

SEMI C58-0305 (Reapproved 0211) SPECIFICATIONS AND GUIDELINES FOR HYDROGEN

This Standard was technically approved by the global Gases Committee. This edition was approved for publication by the global Audits & Reviews Subcommittee on December 21, 2010. Available at www.semiviews.org and www.semi.org in February 2011; originally published March 2005.

NOTICE: This document was reapproved with minor editorial changes.

1 Purpose

1.1 The purpose of this document is to provide a series of specifications for different grades of hydrogen (H₂) that are used in the semiconductor industry.

2 Scope

2.1 This document covers requirements for all grades of hydrogen used in the semiconductor industry.

2.2 If analytical methods are not complete, the requirements are presented as a guideline.

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 Description

3.1 Hydrogen is a colorless gas. Its vapors are highly flammable, colorless, tasteless, and nontoxic. It is the lightest gas known.

4 Limitations

4.1 None.

5 Referenced Standards and Documents

5.1 *SEMI Standards*

SEMI C1 — Guide for the Analysis of Liquid Chemicals

SEMI C3 — Specifications for Gases

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

6 Terminology

6.1 Terminology appropriate to this standard is defined in SEMI C3.

7 Requirements

7.1 Purity and other requirements for the various grades of hydrogen are given in Table 1.

Table 1 Impurity and Other Requirements for Various Grades of Hydrogen

<i>Previous SEMI Reference #</i>	<i>C3.19-0200 (Specification)</i>	<i>C3.30-0999 (Specification)</i>
Grade	5.5	5.7
Purity	99.9995%	99.9997% ^{#1}
Impurities	Maximum Acceptable Level (ppm) ^{#2}	
Carbon Dioxide (CO ₂)	0.5	0.2
Carbon Monoxide (CO)	0.5	0.2
Nitrogen (N ₂)	2	2

<i>Previous SEMI Reference #</i>	<i>C3.19-0200 (Specification)</i>	<i>C3.30-0999 (Specification)</i>
Oxygen (O ₂)	0.5	0.2
Total Hydrocarbons expressed as Methane (THC)	0.5	0.2
Water (H ₂ O) (v/v)	0.5	0.2
TOTAL SPECIFIED IMPURITIES	4.5	2.8
Particles	#3	#3

#1 A purifier is allowed to be used to meet this specification.

#2 An analysis of significant figures has not been considered. The number of significant figures is based on analytical accuracy and the precision of the provided procedure.

#3 To be determined between supplier and user.

8 Physical Constants

8.1 The physical constants of hydrogen are given in Table 2 (for information only).

Table 2 Physical Constants of Hydrogen (for information only)

	<i>Metric Units</i>	<i>US Units</i>
Molecular weight	2.016	2.016
CAS Number	1333-74-0	1333-74-0
Boiling point at 1 atm	−252.7°C	−423.0°F
Density of gas at 21.1°C (70°F) and 1 atm	0.0834401 kg/m ³	0.005209 lb/ft ³
Specific gravity of gas at 21.1°C and 1 atm (air = 1)	0.06950	0.06950
Density of liquid at boiling point	68.6 kg/m ³	4.28 lb/ft ³

9 Analytical Procedures for Grade 5.5 Hydrogen

NOTE 1: Introduce the calibration standard as many times as necessary to achieve the desired precision.

NOTE 2: All gases used in the analysis of the sample should contain no more than 10% of the sample value of the component of interest unless otherwise specified.

9.1 *Carbon Monoxide and Carbon Dioxide* — This procedure is for the determination of carbon monoxide and carbon dioxide in hydrogen using a gas chromatograph with a flame ionization detector and methanizer.

9.1.1 *Detection Limit* — 100 ppb (mol/mol).

9.1.2 *Instrument Parameters*

9.1.2.1 *Column* — Porapak® T or Q, 3 m (9.8 ft.) by 3 mm (1/8 in.) ID by 2.2 mm (0.085 in.) OD stainless steel; or Chromosorb® 102, 2 m (6.6 ft.) by 3 mm (1/8 in.) stainless steel; or equivalent

9.1.2.2 *Carrier Flow* — 30 mL/min helium.

9.1.2.3 *Sample Volume* — 0.5 to 2.0 mL.

9.1.2.4 *Temperatures*

- *Detector* — 280°C
- *Column Oven* — 60°C
- *Methanizer* — 350°C

9.1.3 *Calibration Standards* — 0.5 to 2.5 ppm (mol/mol) carbon monoxide, 0.5 to 2.5 ppm (mol/mol) carbon dioxide, balance hydrogen.

9.1.4 *Operating Procedure*

9.1.4.1 Inject the calibration standard into the column using a gas sampling valve. Record the retention times and peak areas. The order of elution is carbon monoxide, carbon dioxide.

9.1.4.2 Inject the sample to be tested in same manner as the calibration standard. Record the retention times and peak areas.

9.1.4.3 Repeat ¶ 9.1.4.1.

9.1.4.4 Compare the average peak areas of the calibration standard to that of the hydrogen sample being tested. Calculate the concentrations of carbon monoxide and carbon dioxide, using the formula below.

$$\frac{\text{Sample Peak Area}}{\text{Standard Peak Area}} \times \text{Concentration of Standard} = \text{Concentration of Sample} \quad (1)$$

9.1.4.5 The result may not exceed the specification in Table 1.

9.2 *Nitrogen* — This procedure is for the determination of nitrogen in hydrogen using a gas chromatograph with a helium ionization detector.

9.2.1 *Detection Limit* — 500 ppb (mol/mol).

9.2.2 *Instrument Parameters*

9.2.2.1 *Column* — 5A Molecular Sieve 1.9 m (6 ft.) by 3.2 mm (1/8 in.) OD by 2.2 mm (0.085 in.) ID by stainless steel or equivalent.

9.2.2.2 *Carrier Flow* — 30 mL/min helium.

9.2.2.3 *Sample Volume* — 3.0 mL.

9.2.2.4 *Temperatures*

- *Detector* — 125°C
- *Column Temperature* — 65°C

9.2.3 *Calibration Standard* — 0.5 to 2.5 ppm, (mol/mol) nitrogen in hydrogen.

9.2.4 *Operating Procedure*

9.2.4.1 Inject the calibration standard into the column using a gas sampling valve. Record the retention times and peak areas.

9.2.4.2 Inject the sample to be tested in same manner as the calibration standard. Record the retention times and peak areas.

9.2.4.3 Repeat ¶ 9.2.4.1.

9.2.4.4 Compare the average peak area of the calibration standard to that of the hydrogen sample being tested. Calculate the concentration of nitrogen, using the formula below.

$$\frac{\text{Sample Peak Area}}{\text{Standard Peak Area}} \times \text{Concentration of Standard} = \text{Concentration of Sample} \quad (2)$$

9.2.4.5 The result may not exceed the specification in Table 1.

9.3 *Oxygen* — This procedure is for the determination of oxygen in hydrogen using a continuous flow analyzer using an electrochemical method.

9.3.1 *Detection Limit* — 100 ppb (mol/mol).

9.3.2 *Flow Rate* — Set sample flow rates in accordance with the instrument manufacturer's instructions.