

# SEMI E16-90 (Reapproved 0699) GUIDELINE FOR DETERMINING AND DESCRIBING MASS FLOW CONTROLLER LEAK RATES

This Guideline 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 December 18, 1998. Initially available at [www.semi.org](http://www.semi.org) February 1999; to be published June 1999. Originally published in 1990.

Editorial changes were made to Sections 4.2.2, 4.3.1, and 4.3.2.

## 1 Purpose

1.1 The purpose of this guideline is to establish a uniform, worldwide means for describing and measuring leak rates of mass flow controllers. The leak integrity of a gas delivery system is important to maintaining product quality and performance. This guideline is intended to prevent confusion and misunderstanding between manufacturers and users. In particular, it distinguishes between mechanical and diffusion leak rates.

## 2 Scope

2.1 This guideline contains definitions of terms and procedures for determining the Leak Rates of mass flow controllers as used in the semiconductor industry.

## 3 Definitions

3.1 *Leak* — A path or paths in a sealed system which will pass helium when a partial pressure differential exists. A partial pressure differential can exist for helium even though a total gas pressure differential may not exist. There are two major leak mechanisms, a mechanical passage or a material through which gas can diffuse or permeate. In a real system, a leak may have both mechanisms operating in parallel.

3.1.1 A mechanical leak may be a physical crack, pit, scratch or other imperfection in a sealing surface, or contamination or debris on the seals. A diffusion or permeation leak is caused by the movement of helium through gaskets, O-rings, polymers, or other materials through which helium can diffuse.

3.2 *Standard Leak Rate* — The quantity of helium at 25°C and 101.3 kPa (760 Torr) flowing through a leak when the high pressure side is at 101.32 kPa and the low pressure side is below 100 Pa (approximately 1 Torr). Standard Leak Rate shall be expressed in the following units:

Pa-m<sup>3</sup>/s (He) = "Pascal cubic meters per second, helium"

or, alternatively,

atm-cc/s (He) = "atmospheric cubic centimeters per second, helium"

NOTE 1: The Pascal (1Pa = 1 N/m<sup>2</sup>) is defined as the pressure unit of the international unit system SI. Therefore, the SI units above are preferred. Atm-cc/s is acceptable, as it is widely used in the semiconductor industry.

3.2.1 The "mass spectrometer helium leak detector" is generally used for leak rate testing of high and medium level vacuum apparatus. Units of sccs, Torr-L/s, and m bar-L/s, have been used in the past but are not encouraged. Reference materials include MIL STD-202E, C-1.

3.3 *Measured Leak Rate* — The leak rate of a given system measured under specified conditions and employing a specified test gas (helium). For the purposes of comparison with rates determined by other methods of testing, measured leak rates must be converted to equivalent standard leak rates.

3.4 *Sensitivity (Minimum Detectable Leak Rate)* — The smallest standard leak rate that an instrument, method or system is capable of measuring under specified conditions.

3.5 For the purposes of this document, the Measured Leak Rate shall be corrected to Standard Leak Rate by multiplying by the ratio of 101.32 kPa to the absolute value of the pressurizing helium unless otherwise called for by the MFC specifications.

$$\frac{\text{Measure Leak Rate} \times 101.32 \text{ kPa}}{\text{He Actual Pressure}} = \text{Standard Leak Rate}$$

## 4 Testing

### 4.1 General Requirements

4.1.1 *Leak Detector* — The leak detector shall be of the helium mass spectrometer type. It shall have a sensitivity at least equal to or smaller than the specified leak rating of the mass flow controller to be tested. If the actual leak rate is to be reported, the sensitivity shall be five times smaller than the leak to be measured. If the sensitivity is not five times smaller, the actual leak

rate may be reported if the sensitivity of the detector is also reported.

4.1.2 Helium must have access to all primary seals.

4.1.3 Connections between the MFC and the leak detector must be leak-tight.

4.1.4 The ambient temperature of the MFC should be  $25^{\circ} \pm 5^{\circ}\text{C}$  unless otherwise specified. If another test temperature is used, it must be recorded during the test.

