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SEMI S13-0305

ENVIRONMENTAL, HEALTH AND SAFETY GUIDELINE FOR DOCUMENTS PROVIDED TO THE EQUIPMENT USER FOR USE WITH SEMICONDUCTOR MANUFACTURING EQUIPMENT

This safety guideline was technically approved by the Global Environmental Health & Safety Committee and is the direct responsibility of the Japanese Environmental Health & Safety Committee. Current edition approved by the Japanese Regional Standards Committee on November 24, 2004. Initially available at www.semi.org in January 2005; to be published in March 2005. Originally published in February 1998.

NOTICE: This document was rewritten in its entirety in 2005.

1 Purpose

1.1 This guideline presents considerations for environmental, health and safety information in documents (such as operation, maintenance, installation and safety manuals) provided for use with semiconductor or Flat Panel Display (FPD) manufacturing equipment in order to help risk reduction in operation, maintenance, and installation of equipment used in semiconductor or FPD manufacturing.

1.2 It is intended that personnel who operate, maintain, service, install, decontaminate or decommission equipment should read the documents provided to the equipment user that describe the tasks they are to perform.

2 Scope

2.1 This guideline applies to the documents provided to the equipment user to be used with equipment for production, measurement, assembling, and testing of semiconductor or FPD products.

2.2 This guideline contains the following items:

- Purpose
- Scope
- Limitations
- Referenced Standards
- Terminology
- General Criteria of Documents Provided to the Equipment User
- Hazards Inherent in Equipment
- Hazardous Energy Control Procedures
- Hazard Alerts
- Hazards Inherent in Tasks
- Material Safety Data Sheet (MSDS)
- Personal Protective Equipment (PPE)
- Equipment Inspection, Consumables, and Maintenance
- Training Requirements
- Emergency Contact and Response
- Related Documents
- Appendix 1: Document Criteria to be added to SEMI S2



NOTE 1: This document contains several Related Information sections that restate documentation criteria that appear in other SEMI documents. These restatements were current as of the dates that the Related Information sections were written and are included for the convenience of the users of this document. As the other SEMI documents may be changed at any time, the users of this document must refer to the other SEMI documents for the official versions of these criteria.

NOTE 2: This document contains several Related Information sections that include proposed subject-specific documentation criteria developed by the SEMI S13 Revision TF. It was the intent of the Task Force responsible for SEMI S13 that the criteria in these Related Information sections be incorporated in future revisions of the documents to which they pertain and that these Related Information sections be removed from SEMI S13 by revising SEMI S13 with the same effective date as the effective date of the addition of these criteria to the documents to which they pertain.

NOTICE: This safety guideline does not purport to address all of the safety issues associated with its use. It is the responsibility of the users of this safety guideline to establish appropriate safety and health practices and determine the applicability of regulatory or other limitations prior to use.

3 Limitations

- 3.1 Evaluation reports are not within the scope of SEMI S13.
- 3.2 SEMI S13 does not address physical characteristics of documents.

4 Referenced Standards

4.1 SEMI Standards

- SEMI S1 — Safety Guideline for Equipment Safety Labels
- SEMI S2 — Environmental Health, and Safety Guideline for Semiconductor Manufacturing Equipment
- SEMI S6 — Safety Guideline for Ventilation
- SEMI S8 — Safety Guidelines for Ergonomics Engineering of Semiconductor Manufacturing Equipment
- SEMI S10 — Safety Guideline for Risk Assessment and Risk Evaluation Process
- SEMI S12 — Guideline for Equipment Decontamination
- SEMI S14 — Safety Guideline for Fire Risk Assessment and Mitigation for Semiconductor Manufacturing Equipment
- SEMI S16 — Environmental, Health and Safety Guidelines for Semiconductor Manufacturing Equipment Disposal

4.2 ANSI Standard¹

- ANSI Z400.1 — American National Standard for Hazardous Industrial Chemicals - Material Safety Data Sheets - Preparation

4.3 Other Standards

- International Labor Convention No. 170²—Convention Concerning Safety in the Use of Chemicals at Work
- EN1050³—Safety of Machinery — Principles for risk assessment

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

¹ American National Standards Institute, Headquarters: 1819 L Street, NW, Washington, DC 20036, USA. Telephone: 202.293.8020; Fax: 202.293.9287, New York Office: 11 West 42nd Street, New York, NY 10036, USA. Telephone: 212.642.4900; Fax: 212.398.0023, www.ansi.org

² International Labour Organization, 4, route des Morillons CH-1211 Geneva 22 Switzerland, Tel: +41.22.799.6111 , Fax: +41.22.798.8685, <http://www.ilo.org/>

³ European Committee for Standardization(CEN) 36 rue de Stassart, B - 1050 Brussels, Tel: + 32 2 550 08 11, Fax: + 32 2 550 08 19, <http://www.cenorm.be/cenorm/index.htm>; European Committee for Electrical Standardization(CENELEC), 35, Rue de Stassartstraat, B-1050 Brussels, Belgium, Phone: +32 2 519 68 71, Fax: +32 2 519 69 19, <http://www.cenelec.org/Cenelec/Homepage.htm>



5 Terminology

NOTE 3: Terminology defined in SEMI S1, SEMI S2, SEMI S6, SEMI S8, SEMI S10, SEMI S12, SEMI S14 and SEMI S16 is incorporated herein by reference.

5.1 Definitions

5.1.1 *consumable parts* — parts which are recognized by the equipment supplier as having a useful lifetime which is expected to be significantly less than the lifetime of the equipment.

NOTE 4: Consumable parts include some parts that degrade gradually (such as o-rings) and some that degrade suddenly (such as drive belts).

5.1.2 *decommissioning* — the process of removing equipment from service for disposition by sale, storage, or disposal.

5.1.3 *documents provided to the equipment user* — documents provided by the equipment supplier, such as operation manual, maintenance manual, installation manual, safety manual, or OEM manual, which are intended for use with equipment.

NOTE 5: Additional safety features provided in the equipment according to the equipment user's requisition or request may be described separately. Documents concerning the additional safety features may be provided with the documents provided to the equipment user as a separate attachment.

5.1.4 *evaluation report* — a report describing the results of an evaluation to determine the conformance of equipment to a SEMI document.

5.1.5 *supporting device* — a device which is prepared to assist in the use of equipment.

5.1.6 *unjamming* — service task used to loosen automated material handler from entanglement.

6 General Criteria of Documents Provided to the Equipment User

6.1 The EHS information needed to perform a task should either be included in the document provided to the user that describes how to perform a task or be provided separately in another document. In latter case, the document provided to the user describing the task should identify where to find EHS information relevant to the task.

6.2 Documents provided to the equipment user should provide specific instructions to enable safe installation, operation, maintenance, decontamination and decommissioning of the equipment.

EXCEPTION: Any procedure that is to be performed only by the equipment supplier's personnel does not need to be described in the documentation provided to the equipment user.

NOTE 6: A service manual may be included in the documents provided by the equipment supplier based on the contract.

6.2.1 The documents provided to the equipment user should describe the hazards inherent in equipment, warn of the potential of exposure to hazards, and provide information as to how to minimize risk.

6.3 The equipment supplier should identify, within the documents provided to the equipment user, the intended audience for each equipment document supplied to the user.

6.4 The equipment supplier should provide, in the documents provided to the equipment user, at least the EHS information related to items in the following list. Other SEMI "S" series documents address these subjects for inclusion in documents provided to the equipment user.

- Safety interlocks
- Emergency shutdown
- Ergonomics
- Seismic performance
- Environmental performance
- Industrial Hygiene
- Fire Protection



- Decontamination and decommissioning

NOTE 7: Some documentation criteria regarding Safety interlock systems are given in Appendix 1 of this guideline at the time of publication.

6.5 Where contractually agreed upon, it is recommended that the documents provided to the equipment user should be provided in the primary languages of the location in which the equipment is to be used.

NOTE 8: Where required by law, the documents provided to the equipment user must be provided in the primary languages of the location in which the equipment is to be used.

6.6 Each document should identify the language(s) in which it was originally written.

6.7 Procedures needed to maintain the effectiveness of safety design features or devices should be described in the documents provided to the equipment user.

6.8 The documentation provided to the user may state that the user is responsible for analyzing and controlling the risks of work not described in the documentation.

6.9 The Equipment supplier should provide information in the documents provided to the equipment user about how to check if the documents are applicable for the particular model.

6.9.1 Each document provided to the equipment user (e.g., operations, maintenance, installation, drawings, sub-systems) should include at least a reference to a list of all documents that are necessary to compose a complete set of documents for the equipment model. Reference may be made to a website containing the list.

7 Hazards Inherent in Equipment

7.1 The hazards inherent in equipment identified as part of the SEMI S2 evaluation should be described in the documents provided to the equipment user.

7.2 The summary should include the location and the type of each hazard in a safety section of the documents provided to the equipment user.

7.3 The documents provided to the equipment user should include a list of hazardous materials (e.g., lubricants, cleaners, and coolants) required for maintenance, ancillary equipment or peripheral operations.

NOTE 9: See §11 for discussion of MSDSs.

7.4 Hazards related to by-products and effluents of supplier-characterized baseline processes should be described in the documents provided to the equipment user.

7.5 The documents provided to the equipment user should describe the safety measures in the equipment that mitigate risk in the event of fire, explosion or chemical leakage within the equipment or of earthquake.

8 Hazardous Energy Control Procedures

8.1 Any source of hazardous energy (such as electrical, chemical, thermal, mechanical, radiation, pneumatic or hydraulic energy) that exists in equipment and which may pose a risk to workers maintaining or servicing the equipment should be described in the documents provided to the equipment user along with the procedures for isolation (“lockout/tagout”) and control of each of the hazardous energies.

NOTE 10: The procedures must allow compliance with requirements at the locations of use. In the USA, the procedure must be consistent with 29 CFR1910.147.

9 Hazard Alerts

9.1 The equipment supplier should explain, in the documents provided to the equipment user, the meaning of hazard alerts. Examples of hazard alerts include: visual alerts, auditory alarms, safety labels, status indicators; or hazard alert systems integral with the equipment’s operating system (e.g., displayed through the video display).

9.2 Descriptions of the label locations and, if appropriate, additional safety information relating to the hazards they describe should also be provided.

9.3 Pictographs or symbols may be used to represent the hazard alerts in the document provided to the equipment user.



NOTE 11: Pictographs or symbols may also be adapted to help communicate safety information in installation instructions, operation and maintenance manuals, and other similar written communication relating to a product.

NOTE 12: If pictographs or symbols are used instead of text, then it is recommended that the documentation include explanations of the pictographs or symbols. This recommendation does not apply if the pictographs are used with text messages, as is the common practice in Hazard Alert Labels that conform to SEMI S1.

10 Hazards Inherent in Tasks

10.1 In the documents provided to the equipment user, hazards inherent in each task should be indicated using the signal words “Danger,” “Warning,” or “Caution”, as described in SEMI S1. The signal word and the explanation of the hazard should be highlighted in the documentation (e.g., by enlarged lettering or by being enclosed in a box). The equipment supplier should include the definitions of “Danger,” “Warning,” and “Caution” that are provided in SEMI S1 in the documents provided to the equipment user if those terms are used.

