ¶ 7.7).

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

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 , and

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

7.4 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.

7.5 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.

7.5.1 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.

7.6 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.

7.6.1 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 (example shown in Figure 5).

7.7 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