

SEMI F113-1116

TEST METHOD FOR PRESSURE TRANSDUCERS USED IN GAS DELIVERY SYSTEMS

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1 Purpose

1.1 The purpose of this Document is to outline the test method for electronic pressure transducers used in gas delivery systems for semiconductor processing.

2 Scope

2.1 This Document describes the procedures for testing the leak integrity, warm up time, voltage sensitivity, inaccuracy, linearity, repeatability, hysteresis, reproducibility, thermal coefficient, drift, accelerated life cycle, and proof pressure of pressure transducers with a full pressure range of 2757.9 KPa (400 psia) or less in gas delivery systems.

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 Document does not cover the testing of absolute pressure measurement instruments, pressure switches or mechanical pressure gauges, such as Bourdon tube pressure gauges.

4 Referenced Standards and Documents

4.1 SEMI Standards and Safety Guidelines

SEMI C59 — Specifications and Guidelines for Nitrogen

SEMI E27 — Guide for Mass Flow Controller and Mass Flow Meter Linearity

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

SEMI E49 — Guide for High Purity and Ultrahigh Purity Piping Performance, Subassemblies, and Final Assemblies

SEMI E56 — Test Method for Determining Accuracy, Linearity, Repeatability, Short-Term Reproducibility, Hysteresis, and Dead Band of Thermal Mass Flow Controllers

SEMI E89 — Guide for Measurement System Analysis (MSA)

SEMI F1 — Specification for Leak Integrity of High-Purity Gas Piping Systems and Components

SEMI F62 — Test Method for Determining Mass Flow Controller Performance Characteristics from Ambient and Gas Temperature Effects

4.2 ANSI Standard¹

ANSI/ISA-S51.1-1979 (R1993) — Process Instrumentation Terminology

¹ American National Standards Institute, 25 West 43rd Street, New York, NY 10036, USA; Telephone: +1.212.642.4900, Fax: +1.212.398.0023, <http://www.ansi.org>

4.3 IEC Standards²

IEC 61298-2 — Process Measurement and Control Devices – General Methods and Procedures for Evaluating Performance – Part 2: Tests Under Reference Conditions

IEC 61298-3 — Process Measurement and Control Devices – General Methods and Procedures for Evaluating Performance – Part 3: Tests for the Effects of Influence Quantities

NOTICE: Unless otherwise indicated, all documents cited shall be the latest published versions.

5 Terminology

5.1 Abbreviations and Acronyms

5.1.1 *BFSL* — best-fit straight line

5.1.2 *DUT* — device under test

5.1.3 *FS* — full scale

5.2 Definitions

5.2.1 *absolute pressure* — the pressure measured relative to zero pressure (perfect vacuum). [SEMI E28]

5.2.2 *accelerated life cycle test* — the process by which the device under test (DUT) is subjected to cycles between its minimum and maximum rated full scale range.

5.2.3 *best-fit straight line (BFSL)* — the line positioned by minimizing the sum of the squares of the differences between the measurement values and the ideal values.

5.2.4 *drift* — the change in output over a specified time period for a constant pressure input under specified reference operating conditions. [SEMI E56]

5.2.5 *gauge pressure* — the pressure measured relative to ambient pressure. For example, when the pressure within a system equals the prevailing ambient pressure, the gauge pressure equals zero.

5.2.6 *hysteresis* — the difference between the output readings of a pressure transducer when the same pressure is applied consecutively, under the same conditions but coming from opposite (ascending and descending) directions. [SEMI E56]

5.2.7 *inaccuracy* — the greatest deviation (absolute value) of any measured value from the ideal value for increasing and decreasing inputs for any test cycle separately, and reported in percent of output span or in percent of reading. [IEC 61298-2]

NOTE 1: When testing devices for inaccuracy, best results will be achieved when using a test device traceable to a national standards lab, such as National Institute of Standard Technologies (NIST). The device shall have a relative inaccuracy of at least 4 to 1 with respect to the DUT.

5.2.8 *input voltage sensitivity* — the change in output value across the range of the input voltage.

5.2.9 *leak integrity* — the leak measured between the wetted surface volume and the ambient environment surrounding the device. [SEMI F1]

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. [SEMI E27, SEMI E56]

5.2.11 *operating range* — the range of operating conditions within which a device is designed to operate and for which operating conditions are stated. [ANSI/ISA S51.1, SEMI E56]

5.2.12 *operating temperature range* — The range of ambient temperatures, given by their extremes, within which the transducer is intended to operate; within this range of ambient temperature all tolerances specified for temperature error, temperature error band, temperature gradient error, thermal zero shift and thermal sensitivity shift are applicable.

² International Electrotechnical Commission, 3 rue de Varembe, Case Postale 131, CH-1211 Geneva 20, Switzerland; Telephone: +41.22.919.02.11, Fax: +41.22.919.03.00, <http://www.iec.ch>

5.2.13 *pressure standard* — a device used to measure the actual test gas pressure through the device under test (DUT).

5.2.14 *proof pressure* — the maximum pressure the device could be subjected to without any permanent damage.

5.2.15 *repeatability* — the closeness of agreement among a number of measured values at the same pressure setpoint, under the same operating conditions, operator, apparatus, laboratory and short intervals of time. It is usually measured as a non-repeatability and expressed as repeatability in percent of full scale. [SEMI E56]

NOTE 2: Repeatability specifically refers to the repeatability of an individual transducer, not the repeatability of a group of transducers.