10.2 Specific instructions should be provided for routine Type 4 energized electrical work tasks (as defined in SEMI S2), excluding troubleshooting. General procedures for troubleshooting, including Type 4 work, should be provided.

NOTE 13: SEMI S2 provides guidance that suppliers should design the equipment to minimize the need to calibrate, modify, repair, test, adjust, or maintain equipment while it is energized, and to minimize work that must be performed on components near exposed energized circuits. SEMI S2 also states that the supplier should move as many tasks as practical from category Type 4 to Types 1, 2, or 3.

NOTE 14: NFPA70E describes the identification of the Flash Protection Boundary in the USA.

10.3 Specific instruction may be provided for the unjamming task.

NOTE 15: “Unjamming” (also called “jam clearing”) is considered to be a service task.

10.4 Each maintenance and service task should include a list of the materials required for the task.

11 Material Safety Data Sheet (MSDS)

11.1 The equipment supplier should provide MSDSs covering those chemical substances which are inherent in, or shipped with, the equipment.

11.2 For those chemical substances which are used for processing, maintenance, or service of equipment, but are not provided in or with the equipment, the documents provided to the equipment user should state that the user must obtain the MSDSs from their chemical suppliers, rather than from the equipment supplier. The user is responsible for obtaining process related MSDSs and should contact their suppliers to obtain them.

NOTE 16: The equipment user may request, from the equipment supplier, the list of chemicals prepared in accordance with the chemical section in SEMI S2.

NOTE 17: International Labor Convention No. 170 and ANSI Z400.1 call for MSDSs to describe:

- Product and company identification
- Composition
- Hazard identification
- First aid measures
- Fire fighting measures
- Accidental release measure
- Handling and storage
- Exposure controls / Personal protection
- Physical and chemical properties
- Stability and reactivity
- Toxicological information



- Ecological information
- Disposal considerations
- Transport information
- Regulatory information
- Other information

12 Personal Protective Equipment (PPE)

12.1 The documents provided to the equipment user should clarify which tasks require personal protective equipment and which kind of PPE (e.g., goggles, aprons, gloves, masks, safety shoes, helmets) is needed for each task.

12.2 The documents should identify the characteristics, such as being shatterproof or acid resistant, of the personal protective equipment to be used.

12.3 The equipment supplier should state in the documents provided to the equipment user that PPE should be used in accordance with the instructions provided by the PPE supplier, except where additional instructions by the equipment supplier are required.

13 Equipment Inspection, Consumables, and Maintenance

13.1 The documents provided to the equipment user should describe the recommended methods of periodic inspections including the frequency of each inspection.

13.1.1 Periodic inspections include periodic situations that have long intervals between procedures (e.g., changing memory batteries in computers, replacing UPS batteries, replacing sensor modules for detection systems).

13.2 The equipment supplier should provide a list of consumable parts and materials, with their replacement intervals, maintenance methods, and part/material number in the documents provided to the equipment user.

13.3 The equipment supplier should provide information on the specific tools necessary for inspections and maintenance in the documents provided to the equipment user.

14 Training Requirement

14.1 The equipment supplier should describe the training required for safe operations and maintenance in the documents provided to the equipment user.

14.2 Documents provided to the equipment user should define what level of training is considered, by the supplier, to be sufficient.

15 Emergency Contact and Response

15.1 The documents provided to the equipment user should include information on how to contact the equipment supplier in case of EHS issues related to the equipment.

15.2 The documents provided to the equipment user should include an explanation of how the user may keep the supplier notified of the appropriate user contact information for EHS related issues and notified of what supplier equipment models are in use at which user locations.

15.3 When supplier contact information changes for EHS issues or the supplier wishes to communicate regarding EHS issues, the supplier should notify equipment users through their most recently provided EHS contacts. Which contacts are notified may depend on which equipment models are of concern.



16 Related Documents

16.1 *International SEMATECH*⁴

01104197AXFR — Guidelines for Environmental Characterization of Semiconductor Equipment

⁴ SEMATECH, 2706 Montopolis Drive, Austin, TX, website: <http://www.sematech.org>



APPENDIX 1

DOCUMENT CRITERIA RELATING TO SEMI S2

NOTICE: The material in this Appendix is an official part of SEMI S13 and was approved by full letter ballot procedures on November 24, 2004.

NOTE 1: Documentation criteria described in §A1-2 regarding safety interlock systems are part of conformance criteria to this guideline.

A1-1 Purpose of this Appendix

A1-1.1 This appendix contains criteria for documents that relate to technical criteria that are presented in SEMI S2.

A1-1.2 The criteria in this appendix are not included in SEMI S2 as of the time this Appendix was written, but are included herein as criteria for determining whether the documents provided to the equipment user conform to SEMI S13.

A1-1.3 The criteria in this appendix were included in SEMI S13-0298.

A1-1.4 The criteria in this appendix are arranged to correspond with the sections of SEMI S2.

NOTE 1: It was the intent of the Task Force responsible for SEMI S13 that the criteria in this appendix be incorporated in a future revision of SEMI S2 and that this appendix be removed from SEMI S13 by revising SEMI S13 with the same effective date as the effective date of the addition of these criteria to SEMI S2.

A1-2 Safety Interlock Systems

A1-2.1 The equipment supplier should describe the safety interlock systems provided for the equipment and their operation in a list or similar format in the documents provided to the equipment user. Each interlock system description should include at least the hazard for which the interlock system is provided, the detection methods utilized, and equipment condition after the interlock system is activated.

A1-2.2 The locations of safety interlock sensors (e.g. door switches, pressure sensors, gas detectors) should be clearly indicated using a layout sketch.



RELATED INFORMATION 1 LAWS AND REGULATIONS

NOTICE: This related information is not an official part of SEMI S13 and was derived from the work of the SEMI S13 Revision Task Force. This related information was approved for publication by a letter ballot on November 24, 2004.

R1-1 Laws and Regulations

R1-1.1 The contents of this section should be addressed in the terms and conditions of sale or other contractual agreements between the supplier and user. The following information may be included in the documents provided to the equipment user.

R1-1.2 *Relevant Administrative Laws and Regulations* — These may include laws and regulations relevant to installation, operation, maintenance, and decommissioning of the equipment.

R1-1.2.1 The supplier may describe, in the documents provided to the equipment user, the laws and regulations related to EHS of the user's jurisdiction relevant to operation, maintenance, and supervision of the system.

R1-1.2.2 The supplier may describe the measure of support by the supplier for the implementation of laws and regulations related to EHS after delivery of the equipment.

NOTE 1: It is recommended that equipment supplier and equipment user jointly investigate the laws and regulations of the jurisdiction where the equipment is to be used, and they incorporate these requirements into the purchase specification. In addition, the supplier has a right to describe the laws and regulations considered, and means of compliance implemented, during the development and production of the equipment.

R1-1.3 *Issues Regarding Product Liability (PL)*

R1-1.3.1 The supplier may describe the following in the documents provided to the equipment user to ensure mutual understanding of the issues regarding product liability for the equipment:

R1-1.3.1.1 How a field retrofit is announced and implemented.

R1-1.3.1.2 How to notify discontinuance information of the equipment production to the equipment user and what repair and maintenance services are available after discontinuation of production of the equipment.

R1-1.3.1.3 How parts should be handled by the user for the transport for repair.

R1-1.3.1.4 The equipment supplier should describe, in the documents provided to the equipment user, the possibility of not being able to carry out servicing for reasons of safety and health of the dispatched personnel, if the equipment user refuses to disclose the names and contents of materials being used, for reasons of confidentiality or trade secret protection.

R1-1.3.1.5 The limit of the responsibility of the equipment supplier when the equipment user transports, reuses, resells, or modifies the equipment without the equipment supplier's agreement.

R1-1.3.1.6 The responsibility with regard to the parts designed by the equipment user without the approval of the equipment supplier.



RELATED INFORMATION 2

DOCUMENT CRITERIA INCLUDED IN SEMI S2

NOTICE: This related information is not an official part of SEMI S13 and was derived from SEMI S2. This related information was approved for publication by a letter ballot on November 24, 2004.

R2-1 Purpose of this Related Information

R2-1.1 This related information contains criteria for documents that are presented in SEMI S2.

R2-1.2 The criteria in this related information are included in SEMI S2 as of the time this related information was written, and are included herein for the convenience of users of this document.

NOTE 1: The information in this related information may not be current with the source document. The source document contains the actual documentation criteria.

R2-1.3 The criteria in this related information are arranged to correspond with the sections of SEMI S2.

NOTE 2: It was the intent of the Task Force responsible for SEMI S13 that this related information be updated to incorporate future revisions of SEMI S2 related to criteria for documents.

R2-2 Safety Interlock Systems

R2-2.1 SEMI S2-0703, ¶11.7.2.2 — If a safety interlock is defeated, the maintenance manual should identify administrative controls to safeguard personnel or to minimize the hazard.

R2-3 Emergency Shutdown

R2-3.1 In case assemblies that are not intended to be used as stand-alone equipment and EMO circuit is not necessary in the assemblies of the equipment, assembly's installation manual should provide clear instructions to the equipment installer to connect the assembly to the integrated system's emergency off circuit, (based on SEMI S2-0703, ¶12.1).

R2-3.1.1 SEMI S2-0703, ¶12.1.1 — If the supplier provides an external EMO interface on the equipment, the supplier should include instructions for connecting to the interface.

R2-4 Electrical Design

R2-4.1 SEMI S2-0703, ¶13.3 — Routine Type 4 tasks, excluding troubleshooting, should have specific written instructions in the maintenance manuals.

R2-4.2 SEMI S2-0703, ¶13.4.9 — The current interrupting capacity (also known as amperes interrupting capacity, or AIC) of the equipment main disconnect should be identified in the facility installation and maintenance manuals.

R2-4.3 SEMI S2-0703, ¶13.5.1 — Whenever a UPS is provided with the equipment, its location and wiring should be clearly described within the installation and maintenance manual.

R2-5 Seismic Information

R2-5.1 SEMI S2-0703, ¶19.3 — The supplier should provide the following data and procedures to the user. This information should be included in the installation instructions as part of the documentation covered in §9.

- A drawing of the equipment, its support equipment, its connections (e.g., ventilation, water, vacuum, gases) and the anchorage locations identified in ¶19.4.
- The type of feet used and their location on a base frame plan drawing.
- The weight distribution on each foot.
- Physical dimensions, including width, length, and height of each structurally independent module.
- Weight and location of the center of mass for each structurally independent module.
- Acceptable locations on the equipment frame for anchorage.



R2-6 Environmental Information

R2-6.1 SEMI S2-0703, ¶9.4 — The manufacturer should provide the user with the following environmental documentation as applicable:

R2-6.1.1 ¶9.4.1 — Energy consumption information, including idle, average, and peak operating conditions, for the manufacturer's most representative ("baseline") process.

R2-6.1.2 ¶9.4.2 — Mass balance, including idle, average, and peak operating conditions, for the manufacturer's most representative ("baseline") process.

NOTE 3: The mass balance may include resource consumption rates, chemical process efficiencies, wastewater effluent and air emission characterization, solid and hazardous waste generation (quantity and quality), and by-products.

R2-6.1.3 ¶9.4.3 — Information regarding routes of unintended release (of effluents, wastes, emissions, and by-products) and methods and devices to monitor and control such releases. This should include information on features to monitor, prevent, and control unintended releases (see ¶21.2.4).

