SEMI C3-0317
SPECIFICATION FOR GASES

This Standard was technically approved by the Gases Global Technical Committee. This edition was approved for publication by the global Audits and Reviews Subcommittee on February 2, 2017. Available at www.semiviews.org and www.semi.org in March 2017; originally published in 1981; previously published April 2013.

1 Purpose

1.1 Recognizing the importance of impurity content of gases in the manufacture of semiconductors, suppliers responded by introducing products with improved analytical characterization, notably for trace impurities.

1.2 The SEMI Gases Committee began its efforts in the spring of 1979. With this publication, the committee establishes the definitions, general procedures, specifications, and analytical procedures for the gases listed in the index.

1.3 Products which meet all of the requirements may be described as 'meeting SEMI Specifications.'

1.4 Where an analytical procedure different from that provided is substituted by a supplier or user, the burden of proof is on said supplier or user to confirm the equivalency. It should be noted that the following list of criteria was considered when determining the specified analytical method.

- Reliability
- Ease of Use
- Maintenance
- Precision
- Accuracy
- Sensitivity
- Versatility
- Availability of Equipment

2 Scope

2.1 The specifications provided by this Standard are intended to serve for gases to be used in the manufacture and processing of semiconductors and advanced electronic devices and circuits. The specifications and the associated test procedures are guidelines based on the experience of suppliers and users. The function of the specifications is to establish desired standards of quality.

2.2 Where feasible, a specification of content shall be expressed as a numerical limit in units of mole per mole (mole/mole).

2.3 For a major component, the value (assay or purity) shall be expressed as a minimum permissible limit. For an impurity, the value shall be expressed as a maximum permissible limit.

2.4 A gas conforming to the specifications will commonly contain more of the major component than the minimum permissible limit or contain less of an impurity (or several impurities) than the SEMI C3 maximum permissible limit. In neither case shall the gas be considered as of higher quality than that defined by the specification.

2.5 It is not practical to consider every impurity or contaminant that might be present. For certain applications, it is recognized that more stringent or additional specifications and procedures might be required. The intent of these specifications and the associated procedures is, on one hand, to assure that a gas is suitable for the common uses to which it may be put in the manufacture and processing of semiconductor devices and, on the other hand, to be consistent with contemporary manufacturing processes for that gas.

2.6 The committee is continuing work on improvement of specifications and procedures, and addition of other gases and systems such as mixed gases. The committee welcomes comments, suggestions, and recommendations.

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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 *United States Military (MIL) Standard*[1]

MIL-S-27626F — Sampler, Cryogenic Liquid

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

4 Terminology

4.1 *Abbreviations and Acronyms* — In this Standard, abbreviations used shall be restricted to those listed as follows.

4.1.1 *ASTM* — ASTM International

4.1.2 *atm* — atmosphere

4.1.3 *BP* — boiling point

4.1.4 *CGA* — Compressed Gas Association

4.1.5 *DOT* — Department of Transportation (U.S.)

4.1.6 *max* — maximum

4.1.7 *min* — minimum

4.1.8 *MP* — melting point

4.1.9 *SCF* — standard cubic foot (feet)

4.1.10 *temp.* — temperature

4.1.11 *vol* — volume

4.1.12 *vol/vol* — volume/volume

4.1.13 *wt.* — weight

4.1.14 *w/v* — weight/volume

4.1.15 *w/w* — weight/weight

4.2 *Definitions*

4.2.1 *accuracy* — closeness of agreement between a test result or a mean group of test results and the true value (accepted reference value).

4.2.2 *assay* — determination of the content of a specific component with no evaluation of other components.

4.2.3 *comparison of analytical results with specific limits* — in the comparison of an analytical result for a test with the numerical limit associated with that specification, the result shall be rounded to the number of significant figures indicated for that limit. (See Rounding Numbers, § 4.2.21.)

4.2.3.1 Consequently, a specification stated as 96% minimum will be met by a result as small as 95.5%, and that stated as 96.0% minimum will be met by a result as small as 95.95%. A specification of 0.1% maximum will be met as large as 0.14%, and that of 0.10% maximum by a result as large as 0.104%.

4.2.4 *cryogenic liquid* — liquid with a normal boiling point below −150°C.