5.2.16 *reproducibility* — the closeness of agreement among output readings of the different devices when the same pressure setpoints are applied to them consecutively under the same operating conditions, operator, apparatus, laboratory, during the same test time frame, and approaching from both pressure directions (ascending and descending).

5.2.17 *span* — the algebraic difference between the upper and lower range values. [SEMI E27]

5.2.18 *uncertainty_{RSS}* — It is a parameter that is associated with a measurement and characterizes the dispersion of values that can be reasonably attributed to the object being measured. In this case, it is a calculated value that includes repeatability, linearity, and hysteresis. It is traditionally quantified by the root sum square (RSS) of repeatability, linearity and hysteresis and expressed in percent of full scale. [SEMI E89]

NOTE 3: This is as same as the term ‘accuracy_{RSS}’ which has been widely used by most pressure transducer manufacturers. Accuracy_{RSS} is a misleading term and its use should be discontinued.

5.2.19 *warm up time* — a period of time that it takes for the device to produce stable output from the time the input power is first applied after the device has been un-powered for a minimum time period of 24 hours.

5.2.20 *zero adjustment* — a process of adjusting the output of the device under test (DUT) to zero per the manufacturer’s instructions.

5.3 Symbols

5.3.1 T_e — the temperature of the environmental chamber.

5.3.2 TC_{zero} — the thermal coefficient at zero.

5.3.3 TC_{span} — the thermal coefficient across the span range.

5.3.4 T_{min} — minimum operating temperature specified by the DUT manufacturer.

5.3.5 T_{max} — maximum operating temperature specified by the DUT manufacturer.

5.3.6 V_{min} — minimum voltage supply specified by the DUT manufacturer.

5.3.7 V_{max} — maximum voltage supply specified by the DUT manufacturer.

6 Apparatus

6.1 *Pressure Reference Standard Device* — A pressure measurement device that shall have a relative inaccuracy of at least 4 to 1 with respect to the device under test (DUT).

6.2 *Environmental Chamber* — Capable of stable temperature control ($\pm 1^\circ\text{C}$) from at least the minimum rated pressure transducer temperature (T_{min}) to the maximum rated pressure transducer temperature (T_{max}) plus 10°C .

6.3 *Leak Detector*

6.4 *Power Supply*

6.5 *Tubing* — Cleaned and maintained to have no adverse effect on the test.

6.6 *Valves* — Capable of unimpaired operation at T_{max} and two times of the maximum operating pressure.

7 Reagents and Materials

7.1 *Test Gas* — 99.9995% nitrogen (Grade 5.5) per SEMI C59.

8 Safety Precautions

8.1 All manufacturers' recommendations shall be followed and noted when testing the unit. Any safety precautions shall be followed.

9 Technical Precautions

9.1 The manufacturer's specification and instructions for installation and operation must be applied during all testing.

9.2 The mounting position of the device must be in accordance with the manufacturer's specifications. No external mechanical constraints beyond the manufacturer's recommended mounting position shall be used.

10 Calibration and Standardization

10.1 The pressure standard used is to be traceable to a recognized national standards lab, such as the US National Institute of Standards and Technology (NIST).

10.2 All measurement devices shall be calibrated and maintained to the manufacturer's recommendations. Current calibration records shall be maintained.

11 Sampling

11.1 Randomly selected devices shall be sampled in accordance with SEMI E49.

12 Summary of Test Method

12.1 *Leak Integrity* — This test measures the allowable leak rate per SEMI F1. The device shall be measured following each test for performance and endurance.

12.2 *Warm Up Time* — Warm up time is the period that a device takes from its initial power-on or after the device has been turned off for an extended time to read accurately.

12.3 *Input Voltage Sensitivity* — The voltage shall be varied across the specified range of voltages for the DUT while all other major parameters remain constant.

12.4 *Inaccuracy* — This test shall determine the deviation between a measured value and the expected value of a device. The maximum deviation among all the setpoints will be recorded as the inaccuracy of the device.

12.4.1 *Hysteresis* — Hysteresis shall be obtained by subtracting the ascending signal value from corresponding descending signal value. The highest value among all the tested setpoints will be reported as the hysteresis of the device.

12.4.2 *Linearity* — The linearity of the device shall be determined to be the maximum difference between the observed value and the best-fit straight line (BFSL).

12.4.3 *Repeatability* — This test determines the repeatability of an individual device at identical pressures in a number of consecutive cycles. The device will be pressurized at least three consecutive cycles in both of ascending and descending directions.

12.5 *Reproducibility* — This test shall determine the reproducibility of different devices for the identical pressures. A minimum of four devices shall be tested at the same time.

12.6 *Thermal Coefficient* — This test shall measure the output changes of the device in response to changes in ambient temperature.

12.7 *Accelerated Life Cycle* — The device shall be capable of withstanding repeated full scale cycling. The device shall meet its accuracy and leak integrity specifications during and at the end of the life cycle process.

12.8 *Proof Pressure* — Proof pressure test will determine maximum pressure that can be applied to a device under test while ensuring that the performance of the device is not permanently affected.

13 Test Procedure

13.1 Preparation

13.1.1 Record ambient temperature, pressure units and gas type used for the test.