R2-6.1.4 ¶9.4.4 — Information regarding routes of intended release (of effluents, wastes, and emissions) and features to monitor and control such releases (see ¶21.2.5).

R2-6.1.5 ¶9.4.5 — A list of items that become solid waste as a result of the operation, maintenance, and servicing of the equipment, and that are constructed of or contain substances whose disposal might be regulated (e.g., beryllium-containing parts, vapor lamps, mercury switches, batteries, contaminated parts, maintenance wastes).

R2-7 Exhaust Ventilation

R2-7.1 SEMI S2-0703, ¶22.3 — Documentation should be developed showing the equipment exhaust parameters and relevant test methods, and should include (see also Appendix 2):

- duct velocity (where needed to transport solid particles);
- volumetric flow rate Q;
- capture velocity (where airborne contaminants are generated outside an enclosure);
- face velocity (where applicable);
- hood entry loss factor F_h or K;
- coefficient of entry C_e ;
- hood static pressure SP_h ;
- duct diameter at the point of connection to facilities; and
- location(s) on the duct or hood where all ventilation measurements were taken.

R2-8 Manuals

R2-8.1 SEMI S2-0703, ¶9.6

R2-8.1.1 ¶9.6.1 — The supplier should provide the user with manuals based on the originally intended use of the equipment. The manuals should describe the scope and normal use of the equipment, and provide information to enable safe facilitization, operation, maintenance, and service of the equipment.

R2-8.1.2 ¶9.6.2 — The manuals should conform to SEMI S13.

NOTE 4: Fire suppression agents, and chemicals used to test fire detection or suppression systems, fall under the MSDS provisions of SEMI S13 when they are provided with the equipment.

NOTE 5: Hazardous energies within fire detection or suppression systems fall under the hazardous energy control provisions of SEMI S13 when fire detection or suppression systems are provided with the equipment.

R2-8.1.3 ¶9.6.3 — In addition to the provisions of SEMI S13, the manuals should include:

- specific written instructions on routine Type 4 tasks, excluding troubleshooting (refer to ¶13.3);



- instructions for energy isolation (“lockout/tagout”) (refer to ¶17.2);
- descriptions of the emergency off (EMO) and interlock functions;
- a list of hazardous materials (e.g., lubricants, cleaners, coolants) required for maintenance, ancillary equipment or peripheral operations, including anticipated change-out frequency, quantity, and potential for contamination from the process;
- a list of items that become solid waste as a result of the operation, maintenance, and servicing of the equipment, and that are constructed of or contain substances whose disposal might be regulated (e.g., beryllium-containing parts, vapor lamps, mercury switches, batteries, contaminated parts, maintenance wastes); and
- maintenance and troubleshooting procedures needed to maintain the effectiveness of safety design features or devices (i.e., engineering controls).

R2-8.1.4 ¶9.6.4 — Information should be provided regarding potential routes of unintended releases (see ¶21.2.4).

R2-8.1.5 ¶9.6.5 — Recommended decontamination and decommissioning procedures should be provided in accordance with SEMI S12, and should include the following information:

- identity of components and materials of construction, in sufficient detail to support recycling, refurbishment, and reuse decisions (see ¶8.5.3); and
- residual hazardous materials, or parts likely to become contaminated with hazardous materials, that may be in the equipment prior to decommissioning.

NOTE 6: It is recommended that the manual state that changes to the typical process chemistry or to the equipment could alter the anticipated environmental impact.

R2-8.1.6 ¶9.6.6 — *Maintenance Procedures with Potential Environmental Impacts* — The supplier’s recommended maintenance procedures should:

R2-8.1.6.1 Identify procedural steps during which releases might occur, and the nature of the releases; and identify waste characteristics and methods to minimize the volume of effluents, wastes, or emissions generated during maintenance procedures.



RELATED INFORMATION 3 DOCUMENT CRITERIA INCLUDED IN SEMI S8

NOTICE: This related information is not an official part of SEMI S13 and was derived from SEMI S8. This related information was approved for publication by a letter ballot on November 24, 2004.

R3-1 Purpose of this Related Information

R3-1.1 This related information contains criteria for documents that are presented in SEMI S8.

R3-1.2 The criteria in this related information are included in SEMI S8 as of the time this related information was written, and are included herein for the convenience of users of this document.

NOTE 1: The information in this related information may not be current with the source document. The source document contains the actual documentation criteria.

R3-1.3 The criteria in this related information are arranged to correspond with the sections of SEMI S8.

NOTE 2: It was the intent of the Task Force responsible for SEMI S13 that this related information be updated to incorporate future revisions of SEMI S8 related to criteria for documents.

R3-2 Documentation

R3-2.1 SEMI S8-0701, ¶7.2 — Supplier provided documentation should include administrative controls intended by the supplier to mitigate ergonomic risks.

R3-2.2 SEMI S8-0701, ¶7.3 — Supplier provided documentation should illustrate any installation requirement necessary to meet SEMI S8 guidelines (e.g., Diagram should show clearance area required for opening hinged panels, operator working area, allowable range of vertical foot adjustment to keep ergonomic measurements within SESCs acceptable limits, etc.).



RELATED INFORMATION 4

DOCUMENT CRITERIA INCLUDED IN SEMI S16

NOTICE: This related information is not an official part of SEMI S13 and was derived from SEMI S16. This related information was approved for publication by a letter ballot on November 24, 2004.

R4-1 Purpose of this Related Information

R4-1.1 This related information contains criteria for documents that are presented in SEMI S16.

R4-1.2 The criteria in this related information are included in SEMI S16 as of the time this related information was written, and are included herein for the convenience of users of this document.

NOTE 1: The information in this related information may not be current with the source document. The source document contains the actual documentation criteria.

R4-1.3 The criteria in this related information are arranged to correspond with the sections of SEMI S16.

NOTE 2: It was the intent of the Task Force responsible for SEMI S13 that this related information be updated to incorporate future revisions of SEMI S16 related to criteria for documents.

R4-2 Information Provided by the Supplier

R4-2.1 SEMI S16-0600, §7 ¶7.1 — The supplier should provide the equipment owner with operation and/or maintenance manuals or similar documents drafted according to SEMI S13, which include the following information on the materials used in equipment, subassemblies and components upon the delivery of the equipment.

NOTE 3: The supplier may gather appropriate information at the time of design in conjunction with a disposal party.

R4-2.1.2 ¶7.1.1 — Primary materials of appropriate disassembleable unit in consideration with reuse, refurbishing, recycling and disposal of each component such as chemicals (e.g., mercury), metals (e.g., stainless steel, steel, or copper), plastics (e.g., ABS - i.e. Acrylonitrile Butadiene Styrene plastics - or non-combustible ABS), glass, or ceramics.

R4-2.1.3 ¶7.1.2 — Describe opportunities for reuse, refurbishing or material recycling of every component or recyclable subassembly. If there are no opportunities, a waste disposal method should be recommended based on assumption of usage with baseline process by the supplier. (e.g. ABS can be recycled after decontamination as class X plastic and mercury requires reclaim or hazardous waste disposal.)

R4-2.1.4 ¶7.1.3 — *Disassembly procedure*

R4-2.1.4.1 ¶7.1.3.1 — A disassembly procedure should be recommended by the supplier to the level required to facilitate complete decontamination and material separation for waste disposal.

R4-2.1.4.2 ¶7.1.3.2 — The disassembly procedure should include procedures to remove all hazardous energies.

R4-2.1.4.3 ¶7.1.3.3 — The disassembly procedure should prevent the mixture of incompatible chemicals. If it is not feasible, administrative control procedures should be included.

R4-2.1.4.4 ¶7.1.3.4 — If the chemicals/materials described in ¶¶7.1.3.4.1 to 7.1.3.4.4 are hazardous, the disassembly procedure should prevent the release of them to the environment. The chemicals include:

NOTE 4: Byproducts are changeable according to several kinds of conditions such as exhaust diameter/length/volume, chamber volume/pressure/configuration, maintenance method/cycle, and evacuation frequency.

R4-2.1.4.5 ¶7.1.3.4.5 — The disassembly procedure should address any hazards of ionizing radiation sources, if they are present, and address safe removal and storage procedures.

R4-2.1.5 ¶7.1.4 — Disposal procedure should be described by a safer way based on the result of risk assessment such as SEMI S10 or EN 1050 and job hazard analysis.



RELATED INFORMATION 5

DOCUMENT CRITERIA WHICH MAY BE DISCUSSED IN A FUTURE REVISION OF SEMI S2

NOTICE: This related information is not an official part of SEMI S13 and was derived from the work of the SEMI S13 Revision TF. This Related Information was approved for publication by a letter ballot on November 24, 2004.

R5-1 Purpose of this Related Information

R5-1.1 This related information contains criteria for documents that relate to technical criteria that may be discussed for a future revision of SEMI S2.

R5-1.2 The criteria in this related information are not included in SEMI S2 as of the time this related information was written, but are newly suggested as necessary criteria for determining whether the documents provided to the equipment user conform to SEMI S13.

R5-1.3 The criteria in this related information are arranged to correspond with the sections of SEMI S2.

NOTE 1: It was the intent of the Task Force responsible for SEMI S13 that the criteria in this related information be incorporated in a future revision of SEMI S2 and that this related information be removed from SEMI S13 by revising SEMI S13 with the same effective date as the effective date of the addition of these criteria to SEMI S2.

R5-2 Safety Interlock

R5-2.1 The equipment supplier should describe the safety interlocks provided as part of the equipment and their function in a list in the documents provided to the equipment user. The interlock list should include the hazards against which they protect, type of sensors/actuators used, the type of interlock circuit (e.g. hardware or software, etc.), and equipment conditions after the interlocks are activated.

R5-2.2 The equipment supplier should describe how to restore each interlock and put equipment or parts of the equipment back to operation after an interlock is activated.

R5-2.3 The locations of sensors and actuators used for safety interlocks protecting personnel should be described.

R5-2.4 Calibration and testing procedures and frequencies should be provided for all sensors and detectors which require calibration and testing to be conducted by the user. Where applicable, gases used for calibration and test apparatus should be identified.

R5-3 Emergency Shutdown

R5-3.1 The documents provided to the equipment user should describe the function and operation of the EMO circuit that is provided as part of the equipment.

R5-3.2 The locations of EMO buttons should be described.

R5-4 Environmental Information

R5-4.1 Maintenance Procedures with Potential Environmental Impacts — The supplier's recommended maintenance procedures should:

- identify procedural steps during which releases might occur, and the nature of the releases; and
- identify waste characteristics and methods to minimize the volume of effluents, wastes, or emissions generated during maintenance procedures.

R5-5 Fire Protection Information

R5-5.1 Information of fire protection should be written in the documents provided to the equipment user.

R5-5.2 The following ¶¶R5-5.2.1 to R5.5.2.3 apply only if the equipment includes the features to which the information relates.

R5-5.3 Operation, maintenance and test procedures for fire detection and alarm system should be described.



R5-5.4 Operation, maintenance, and test procedures for fire suppression and alarm system should be described.

R5-5.5 A list of any special apparatus needed to test the fire detection or suppression features of the equipment should be provided. The list should note whether the apparatus is included with the equipment, or is sold separately.