4.2 *Test Procedures* — There are two basic setups which may be used to measure the leak rate from the external environment to the internal gas passages of the MFC or from the internal passages to the external environment. Results for either test method may be reported. The method used must be reported as well. A third test, the through-the-valve setup, is intended to measure the quality of the valve seat shutoff.

4.2.1 *Internally-Pressurized Leak Test* — The purpose of this test set-up is to simulate operation of the MFC under conditions where the internal pressure is above ambient. The recommended internal pressure is 300 kPa absolute (30 psig) of helium. (See Figure 1.)

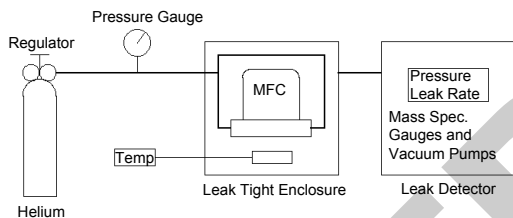


**Figure 1**

### Internally-Pressurized Leak Test

4.2.2 *Externally-Pressurized Leak Test* — The purpose of this test is to simulate operation of the MFC under conditions where the internal pressure is at vacuum. The external pressure should be equal to atmospheric pressure. The internal pressure should be less than 100 kPa. (See Figure 2.)

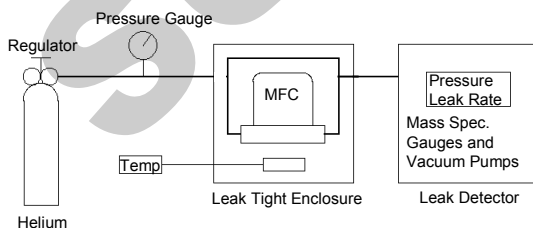


**Figure 2**

### Externally-Pressurized Leak Test

4.2.3 *Control Valve Seat Leak Test* — The purpose of this test is to determine the leakage through the control

valve under simulated operation in the closed control mode. The MFC should be electrically energized for normal operation and placed in the closed position as specified for the operation of the MFC. The input pressure to the MFC should be  $100 \text{ kPa} \pm 20\%$ . The outlet should be connected directly to the helium leak detector, and pressure should be as low as possible using good leak detector practice. (See Figure 3)

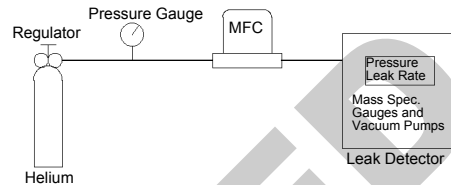


**Figure 3**

### Control Valve Seat Leak Test

4.2.3.1 In the case of MFCs which are not designed for positive shutoff at the control valve, alternative methods may be employed if documented and reported.

4.3 *Reporting Results* — The example shown in Figure 4 is a plot of leak detector output value vs. time for a representative elastomer-sealed MFC. This curve is the sum of mechanical and permeation leak components.

NOTE 2: All times are from application of helium, starting with a leak detection system pumped down to base reading.

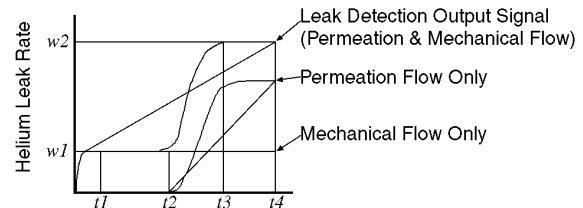


**Figure 4**

### Leak Detector Output Value vs. Time

| Interval                             | Rate | Example                |
|--------------------------------------|------|------------------------|
| t1 Initial System Response           |      | Less than 10 seconds   |
| t2 Leak Prior to Onset of Permeation | w1   | 10 seconds to 1 minute |
| t3 Increasing Permeation             |      | 1 minute to 30 minutes |
| t4 Total Saturation                  | w2   | Beyond 30 minutes      |

4.3.1 The actual shape of these curves and time intervals is dependent on the design of the MFC under test, the elastomer used, if any, and the characteristics