4.2.5 *cylinder pressure* — pressure contained in a gas cylinder prior to regulation.

[1] United States Military Standards, Available through the Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120-5099, USA; Telephone: +1.215.697.3321.

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4.2.6 *cylinder tare weight* — containers which are stamped to denote the weight of the container or the weight of the container and the valve less the product. The weight does not include the weight of any protective cylinder cap.

4.2.7 *density* — weight per unit volume (w/v) is expressed as grams per liter for gases at zero degrees Celsius, one atmosphere.

4.2.8 *detection limit* —the detection limit for all the analytical methods that appear in this section of the Document must be established for each impurity defined. The detection limit must be stated as well as the statistical method used to establish that detection limit. The analytical method should be chosen such that the detection limit is at or below the specification.

4.2.9 *dewpoint* — the temperature at which liquid first condenses when vapor is cooled.

4.2.10 *expression of content and concentration* — unless otherwise stated, a specification limit and the analytical result related to it shall be expressed in units of mole per mole (mole/mole).

4.2.11 *Gas Purity Guideline* — a Gas Purity Guideline is a proposed specification recommended by one or more users as needed in the future for the production of semiconductor devices. They reflect future needs in which test methods are not generally available at the time of proposal. These guidelines are approved by the Gases Committee for publication. Products meeting these guidelines are not necessarily commercially available.

4.2.12 *liquefied compressed gas* — a gas which under the charged pressure is partially liquid at a temperature of 21.1°C (70°F).

4.2.13 *metals* — elements that are shiny, highly conducting solids that form alloys with one another and salt-like ionic compounds with non-metals (other than noble gases).

4.2.14 *molecular weight* — the sum of the atomic weights of all the atoms in the molecule.

4.2.15 *non-liquefied compressed gas* — a gas, other than a gas in solution, which under the charging pressure is entirely gaseous at a temperature of 21.1°C (70°F).

4.2.16 *physical properties* — physical properties shall not usually be employed for specification purposes; for information, however, representative values for a particular gas, as supplied, may be included as an item in the monograph for that gas.

4.2.17 *quality* — the quality is determined by subtracting the sum of the maximum acceptable gas phase impurity levels, expressed in percent, from 100. The result is truncated after the first significant figure which is not a nine. The quality does not represent an assay.

4.2.18 *rare gas* — any of the six gases, all noble, comprising the extreme right-hand group of the Periodic Table; namely helium, neon, argon, krypton, xenon, and radon.

4.2.19 *rounding numbers* — the following rules for rounding of measured or calculated values shall be employed:

4.2.19.1 When the figure next beyond the last place to be retained is less than 5, leave unchanged the figure in the last place retained.

4.2.19.2 When the figure next beyond the last place to be retained is greater than 5, increase by 1 the figure in the last place retained.

4.2.19.3 When the figure next beyond the last place to be retained is 5 and there are no figures beyond this 5 or only zeroes, (a) increase by 1 the figure in the last place retained if it is odd, or (b) leave the figure unchanged if it is even.

4.2.19.4 When the figure next beyond the last place to be retained is 5 and there are figures other than zeroes beyond this 5, increase by 1 the figure in the last place retained.

4.2.19.5 Obtain the rounded value in one step by direct rounding and not in two or more steps of successive rounding.

4.2.20 *specific gravity* — the ratio of the mass of a gas to the mass of an equal volume of air at a specified temperature. For liquids, it is the ratio of the mass of the liquid to the mass of an equal volume of water.

4.2.21 *specification and specification limits* — the specification limit should fall above or in the range of the result and its uncertainty.

4.2.22 *temperature* — temperature values shall be expressed in degrees Celsius.

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4.2.23 *tolerances in measurements* — use the following guidelines for mixture tolerances:

4.2.23.1 Mixtures should be specified by the major component and the concentration of the desired minor component(s).

4.2.23.2 All component gases shall adhere to the appropriate SEMI Specification, if available.

4.2.23.3 The impurity levels in the mixture shall not exceed the algebraic sum of the impurities specified for the designated components.