R5-6 Industrial Hygiene Information

R5-6.1 Byproducts expected from the baseline process should be described.

R5-6.2 Documents provided to the equipment user should describe any exposure risk that is present.

R5-6.3 Methods for reducing exposure risk during performance of tasks (e.g., use of portable exhaust, use of respirators, use of portable detection equipment to warn the worker) should be described.

R5-6.4 Radiation including ionizing (e.g., implanters, static elimination bars, X-ray) and non-ionizing (e.g., lasers, Ultraviolet, infrared, RF, EMF) should be described.



RELATED INFORMATION 6

DOCUMENT CRITERIA WHICH MAY BE DISCUSSED IN A FUTURE REVISION OF SEMI S6

NOTICE: This related information is not an official part of SEMI S13 and was derived from the work of the SEMI S13 Revision TF. This related information was approved for publication by a letter ballot on November 24, 2004.

R6-1 Purpose of this Related Information

R6-1.1 This related information contains criteria for documents that relate to technical criteria that may be discussed for a future revision of SEMI S6.

R6-1.2 The criteria in this related information are not included in SEMI S6 as of the time this related information was written, but are newly suggested as necessary criteria for determining whether the documents provided to the equipment user conform to SEMI S13.

R6-1.3 The criteria in this related information are arranged to correspond with the sections of SEMI S6.

NOTE 1: It was the intent of the Task Force responsible for SEMI S13 that the criteria in this related information be incorporated in a future revision of SEMI S6 and that this related information be removed from SEMI S13 by revising SEMI S13 with the same effective date as the effective date of the addition of these criteria to SEMI S6.

R6-2 Equipment Parameter Change

R6-2.1 Documents provided to the equipment user should describe changing any parameter of the systems in the equipment (e.g., changing exhaust monitoring set points, working with portions of the enclosure removed) may cause an unexpected condition.



RELATED INFORMATION 7

DOCUMENT CRITERIA WHICH MAY BE DISCUSSED IN A FUTURE REVISION OF SEMI S8

NOTICE: This related information is not an official part of SEMI S13 and was derived from the work of the SEMI S13 Revision TF. This related information was approved for publication by a letter ballot on November 24, 2004.

R7-1 Purpose of this Related Information

R7-1.1 This related information contains criteria for documents that relate to technical criteria that may be discussed for a future revision of SEMI S8.

R7-1.2 The criteria in this related information are not included in SEMI S8 as of the time this related information was written, but are newly suggested as necessary criteria for determining whether the documents provided to the equipment user conform to SEMI S13.

R7-1.3 The criteria in this related information are arranged to correspond with the sections of SEMI S8.

R7-1.3.1 It was the intent of the Task Force responsible for SEMI S13 that the criteria in this related information be incorporated in a future revision of SEMI S8 and that this related information be removed from SEMI S13 by revising SEMI S13 with the same effective date as the effective date of the addition of these criteria to SEMI S8.

R7-2 Supporting Device

R7-2.1 When supporting device provided by the equipment supplier is to be used by the equipment users as a measure of ergonomic risk mitigation, the documentation should describe how to use it. For example, supporting devices are appliances that support the user's body (e.g., a platform to step on), the user's hands (e.g., palm rest for a keyboard), or a heavy object (e.g., hoist).



RELATED INFORMATION 8

DOCUMENT CRITERIA WHICH MAY BE DISCUSSED IN A FUTURE REVISION OF SEMI S12

NOTICE: This related information is not an official part of SEMI 13 and was derived from the work of the SEMI S13 Revision Task Force. This related information was approved for publication by a letter ballot on November 24, 2004.

R8-1 Purpose of this Related Information

R8-1.1 This related information contains criteria for documents that relate to technical criteria that may be discussed for a future revision of SEMI S12.

R8-1.2 The criteria in this related information are not included in SEMI S12 as of the time this related information was written, but are newly suggested as necessary criteria for determining whether the documents provided to the equipment user conform to SEMI S13.

R8-1.3 The criteria in this related information are arranged to correspond with the sections of SEMI S12.

NOTE 1: It was the intent of the Task Force responsible for SEMI S13 that the criteria in this related information be incorporated in a future revision of SEMI S12 and that this related information be removed from SEMI S13 by revising SEMI S13 with the same effective date as the effective date of the addition of these criteria to SEMI S12.

R8-2 Decontamination and Decommissioning Information

R8-2.1 Documents provided to the equipment user should provide recommended decontamination procedure based on the equipment supplier's baseline process including the following information:

- decontamination methods in accordance with SEMI S12;
- equipment modules or components requiring decontamination and contaminants, including by-products;
- procedures required to decontaminate equipment effectively;
- components and equipment that require special handling and disposal procedures, including contaminated parts; parts containing lead, mercury, cadmium, chromium, arsenic, beryllium, barium, vanadium, selenium, organic solvents, PCB's, PPB's, CFCs and other regulated wastes; and
- residual hazardous materials that may remain despite decontamination efforts prior to decommissioning.

R8-2.2 Decommissioning Procedure

R8-2.2.1 Documents provided to the equipment user should provide a recommended decommissioning procedure to facilitate decontamination and material separation.

R8-2.2.2 The decommissioning procedure should include removal of all hazardous energies (such as chemical, pneumatic, electrical, pressure, and elevated loads).

R8-2.2.3 The decommissioning procedure should be documented to prevent the mixture of incompatible chemicals. If it is not feasible, administrative control procedures in order to minimize various risks such as fire, explosion, air or water pollution and toxicity should be included.

R8-2.2.4 If the chemicals/materials are hazardous, the decommissioning procedure should address how to prevent their release to the environment. The chemicals include:

- Chemicals used to operate or maintain the equipment (e.g., lubricant and coolant),
- Other potentially hazardous items which are parts of the equipment, such as capacitors, batteries, lamps or mercury, which require special disposal procedures, and
- Chemicals used in the baseline process of the equipment supplier for which the decontamination and decommissioning procedures have been provided and their anticipated by-products.



NOTE 2: Byproducts vary with conditions such as exhaust duct diameter/length/volume, temperature, exhaust gas velocity, chamber volume/pressure/configuration, maintenance method/cycle, and purge frequency.

R8-2.2.5 The decommissioning procedure should address any hazards of ionizing radiation sources, if they are present, and address safe removal and storage procedures for these sources.

R8-2.2.6 Specific hazards known to be the result of failures during operation (e.g., mercury vapor lamps create mercury deposits when a lamp bursts) should be described.

NOTICE: SEMI makes no warranties or representations as to the suitability of the standards set forth herein for any particular application. The determination of the suitability of the standard is solely the responsibility of the user. Users are cautioned to refer to manufacturer's instructions, product labels, product data sheets, and other relevant literature, respecting any materials or equipment mentioned herein. These standards are subject to change without notice.

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SEMI S14-0704

SAFETY GUIDELINES FOR FIRE RISK ASSESSMENT AND MITIGATION FOR SEMICONDUCTOR MANUFACTURING EQUIPMENT

These safety guidelines were technically approved by the Global Environmental Health and Safety Committee and are the direct responsibility of the North American Environmental Health and Safety Committee. Current edition approved by the North American Regional Standards Committee on April 22, 2004. Initially available at www.semi.org June 2004; to be published July 2004. Originally published February 2000; previously published November 2003.

NOTICE: Paragraphs entitled “NOTE” are not an official part of this document and are not intended to modify or supersede the official Safety Guideline. These have been supplied by the Task Force to enhance usage of the Safety Guideline.

NOTICE: The intent of the task force that produced this document is that conformance to the “should” provisions of this guideline comprises conformance with this guideline.

1 Purpose

1.1 This document provides considerations to the manufacturers of semiconductor manufacturing equipment that will assist them in assessing and mitigating the risk to equipment and product associated with fire and combustion by-products.

1.2 Although these guidelines are written in the form of an assessment tool, they are intended for use throughout the design and development of semiconductor manufacturing equipment.

1.3 These guidelines may also be used by the users of such equipment and by other interested parties to assess and compare the described risks of various equipment designs or in the design and evaluation of ancillary equipment or modifications.

1.4 These guidelines are not intended to specify which techniques (e.g., selection of materials or detection systems) are to be used to mitigate fire risk. These guidelines do, however, recommend that the traditional risk management hierarchy of elimination, engineering controls, administrative controls, warning and work practices be followed.

1.5 The appropriate application of these guidelines will result in a report which identifies, analyzes and assesses residual fire risks.

2 Scope

2.1 These guidelines apply to equipment used to manufacture, measure, assemble, and test semiconductor products which is intended to be located in clean-rooms used for semiconductor manufacturing processes or areas within their recirculation airstream. They apply to all of the components of the equipment, as described herein.

NOTE 1: This document is not limited to the structural or large-area components of equipment.

2.2 This document applies to fire risks originating within the subject equipment that may result in damage to it, other equipment, products, or the facility.

2.3 This document identifies considerations for assessing the fire risk of semiconductor manufacturing equipment, means of categorizing the risks, and means of mitigating the risks.

NOTICE: This safety guideline does not purport to address all of the safety issues associated with its use. It is the responsibility of the users of this safety guideline to establish appropriate safety and health practices and determine the applicability of regulatory or other limitations prior to use.

3 Limitations

3.1 These guidelines do not establish acceptance criteria for residual risk.

3.2 This document recommends a hierarchy of approaches (e.g., elimination of a hazard is preferable to an engineering control) but neither prescribes which specific risk mitigation methods (e.g., change of material or elimination of an ignition source) are to be used nor ranks their relative merit.

3.3 These guidelines apply to the protection of property; they do not apply to the protection of personnel.

NOTE 2: Protection of personnel from fire risk is within the scope of SEMI S2.

3.4 This document applies to equipment in its scope when the equipment is used in the environment specified by the equipment supplier. Specifically, it does not apply to the behavior of equipment when it is subject to an external fire.

3.5 This document is not intended to be used to assess compliance with regulatory requirements, nor is it intended to be adopted as regulation.

3.6 Because of these limitations, it may be appropriate for purchasers of equipment to specify the applicable codes and standards and the acceptable level of residual risk.

NOTE 3: Applicable regional, and national codes, international regulations, and the equipment manufacturer's and user's requirements must also be considered. When a conflict exists, the regional and national codes take precedence.

4 Referenced Standards

4.1 SEMI Standards

SEMI E10 — Specification for Definition and Measurement of Equipment Reliability, Availability, and Maintainability (RAM)

SEMI E70 — Guide for Tool Accommodation Process

SEMI S2 — Environmental, Health, and Safety Guideline for Semiconductor Manufacturing Equipment

SEMI S7 — Safety Guidelines for Environmental, Safety, and Health (ESH) Evaluation of Semiconductor Manufacturing Equipment

SEMI S10 — Safety Guideline for Risk Assessment and Risk Evaluation Process

4.2 NFPA Documents¹

National Fire Protection Association: NFPA 12 — Standard on Carbon Dioxide Fire Extinguishing Systems

National Fire Protection Association: NFPA 13 — Standard for the Installation of Sprinkler Systems

National Fire Protection Association: NFPA 72 — National Fire Alarm Code

National Fire Protection Association: NFPA 2001 — Standard on Clean Agent Fire Extinguishing Systems

4.3 Factory Mutual Document²

Factory Mutual Research Corp. Standard 4910 — Clean Room Materials Flammability Test Protocol

¹ National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269, Website: www.nfpa.org

² Factory Mutual Research Corp., 1151 Boston-Providence Turnpike, Norwood, MA 02062, phone: 781-762-4300, fax: 781-762-9375, website: <http://www.factorymutual.com>

4.4 Underwriters Laboratory Documents³

Underwriters Laboratory Standard 94 — Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

Underwriters Laboratories Standard 746A — Polymeric Materials - Short Term Property Evaluations

Underwriters Laboratories Standard 746B — Polymeric Materials - Long Term Property Evaluations

Underwriters Laboratories Standard 746C — Polymeric Materials - Use in Electrical Equipment Evaluations

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

5 Terminology

5.1 Definitions

5.1.1 *accredited testing laboratory* — an independent organization dedicated to the testing of components, devices, or systems; competent to perform evaluations based on established safety standards and recognized by a governmental or regulatory body. [SEMI S2]

5.1.2 *cleanroom* — a confined area in which the humidity, temperature, particulate matter, and contamination are precisely controlled within specified parameters. [SEMI E70]

5.1.3 *combustible liquid* — a liquid that will burn and has a flash point at or above 37.8° C (100° F).

5.1.3.1 For the purpose of this guideline, a combustible liquid, when used by a system capable (under normal or single-fault conditions) of heating it above its flash point, is considered a flammable liquid.

5.1.4 *combustible material* — for the purpose of this document, a combustible material is any material which does not meet the definitions in this section for noncombustible materials.

NOTE 4: A list of criteria, guidelines and standards that may be used to evaluate the fire properties of materials is included in Appendix 2.

5.1.5 *downtime* — the time when the equipment is not in a condition, or is not available, to perform its intended function. It does not include any portion of non-scheduled time. [SEMI E10]

NOTE 5: Downtime may be considered according to the definition of SEMI E10, assuming committed availability of the parts in question.

5.1.6 *flammable liquid* — a liquid having a flash point below 37.8° C (100° F).

³ Underwriters Laboratory, 333 Pfingsten Rd, Northbrook, IL 60062

5.1.7 *hazard* — a condition that is a prerequisite to a mishap.

5.1.8 *hazardous voltage* — unless otherwise defined by an appropriate international standard applicable to the equipment, voltages greater than 30 volts rms, 42.4 volts peak, 60 volts dc are defined in this document as hazardous voltage.

NOTE 6: The specified levels are based on normal conditions in a dry location environment.

5.1.9 *ignition energy* — sufficient energy to ignite a combustible material. The energy required depends on the form of the energy and the composition and form of the combustible material.

NOTE 7: The combustible material may be solid, liquid, or gas.

5.1.10 *likelihood* — the expected frequency with which a mishap will occur. Usually expressed as a rate (e.g., events per year, per product, per wafer processed).

5.1.11 *mishap* — an unplanned event or series of events that results in death, injury, occupational illness, damage to or loss of equipment or property, or environmental damage.

5.1.12 *noncombustible material* — a material that, in the form in which it is used and under the conditions anticipated, will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat. Typical noncombustible materials are metals, ceramics, and silica materials (e.g., glass and quartz).

5.1.13 *process chemicals* — solids, liquids, and gases used in the normal use of the equipment included in the scope of this document.

NOTE 8: Solids, liquids, and gases used in the maintenance procedures (e.g., isopropanol used as a cleaning agent) specified by the equipment supplier should be considered as well as those used in operation.

5.1.14 *pyrophoric material* — a chemical that will spontaneously ignite in air at or below a temperature of 54.4° C (130° F).

5.1.15 *residual risk* — that risk which remains after engineering, administrative, and work practice controls have been implemented.

5.1.16 *risk* — the expected losses from a mishap, expressed in terms of severity and likelihood.

5.1.17 *safe shutdown condition* — a condition in which all hazardous energy sources are removed and hazardous production materials are removed or contained, unless this results in additional hazardous conditions.

5.1.18 *semiconductor manufacturing process* — those manufacturing steps which are part of the creation of active or passive electrical devices on a semiconducting wafer, including the deposition of passivation layers after final metallization, but excluding testing and dicing.

5.1.19 *severity* — the extent of the worst credible loss from a mishap caused by a specific hazard.

5.1.20 *supervisory alarm* — an alarm indicating a supervisory condition.

5.1.21 *supervisory condition* — a condition in which action or maintenance is needed to restore or continue proper function.

5.1.22 *trouble alarm* — an alarm indicating a trouble condition.

5.1.23 *trouble condition* — a condition in which there is a fault in a system, subsystem or component that may interfere with proper function.

6 Fire Risk Assessment

6.1 Overview

6.1.1 This section provides criteria for evaluation of the risks associated with several types of fire hazards.

6.1.2 For each identified hazard described in Section 6, the evaluator should analyze the contributing, causal, and mitigating factors. The evaluator should also review any assessment of the material, component, or equipment as a whole by an accredited testing laboratory.

6.1.3 The risk assessment should include both normal operation and the consequence of reasonably foreseeable, single-point failures within the equipment. It should not include exposure to fire or external ignition sources not within the intended use environment.

6.1.4 Certifications by an accredited testing laboratory of materials, components, or the equipment as a whole may be used in the fire risk assessment. However, such certifications are valid only to the extent that the conditions of use for the certification correlate to the conditions of use for the equipment whose fire risk is being assessed.

NOTE 9: For example, a personal computer certified to IEC 60950 might be incorporated into equipment for use as a controller. The material flammability requirements of IEC 60950 may or may not be sufficient for this use of the personal computer, depending upon its exposure to oxidizers and external sources of ignition when incorporated into the equipment. Also, the levels of smoke tolerable in the environment for which a general industry standard was written may exceed those tolerable in semiconductor manufacturing cleanrooms. Furthermore, if the equipment is

intended to be used in a potentially explosive atmosphere, the certification to IEC 60950 would not sufficiently control its risk of being a source of ignition.

6.1.5 The consequences and the probability of fire from each identified hazard should be assessed and rated, as described in SEMI S10. See Appendix 1 for the criteria used for the assignments of Severity, Likelihood and Risk in this document.

6.1.5.1 The assigned Severity and Likelihood and resulting Risk category should be recorded as part of the analysis.

6.1.5.2 For those hazards for which the Risk depends on the conditions of use or use environment, the equipment supplier should make and state appropriate assumptions. If the equipment supplier is unable to make appropriate assumptions as to the Likelihood because it depends predominantly on factors in the users' sole control (e.g., adherence to specified procedures), the supplier should state that and provide an estimate of the Severity.

NOTE 10: The facilities requirements on which the risk assessment depends are to be specified by the equipment supplier.

6.1.6 For fire to occur, there must be a fuel, an oxidizer and a source of ignition. Elimination of any of these factors eliminates the risk of fire. Similarly, the Severity, Likelihood and Risk of a fire can be reduced by reducing one or more of these elements appropriately.

6.1.7 It is important to remember that there are often implicit oxidizers (e.g., room air) and sources of ignition (e.g., room temperature for a pyrophoric material).

6.1.8 The fire risk assessment should include the judgement of a qualified (as described in SEMI S7) party to determine the level of detail of the assessment. That party may group similar hazards for assessment and reporting.

NOTE 11: Such grouping could include, for example, all of the knobs and buttons of similar materials into one group, the heated surfaces into a second, and the several flammable liquids with similar properties into a third.

6.2 Fuels

6.2.1 Fuels include all those materials capable of reacting with an oxidizer in a fire. The risks of both the materials of which the equipment is constructed and the process chemicals used in it should be assessed.

6.2.2 Materials of Construction

6.2.2.1 The risk assessment should include all of the materials of construction, regardless of quantity or application.

NOTE 12: This includes small parts, such as knobs, buttons, electrical contactors, terminal strips, circuit boards, signal wire and power wiring as well as large components, modules (such as mini-environments) and subassemblies.

NOTE 13: Some of the smallest components can create a high risk, as in the potential for ignition by adiabatic compression of fluoropolymer seats in high pressure oxygen valves.

NOTE 14: The assessment can be simplified by grouping similar items together. Example 1: wiring that has the same type of insulation. Example 2: knobs, switches, handles and latches made from similar polymers. Identified groups should include their approximate total mass.

6.2.2.2 In assessing the risk, the evaluator should consider:

- the size of each component,
- the total quantity and distribution of similar components,
- the inherent properties of the material, such as ignitability, flame spread, heat of combustion, and byproducts (See Appendix 2 for guidance on evaluation of these properties.),
- the exposure to oxidizers, and
- the exposure to ignition sources.

NOTE 15: The specification control of materials used in approved electrical components should also be considered. Approvals may allow for substitution of many materials with equivalent flammability ratings.

NOTE 16: The inherent properties of materials affect two types of risk within the equipment: flame spread risk and contamination risk (i.e., smoke damage from combustion byproducts). In the case of electrical and electronic components used in assemblies and equipment that are constructed and used in accordance with applicable standards (e.g., IEC 61010-1, IEC 60204-1), flame spread risk may be adequately controlled by the standard, and detailed assessment of the material properties of such components that affect flame spread may not be warranted. However, a significant contamination risk could still remain (e.g., a standard may allow a component mounted on a printed circuit board to fail and burn, as long as the burning remains local to the printed circuit board) and warrant a detailed assessment of related material properties of the components. The level of detail of the assessment may also be affected by the mitigation method chosen (see Section 7).

6.2.3 Process Chemicals

6.2.3.1 This portion of the risk assessment should include all of the process chemicals expected (based on the equipment supplier's recommended or baseline processes) to be used in the equipment. It should also include flammable and combustible wastes generated or collected within the equipment and fluids in the equipment which are required for its operation but

which do not participate chemically in the process (e.g., vacuum pump oil).

6.2.3.2 In assessing the risk, the evaluator should consider:

- the quantity, concentration, state, temperature, and pressure of each chemical in each container,
- for those chemicals supplied automatically by the facility, the available flow, pressure, and total quantity,
- the aggregate supplies and distribution of similar chemicals,
- the inherent properties of the chemicals, such as flammable limits, flash point, autoignition temperature, heat of combustion, and the products of combustion and decomposition (see the Material Safety Data Sheets for guidance on evaluation of these properties),
- the exposure to oxidizers, and
- the exposure to ignition sources.

NOTE 17: Chemicals with similar fire properties may be considered together for the purpose of this assessment.

6.3 Sources of Ignition

6.3.1 Sources of ignition can be broadly divided into those within the equipment and those external to it.

6.3.2 Internal Sources

6.3.2.1 Potential electrical ignition sources:

- devices or conditions that in normal operation can generate ignition energy (e.g., heaters, static electricity, lasers);
- devices or conditions that in reasonably foreseeable assembly, use and/or wear conditions can generate ignition energy (e.g., power connectors, terminal strips);
- devices that in reasonably foreseeable single point failure modes can generate ignition energy (e.g., transformers, electronic components); and
- short circuits.

6.3.2.2 Potential chemical ignition sources:

- exothermic process chemical reactions,
- exothermic reactions from inadvertent mixing of process chemicals,
- exothermic reactions between process chemicals and materials of construction, and

- release of pyrophoric or air-reactive chemicals from processing or maintenance.