4.2.23.4 Mixtures shall be prepared according to the following mixing tolerances:

Concentration of Minor Component	*Preparation Tolerance Level*
10–99 ppm	±20%
100–999 ppm	±10%
0.1%–50%	±5%

4.2.23.5 Standards used to verify mixing tolerance (henceforward called Certified Standards) shall meet the following requirements:

Range	*Preparation Tolerance of Each Minor Component*	*Analytical Accuracy of Each Minor Component*
0–9.9 ppm	±20%	±6%
10–99 ppm	±A 10%	±A 3%
100–999 ppm	±A 5%	±A 2%
0.1%–50%	±A 4%	±A 2%

4.2.24 *Calibration Standards* — Calibration Standards shall be as close as practical to specification and may not exceed ten times (10×) the specification unless specifically exempted in procedure.

4.3 *Symbols* — In this Standard, symbols used shall be restricted to those listed as follows.

4.3.1 *°C* — temperature, degrees Celsius

4.3.2 *cc* — cubic centimeter(s)

4.3.3 *cm* — centimeter

4.3.4 *°F* — temperature, degrees Fahrenheit

4.3.5 *ft.* — foot, feet

4.3.6 *g* — gram(s)

4.3.7 *L* — liter(s)

4.3.8 *lb.* — pound(s)

4.3.9 *mL* — milliliter(s)

4.3.10 *mm* — millimeter(s)

4.3.11 *ohm-cm* — ohm-centimeter

4.3.12 *ppm* — mole/mole × 10^6

4.3.13 *ppb* — mole/mole × 10^9

4.3.14 *ppba* — mole/mole × 10^9 atomic

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4.3.15 *ppbw* — weight/weight × 10^9

4.3.16 *psia* — pounds per square inch absolute

4.3.17 *psig* — pounds per square inch gauge

4.3.18 *Mw* — molecular weight (g/mole)

5 Samples

5.1 *Sample Size* — The quantity of gas/liquid in a single sample container shall be sufficient to perform the analysis for all the listed specifications. If a single sample does not contain a sufficient quantity of gas/liquid to perform all of the required analyses, additional samples from the same source shall be taken under similar conditions.

5.2 *Gaseous Samples* — Gaseous samples shall be representative of the gaseous supply. Sampling shall be performed in accordance with one of the following:

5.2.1 By withdrawing a sample from the supply container through a suitable connection into the sample container. (For safety reasons, the sample container and sampling system must have a rated service pressure at least equal to the pressure in the supply container.)

5.2.2 By connecting the container being sampled directly to the analytical equipment.

5.2.3 By selecting a representative cylinder from the cylinders in the lot.

5.3 *Liquid Sampling (Vaporized)* — Vaporized liquid samples shall be representative of the liquid supply. Sampling shall be in accordance with one of the following:

5.3.1 By vaporizing liquid from the supply container in the sample tubing.

5.3.2 By flowing liquid from the supply container into, or through, a suitable container in which a representative sample is collected and then vaporized.

5.4 *Liquid Samples (Liquefied Compressed Gases)* — A direct connection between the liquid phase of liquefied compressed gas containers and the analytical equipment can be achieved, provided suitable flash vaporization is obtained.

5.5 *Lot Acceptance Tests* — These are analyses performed on the gas/liquid in the shipping container, or a sample thereof, which is representative of the lot. (The terms ‘lot’ and ‘batch’ may be used interchangeably.)

5.6 *Lots* — One of the following is to be used:

5.6.1 No specific quantity or any quantity of product agreed upon between the supplier and the customer.

5.6.2 All of the product supplied during the contract period.

5.6.3 All of the product supplied or containers filled during a calendar month.

5.6.4 All of the product supplied or containers filled during seven consecutive days.

5.6.5 All of the product supplied or containers filled during a consecutive 24-hour period.

5.6.6 All of the product supplied or containers filled during one eight-hour shift.

5.6.7 All of the product supplied in one shipment.

5.6.8 All of the product supplied in one shipping container.

5.6.9 All of the product supplied in the container(s) filled on one manifold at the same time.

5.7 *Number of Samples Per Lot* — The number of samples per lot shall be in accordance with one of the following:

5.7.1 One sample per lot.

5.7.2 Any number of samples agreed upon by the supplier and the customer.

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