6.3.2.3 Sudden changes in process conditions:

- rapid (sometimes called “adiabatic”) compression of gas mixtures, and
- rapid increases in temperature.

6.3.2.4 Mechanical friction

6.3.3 External Sources

6.3.3.1 External sources include expected and foreseen conditions of the equipment’s use. As these are factors normally outside the control of the equipment supplier, their risks are difficult to assess. They are outside the scope of this document.

6.4 Oxidizers

6.4.1 The most common oxidizer is air, which is present within and around most semiconductor manufacturing equipment. Unless specific measures are taken to exclude air (e.g., inert pressurizing of an electrical enclosure), it should be assumed to be available in infinite supply.

6.4.2 It is possible that some materials of construction will act as oxidizers or will yield oxidizers when subjected to heat.

6.4.3 Several common process chemicals (e.g., oxygen and hydrogen peroxide) are oxidizers. Their risks should be assessed in a manner similar to that described above for process chemicals that are fuels.

6.5 Reporting

6.5.1 Although these guidelines are intended for use throughout the design and development process, it is not the intent of these guidelines that the equipment supplier should make all of the information recorded during the development of the equipment available to others. The equipment supplier should document the fire risk assessment and mitigation in three forms: internal records, a final fire risk assessment report, and a summary report.

6.5.2 Relevant analyses, assessments, and design decisions should be documented in the equipment supplier’s internal records. These records need not, however, be made available to other parties.

6.5.3 Final Fire Risk Assessment Report

6.5.3.1 This report should contain an itemized list of the residual risks identified in reviewing the final design, considering the risks described in the preceding subsections or otherwise known or foreseen by the evaluator. Only those risks meeting the criteria in

Appendix 1 should be included. For each identified residual risk, the report should:

- explain the mechanism of loss or damage;
- identify aggravating or necessary contributing factors;
- identify the mitigating factors;
- state the assigned Severity for each type of loss and present the rationale for its assignment. A “type” is a column in Table A1-1, e.g., “Equipment Physical Damage”;
- state the assigned Likelihood and present the rationale for its assignment; and
- state the resulting Risk category.

NOTE 18: Criteria for risks may be found in Appendix 1, Sections A1-2.5 through A1-2.8.

6.5.3.2 This report should also describe the fire risk mitigation techniques included in the equipment design.

6.5.3.3 The final fire risk assessment report should be prepared or reviewed by a party qualified, as described in SEMI S7, to do such work.

NOTE 19: This party may be an employee of the equipment supplier or may be a third party.

6.5.3.4 When this guideline is being used as part of a SEMI S2 equipment evaluation, the manufacturer should make the final fire risk assessment report available to the party performing the SEMI S2 evaluation.

6.5.3.5 The equipment supplier may make the final fire risk assessment report available to other parties.

6.5.4 Summary Report

6.5.4.1 The summary report should be prepared from the final fire risk assessment report and contain:

- a list of the residual fire risks and their ratings, and
- brief descriptions of the fire risk mitigation techniques included in the equipment.

6.5.4.2 The equipment supplier should provide the summary report to users of the equipment and may provide it to other parties.

7 Fire Risk Mitigation

7.1 Overview

7.1.1 This section describes several means of mitigating the risks of fire. It describes ways in which the equipment and its use can be designed to minimize the risks.

NOTE 20: The description of a mitigation technique in this section is not intended to imply that such technique should be

used for each system. Therefore, the decision to include a particular mitigation technique should be based on the assessed risk.

NOTE 21: Fire detection and suppression are also means of mitigating fire risk. The criteria for fire detection and suppression systems are in SEMI S2.

7.1.2 In mitigating risks, the general hierarchy of elimination, engineering controls, administrative controls, warning and work practices should be followed. Following this hierarchy comprises using techniques which are highest in it if several techniques are equally applicable. Design and use constraints, as well as relative cost, however, may justify using techniques from generally less preferable categories. In any case, the residual risk should be assessed and reported.

7.2 Fuels

7.2.1 Materials of Construction

7.2.1.1 The lowest fire risk is posed by noncombustible materials of construction. Available noncombustible materials are not, however, suitable or desirable for all applications within semiconductor manufacturing equipment.

NOTE 22: The properties necessary to perform the intended function of system components and the properties necessary to satisfy component-level standards may also restrict the use of noncombustible materials.

7.2.1.2 When materials which are combustible are chosen, the fire risk may be mitigated by:

- selecting those materials with the least undesirable properties as described above; and
- minimizing the total mass and distribution of such materials.

7.2.2 Process Chemicals

7.2.2.1 It may be possible to reduce the fire risk by changing the quantities and species of the chemicals used in the intended processes.

7.2.3 The fire risks of combustible materials of construction and flammable and combustible process chemicals may also be reduced by limiting those factors described in Section 6.

7.3 Sources of Ignition

7.3.1 Potential sources of ignition should be considered in conjunction with the fuels and oxidizers they might ignite.

7.3.2 Risks due to sources of ignition can be mitigated by:

- limiting their number,

- limiting their energy, and
- separating them from combustible materials of construction and from flammable and combustible process chemicals. Separation may be by distance or by barriers.

7.3.3 Equipment in which flammable liquids or gases are used should be assessed to determine if additional precautions (e.g., purging) in the electrical design are necessary.

NOTE 23: NFPA 497 and EN 1127-1 are among the documents that provide methods for making this assessment.

7.4 Oxidizers

7.4.1 Reducing the quantities or pressures of oxidizing process chemicals may reduce the fire risk.

7.4.2 The fire risks of oxidizing process chemicals may also be reduced by limiting those factors described in Section 6.

7.5 Exhaust, Enclosures and Barriers

7.5.1 Mechanical exhaust may reduce the risk of damage to the facility, other equipment, or other portions of the same equipment by limiting the spread of combustion and decomposition products. The mechanical exhaust could be provided by the equipment or by the facility.

7.5.2 Enclosures and barriers within the equipment may reduce the fire risk by separating the fuels and oxidizers from each other and from potential sources of ignition.

7.5.3 These design features may also limit the spread of fire, reducing both the loss of equipment and the emission of combustion and decomposition products.

8 Related Documents

8.1 SEMI Standard

SEMI S11 — Environmental, Safety, and Health Guidelines for Semiconductor Manufacturing Equipment Minienvironments

8.2 NFPA Documents

National Fire Protection Association: NFPA 70 — *National Electric Code (NEC)*

National Fire Protection Association: NFPA 318 — *Standard for Protection of Cleanrooms*

National Fire Protection Association: NFPA 496 — *Standard for Purged and Pressurized Enclosures for Electrical Equipment*

National Fire Protection Association: NFPA 497 — *Recommended Practice for the Classification of*

Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas

8.3 CEN/CENELEC Standards⁴

EN 1127-1 — Explosive Atmosphere – Explosion prevention and protection – Part 1 Basic concepts and methodology

8.4 Other Documents

Building Officials and Code Administrators (BOCA)⁵, NBC: National Building Code

Factory Mutual System Data Sheet 7-7⁶, Semiconductor Fabrication Facilities

International Conference of Building Officials (ICBO)⁷, UBC: Uniform Building Code

International Fire Code Institute⁸, UFC: Uniform Fire Code

International SEMATECH⁹, Process Compatibility Parameters for Wet Bench Plastic Materials (Technology Transfer # 98123623A)

Southern Building Code Congress International (SBCCI)¹⁰, SBC: Standard Building: Code

⁴ European Committee for Standardization (CEN)/European Committee for Electrotechnical Standardization (CENELEC), Central Secretariat: rue de Stassart 35, B-1050 Brussels Belgium

⁵ Building Officials & Code Administrators International, Inc., 4051 West Flossmoor Road, Country Club Hills, IL 60477

⁶ Factory Mutual, 1301 Atwood Ave. P.O. Box 7500 Johnston R.I. 02919, website: www.fmglobal.com

⁷ ICBO, 5360 South Workman Mill Rd., Whittier, CA 90601

⁸ International Fire Code Institute, 5360 South Workman Mill Rd., Whittier, CA 90601

⁹ SEMATECH, 2706 Montopolis Drive, Austin, TX, website: www.sematech.org

¹⁰ SBCCI, 900 Montclair Rd, Birmingham, AL 35213-1206



APPENDIX 1

RISK ASSESSMENT CRITERIA

NOTICE: The material in this appendix is an official part of SEMI S14 and was approved by full letter ballot procedures on September 3, 1999 by the North American Regional Standards Committee.

A1-1 The risk assessment should be performed for each identified fire hazard using the method provided in SEMI S10 and the following definitions of Likelihood and Severity Groupings and Risk Categories.

NOTE A1-1: Unlike SEMI S10, in which the tables are provided only as examples, this document defines the Severity, Likelihood, and Risk to be used herein.

A1-2 *Severity*

A1-2.1 The Severity Groupings are given in Table A1-1.

Table A1-1 Severity Groupings

<i>Severity Group</i>	<i>Equipment Physical Damage</i>	<i>Equipment Loss of Use</i>	<i>Facility Loss of Use (Minimum Times)</i>	<i>Environmental and Real Property Contamination</i>
1 Catastrophic	Loss of entire piece of equipment	One year	One week	Lasting facility or environmental impact
2 Severe	Loss of major subsystem	One month	One day	Temporary facility or environmental impact
3 Moderate	Loss of minor subsystem	One week	One shift	Limited to the equipment, but requiring more than routine cleanup
4 Minor	Non-serious equipment loss	One day	Less than one shift	Requiring routine cleanup but not external reporting

A1-2.2 The Severity should be assigned for each of the columns for which information is available.

A1-2.3 The most severe Group assigned should be used in determining the risk.

A1-2.4 Each of the Severities should be reported.

A1-2.5 Contamination is by release of materials that were used in the equipment or by combustion or thermal degradation byproducts.

A1-2.6 To be included in the assessment, a foreseen occurrence must be unplanned and include a loss.

A1-2.7 Losses exclude the performance of the design function of protective devices, such as fuses.

A1-2.8 The scope of the assessment in this document is limited to the consequences of fire.

A1-2.9 The Equipment Loss of Use time is the downtime, as defined in SEMI E10, resulting from the fire incident.

A1-3 *Likelihood*

A1-3.1 The Likelihood Groupings are given in Table A1-2.

Table A1-2 Likelihood Groupings

<i>Likelihood Group</i>	<i>Expected Frequency (% of Systems per Year)</i>
A Frequent	More than 1%
B Likely	More than 0.2% but not more than 1%
C Possible	More than 0.04%, but not more than 0.2%
D Rare	More than 0.02%, but not more than 0.04%
E Unlikely	Not more than 0.02%



A1-3.2 “System” refers to the equipment as configured and offered by the supplier.

A1-4 *Risk*

A1-4.1 The Risk should be calculated based on the Severity and Likelihood assigned above and the Risk Categories defined in Table A1-3.

Table A1-3 Risk Categories

Severity	Likelihood				
	A	B	C	D	E
1	Critical	Critical	High	Medium	Low
2	Critical	High	Medium	Low	Low
3	High	Medium	Low	Low	Slight
4	Medium	Low	Low	Slight	Slight

A1-4.2 The Risks are to be reported in total for the equipment as offered for sale. (e.g., if the equipment being evaluated is a cluster tool, the risks should be reported by the system integrator for the assembled tool, not the individual modules.)

NOTE A1-2: Although the risks for cluster tools should be reported for the assembled tool, the modules are not necessarily contiguous and this may bear on the risk.

NOTE A1-3: The Risks of components or subsystems may be increased or decreased by their integration into the equipment being assessed.

APPENDIX 2

ASSESSMENT OF THE FIRE PROPERTIES OF MATERIALS

NOTICE: The material in this appendix is an official part of SEMI S14 and was approved by full letter ballot procedures on September 3, 1999 by the North American Regional Standards Committee.

A2-1 This Appendix describes the qualitative criteria for evaluating some of the relevant fire properties of materials. It also provides references to several standards which may be used in these evaluations. Each of the standards listed defines test methods and provides quantitative criteria for consideration.

A2-2 *Preferable Materials:*

A2-2.1 Require higher heat fluxes to be ignited.

A2-2.2 Once ignited may burn locally in the ignition area, but they will not propagate a fire beyond the ignition zone.

A2-2.3 Generate lower quantities of smoke and corrosive products or generate smoke and corrosive products that are less damaging.

A2-3 The following standards provide means of assessing the fire properties of materials. Each of these standards specifies the types of materials and uses of materials to which it applies and the fire properties that its application assesses. Therefore, each must not be used outside of the scope for which it was written. It may be appropriate to use different standards for assessing the materials used in different components in the equipment.

NOTE A2-1: There are many other standard methods available for characterizing the fire properties of materials and it is not the intent of the document to exclude methods other than those listed here, as long as the methods are applied appropriately.

A2-3.1 Factory Mutual Research Corp. Standard 4910, *Clean Room Materials Flammability Test Protocol*

A2-3.2 Underwriters Laboratory Standard 94, *Tests for Flammability of Plastic Materials for Parts in Devices and Appliances*

A2-3.3 Underwriters Laboratories Standard 746A, *Polymeric Materials - Short Term Property Evaluations*

A2-3.4 Underwriters Laboratories Standard 746B, *Polymeric Materials - Long Term Property Evaluations*

A2-3.5 Underwriters Laboratories Standard 746C, *Polymeric Materials - Use in Electrical Equipment Evaluations*

A2-3.6 Underwriters Laboratories Standard 900, *Standard for Safety for Air Filter Units*

A2-3.7 Underwriters Laboratories Standard 2360, *Standard for Test Methods for Determining the Combustability Characteristics of Plastics Used in Semiconductor Tool Construction*

NOTE A2-2: Although the list includes, for some materials, more than one document that could be applied, the intent is to provide alternatives, not to suggest that testing to more than one standard be performed.

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RELATED INFORMATION 1

TEST PROTOCOL FOR WET BENCH MATERIALS PROCESS COMPATIBILITY

NOTICE: This related information is not an official part of SEMI S14 and is not intended to modify or supersede the official guideline. It has been derived from the cited work. Publication is authorized by vote of the responsible committee. Determination of the suitability of this material is solely the responsibility of the user.

R1-1 SEMATECH has published the results of a study on testing of polymeric materials for use in wet benches. The Abstract and citation are provided as Related Information 1 to SEMI S14, Safety Guidelines for Fire Risk Assessment and Mitigation for Semiconductor Manufacturing Equipment as the responsible committee believes the information in this document may be of use in identifying materials that are appropriate for the described applications and consistent with appropriate management of fire risks.

R1-2 The report, SEMATECH Document ID #: 98123623A-ENG, entitled Process Compatibility Parameters for Wet Bench Plastic Materials, was written by Archibald Tewarson, Avtar S. Jassal, Latif Ahmed, and Mark Camenzind and published 30 December 1998.

R1-3 SEMATECH retains the copyright to the document, but has granted SEMI permission to include the Abstract and citation in this Safety Guideline. The complete document (90 pages) is available from SEMATECH's web site:

<http://www.sematech.org/public/docubase/abstract/tech-5.htm>

R1-4 *Abstract*

R1-4.1 This report presents a test protocol of accepted analytical procedures to determine the process compatibility parameters for commonly used wet bench plastic materials (PP, FRPP, and PVC) and proposed plastic materials (CPVC, ECTFE, and PVDF) that may be used for wet bench construction. Three industry standard test methods were used to determine the outgassing, leaching, and extraction parameters, defined in combination as the process compatibility parameters. To supplement them, the presence of critical elements at the surface of the materials and the condition of the surface were examined before and after exposure to water and chemicals. Changes in the mass of plastic materials as a result of outgassing, leaching, and extraction were also used to supplement the parameters. The report includes details of the test procedures, data analysis, surface topography of the plastic materials, before and after exposure to water and chemicals, and discussion of the results.



RELATED INFORMATION 2

SMOKE MANAGEMENT IN CLEANROOMS

NOTICE: This related information is not an official part of SEMI S14 and was derived from the work of a member of the Fire Protection Task Force of the North American Environmental, Health, and Safety Committee. This related information was approved for publication by 2/3 committee vote on July 17, 2003.

R2-1 Introduction

R2-1.1 Semiconductor cleanrooms are operationally sensitive to products of a fire. A fire will result in smoke and corrosive particle contamination to the cleanroom, process equipment, and work in process. A properly designed, installed, and maintained smoke detection and control system will not prevent contamination, but will limit the spread and concentration of the contaminant. The basis of the smoke control system design should be aligned with the organization's risk management objectives.

R2-1.2 This Related Information deals with smoke management systems for cleanrooms themselves, not for equipment. Smoke removal from a cleanroom may be performed by ventilation systems that are in place for other purposes (e.g., process exhaust systems of equipment) or by equipment designed and installed specifically to remove smoke from the room. These may both be parts of the protection for a cleanroom and may differ in how they are activated.

R2-2 Actuation

R2-2.1 Automatic actuation of dedicated smoke control systems is preferable; however, many facilities prefer manual activation. If the system is manually activated, the following should be done.

R2-2.1.1 The smoke detection system should be monitored by qualified personnel 24 hours per day.

R2-2.1.2 Emergency response teams (ERT) or other personnel authorized to actuate the manual smoke control system should be capable of prompt notification.

R2-2.1.3 Detailed smoke control emergency procedures should be documented and practiced. These procedures can include hazardous gas shutdowns and shutdowns of appropriate air recirculation fans as well as activating the smoke control exhaust fans.

R2-2.2 A secondary means of manual actuation of the smoke/contaminant control system should be provided in a clearly marked and accessible area outside the cleanroom.

R2-3 Capacity

R2-3.1 The smoke control system capacity needed is directly related to the design fire size which depends upon the type, amount and arrangement of combustible materials in the cleanroom. In order to achieve a system that is economically feasible, the maximum design fire size should be limited to the fire size at sprinkler operation. For a typical cleanroom configuration, the fire size at sprinkler operation is in the range of 600 to 800 kilowatts.

R2-3.2 Smoke removal system capacity can be designed based on an integrated system approach. The total capacity can include the fume exhaust system capacity and dedicated smoke removal system capacity.

R2-4 Design Considerations

R2-4.1 When the fume exhaust system is used for smoke removal, the following design parameters should be followed.

R2-4.1.1 The fume exhaust system ductwork should be of non-combustible construction or should be listed/approved for smoke removal and not incorporate the use of fire dampers or interrupters.

R2-4.1.2 It should be confirmed that sufficient fume exhaust system intake points exist throughout the clean room. If not, additional intake points should be provided and incorporate the use of normally closed dampers. These dampers should be opened either automatically by activation of the smoke detection system or by manual means.

R2-4.1.3 When the fume exhaust system is used for smoke removal, it can incorporate the use of variable speed fan(s). During the smoke removal mode, fire dampers on supplemental intake points will open and the fan speed will be increased. The design capture velocity at the tool(s) could be affected, and this should be reviewed. Necessary balancing changes should be made to ensure the design capture velocity is maintained.

R2-4.2 The ventilation system make-up air fans should be sized such that under full smoke and process exhaust, the fabrication area maintains a positive pressure relative the adjacent areas.



R2-4.3 Smoke removal system intake locations are dependent on the fabrication area design. Design alternatives should be addressed with a competent fire protection engineering design firm. For example, for open manufacturing areas, smoke removal system intake sequencing should be designed such that individual zones can be activated to prevent contaminant migration to adjacent clean areas of the fab. From a smoke removal perspective, ducted returns are a better option than open attic plenum configurations.

R2-5 Testing

R2-5.1 The smoke/contaminant control system should have a functional test done annually of all detection and

control systems including system dampers and fans. The system should be designed so that operational and functional testing can be done without interruption to the normal clean room air handling.

R2-5.2 The smoke/contaminant control system for new semiconductor facilities should be fully tested during mechanical system tests done near the end of the construction process. Testing should consist of a complete functional test of detection and control systems, plus activation of smoke/contaminant removal fan and damper systems. The performance of the smoke/contaminant removal system should be verified using either sulfur hexafluoride (SF_6) or another tracer gas method.

RELATED INFORMATION 3

ADDITIONAL CONSIDERATIONS FOR FIRE SUPPRESSION SYSTEMS

NOTICE: This related information is not an official part of SEMI S14 and was derived from the work of a member of the Fire Protection Task Force of the North American Environmental, Health, and Safety Committee. This related information was approved for publication by 2/3 committee vote on July 17, 2003.

R3-1 Introduction

R3-1.1 Preventing discharges from occurring accidentally and ensuring that systems are able to fulfill their intended function requires attention to detail from the specification of the system, through design, installation and commissioning and then through ongoing maintenance.

R3-1.2 The following information is intended to assist stakeholders involved in the process of designing, installing, and maintaining fire protection of semiconductor manufacturing equipment. Further information can be found in the appropriate fire protection codes and standards applicable to the type of fire protection system and in related documents.

NOTE R3-1: The term "fire suppression" is limited to extinguishing fire, once it has begun. The term "fire protection" incorporates fire suppression and other means of mitigating the risk of fires, including fire detection and materials selection.

R3-1.3 The use of contractors with previous experience in the design and installation of fire protection of cleanrooms and semiconductor manufacturing equipment is desirable.

R3-1.4 Independent third party review of fire protection designs and installations by a fire protection engineer with relevant experience can also help to ensure that systems are correctly designed and installed.

NOTE R3-2: The material in this Related Information is presented as additional guidance in designing, installing, and maintaining fire protection systems in semiconductor manufacturing equipment. Although this information is believed to be useful in optimizing such systems, the material in this Related Information does not comprise additional criteria for determining conformance to the provisions of SEMI S2 or SEMI S14.

R3-2 Design Review

R3-2.1 Ensure that system proposed uses approved or listed components and that they are used within their listing or approval, e.g., FM Approved wet bench fire suppression systems should be used for open faced wet bench whereas an enclosed tool can use a system comprising of FM approved & compatible components.

R3-2.2 Detection needs to be selected to suit the working environment and the type of fire/smoke that is

anticipated. For example, optical detectors need to have been tested and approved/listed for use with specific flammable liquids or gases. Flames and smoke from burning materials have varying physical characteristics which mean that some detection devices will not always react promptly.

R3-2.3 The location of detection devices in relation to hazards needs to be carefully considered. A detector that is located too close to a heat source may activate when it sees normal process conditions rather than fire conditions.

R3-2.4 Some optical detectors may also be susceptible to accidental activation if they are exposed to welding flashes. Care in detector selection can avoid this, but implementing strict cutting and welding working practices and permissions can also play an important part.

R3-3 Installation Review

R3-3.1 Once completed by the fire protection installer, the fire protection installation should be inspected and reviewed by a competent and experienced fire protection engineer. This review will:

R3-3.1.1 Verify installation against previously working drawings.

R3-3.1.2 Ensure that specified equipment has been installed as indicated on the working drawings and in line with equipment approvals and listings.

R3-3.2 Distribution pipework networks should be complete (including all connections), properly supported using listed and approved equipment. Frequent failures of piped systems, including CO₂ systems, occur due to incorrectly connected pipes or where fittings have not been made or sufficiently tightened.

R3-3.3 Supports for pipework should be able to withstand the expected forces that will be experienced during discharge of the suppression system. This is important to protect personnel and property from moving pipes in high-pressure systems using agents such as carbon dioxide.

R3-3.4 Detection systems should have components installed as per reviewed drawings, however it is not always possible during desktop drawing review to identify that detectors are correctly sited. As a result

the field review should concentrate on ensuring that components are located so that they can see the hazard without obstruction, including clear vision panels, which may prevent detector from “seeing” the flame.

R3-3.5 Similarly detectors need to be sited so that they will not experience normal process temperatures, radiation or be exposed to chemical, liquid or particles that could result in an accidental activation.

R3-3.6 Where linear heat detection cable is used it should be located where it will not be exposed to levels of ambient or process related heat that could trigger an alarm signal. In addition the cable should be securely attached to prevent it dislodging and coming into contact with hot surfaces.

R3-3.7 Nozzle locations in many suppression systems can be critical to ensuring functionality, reliability and safety. For example, CO₂ nozzles incorrectly positioned can result in chemical splashing or dislodging product or quartzware. If nozzles are exposed to chemical action including corrosive chemicals, it is important that the materials are resistant to the chemical

R3-3.8 Where automatic sprinkler heads are used, the fusible link should be adequately protected from chemical and mechanical attack.

R3-4 Commissioning Tests

R3-4.1 All installations should undergo a thorough commissioning and acceptance test conducted by the installer and witnessed by the owner or owner's representative.

R3-4.2 Functional Tests are essential, but not sufficient to ensure that system will operate as intended. The types of problems that can be picked up by functional testing are:

R3-4.2.1 Inability of detection system to detect as intended,

R3-4.2.2 Inability of control system to receive signal from individual detectors, and

R3-4.2.3 Inability of alarm panel to initiate system discharge or send alarm signals to connected devices and safety systems, e.g.,

- local or remote alarm panels,
- sounders & warning devices, and
- interlocks to equipment shutdown and safety systems, EMO.

R3-4.3 Discharge Testing is the only way that we can ensure that that a system will fulfill its intended

function. The types of problems that can be picked up by discharge testing are:

R3-4.3.1 Lack of extinguishing agent

R3-4.3.2 Inability to transfer agent from supply to nozzles due to:

- Blockages arising from incorrect equipment,
- Incomplete piping, loose fittings & supports, and
- Installation, design problems (e.g., icing up of CO₂ pipes or nozzles).

R3-4.4 In many cases discharge testing within the cleanroom environment is not considered acceptable or practical. Accordingly, alternatives such as type testing can prove that the design will provide the necessary protection, but may need to be supplemented by a more rigorous commissioning test of the final systems. Type testing would involve the installation and discharge testing of a system on a tool during manufacture or on a mock up of the tool. The aim would be to prove that distribution pipework and nozzles have been correctly designed and that the concentration of agents and distribution patterns from nozzles is acceptable. This would be supplemented by additional tests on each installation, including pressure tests of pipework and “puff” tests to verify pipework integrity.

R3-5 Burn In

R3-5.1 In order to avoid unnecessary discharges, a period of burn-in for the detection system is advisable. This involves the detection system operating, enabling detection of fires and initiation of alarms, but the detection is not interlocked to shut down the process equipment or initiate a discharge.

R3-5.2 A period of days or weeks may be appropriate depending on the effect of an accidental activation of the system in terms of interruption to processing, damage to product or contamination of the environment.

R3-6 Maintenance & Servicing

R3-6.1 Once systems are installed and commissioned it is important that the routine inspection and maintenance procedures recommended by manufacturers and those required by codes and standards, are adequately implemented.

R3-6.2 The inspection frequencies may need to be modified if the ambient conditions can adversely affect the protection systems. For example sprinkler heads protecting corrosive fume exhaust ducts may need to be inspected weekly or monthly until the appropriate frequency for that particular system can be determined.



R3-6.3 Annual and semi-annual maintenance should be carried out by competent personnel with adequate training for the tasks in hand.

RELATED INFORMATION 4

DOCUMENTING EXPLOSION SAFETY FOR SEMICONDUCTOR MANUFACTURING EQUIPMENT

NOTICE: This related information is not an official part of SEMI S14 and was derived from the work of a member of the Fire Protection Task Force of the North American Environmental, Health, and Safety Committee. This related information was approved for publication by 2/3 committee vote on July 17, 2003.

R4-1 Introduction

R4-1.1 The design of many semiconductor manufacturing machines has to take account of the hazard created by the presence of flammable liquids and gases and as a result the designer will usually have identified the hazards and put in place the necessary mitigation and protection measures to provide a satisfactory level of safety.

R4-1.2 This document is intended to assist equipment designers and third party evaluators in documenting the presence of explosion hazards and detailing how they have integrated explosion safety into the design.

R4-1.3 There are specific requirements with regard to the prevention and mitigation of explosion risks within many jurisdictions. However the theory of explosion prevention and mitigation transcends jurisdictional boundaries. While this document arises out of the need for some equipment to satisfy the European Union ATEX Directive (94/9/EC), it has been developed in such a way that it will not only meet the requirement to document the principles of integrated explosion safety (Essential Health and Safety Requirement 1.0), but will provide information to authorities having jurisdiction (AHJs) in many other parts of the world.

R4-2 Documentation

R4-2.1 For all equipment using flammable liquids or gases an Explosion Risk Document (ERD) should be developed and issued as an appendix to the SEMI S14 Fire Risk Assessment Internal Report. (The main explosion hazards, risks and mitigation features should already be documented in the S14 Final and Summary Reports.)

R4-2.2 The ERD should demonstrate that the equipment designer and manufacturer have adopted an integrated approach to explosion safety adequately mitigating the risk of an explosion.

R4-2.3 The structure of the document is flexible, however a logical structure should be adopted such as that suggested by the headings and sections of this document, e.g.,

- Design Philosophy and Equipment Operation Overview,

- Hazard Identification,
- Mitigation Measures Implemented & Protection Systems Integrated, and
- Residual Explosion Risk.

R4-3 Design Philosophy and Equipment Operation Overview

R4-3.1 The intended purpose of the equipment should be stated, along with its operating environment.

R4-3.2 A functional and technical overview of the process should be provided, where it relates to the flammable and explosive chemicals and gases. This should include significant process parameters including temperature, pressure, and quantities of relevant chemicals and gases. The operating conditions and control system faults that influence explosion safety should be described.

R4-3.3 The explosion protection design philosophy should be thoroughly documented listing the design standards applied, and any significant deviations.

R4-3.4 The classification of hazardous areas or zoning outside and inside equipment should be described indicating the classification system used (e.g., EN1127-1, NFPA 497).

R4-3.5 Where components and equipment are within or are related to areas classified as hazardous, they should be documented including manufacturers' details, listings and approvals and confirmation that they have been used within the scope of the approvals and listings.

R4-4 Hazard Identification

R4-4.1 It is good practice to adopt a comprehensive approach to hazard identification when designing for explosive atmospheres, especially for complicated equipment, protective systems and components. If a structured approach to hazard identification and risk assessment has been taken, for example, if during the design process a HAZOP has been undertaken, the HAZOP itself should form part of the documentation supporting this section.

R4-4.2 In relation to the occurrence of hazardous explosive atmospheres, the origin of the potentially explosive atmosphere should be described. This should include:

R4-4.2.1 The safety data of the chemicals or gases involved (Physical properties, including where available: combustion properties, ignition requirements, explosion behavior),

R4-4.2.2 How and where the chemicals and gases are stored, handled and controlled,

R4-4.2.3 The degree of dispersion of the flammable substance (e.g., gases, vapors, mists, dusts),

R4-4.2.4 The concentration of the flammable substance in air within the explosion range, and

R4-4.2.5 The amount of explosive atmosphere sufficient to cause injury or damage by ignition, and any factors which limit the quantity or the amount that is available to be ignited.

R4-4.3 The scenarios or conditions that result in the explosive atmosphere should be described, indicating the nature of the sequence of events that lead to the explosion. This may include quantification of the explosive atmosphere and/or results of the explosion.

R4-5 Hazard Identification – Ignition Sources

R4-5.1 The ignition sources present within or close to the potentially explosive atmosphere should be classified according to the likelihood of their occurrence in the following manner:

R4-5.1.1 Sources of ignition which are assumed to be present at all times, because the likelihood of occurrence of an effective ignition source cannot be estimated,

R4-5.1.2 Sources of ignition which can occur continuously or frequently,

R4-5.1.3 Sources of ignition which can occur in rare situations, and

R4-5.1.4 Sources of ignition which can occur in very rare situations.

R4-5.2 All potential ignition sources should be considered including:

R4-5.2.1 Sparks, flames, electric arcs, high surface temperatures, acoustic energy, optical radiation, electromagnetic waves,

R4-5.2.2 Electrostatic charges capable of resulting in dangerous discharges,

R4-5.2.3 Stray electric and leakage currents in conductive equipment parts, which could result in, for

example, the occurrence of dangerous corrosion, overheating of surfaces or sparks capable of provoking an ignition may need to be considered,

R4-5.2.4 Overheating caused by friction or impacts occurring, for example, between materials and parts in contact with each other while rotating or through the intrusion of foreign bodies may need to be reduced, as far as possible, at the design stage, and

R4-5.2.5 Adiabatic Compression: Equipment and protective systems may need to be designed or fitted with integrated measuring, control and regulation devices so that pressure compensations arising from them do not generate shock waves or compressions resulting in ignition.

R4-5.2.6 Impact Energy

R4-5.2.7 Chemical Reactions: e.g., combination of highly reactive chemicals producing sufficient energy to ignite these chemicals, by-products or other chemicals/articles in the vicinity.

R4-6 Mitigation Measures Implemented & Protection Systems Integrated

R4-6.1 This section should describe in detail the measures taken to mitigate the explosion risks that have been identified, including those:

- to prevent the creation of explosive or ignitable atmospheres, e.g., through the use of ventilation, purging or inerting and the prevention of releases etc.,
- to prevent the ignition of the atmosphere, e.g., through the use of appropriately rated electrical equipment or relocating ignition sources outside the classified zone,
- to limit the development or propagation of the explosion, e.g., through the use of an explosion suppression system, and
- to limit the damage caused by the explosion, e.g., through venting or barriers.

R4-7 Residual Risk

R4-7.1 The documentation should include a statement of the residual explosion risk describing the expected explosion scenario and summarizing the Residual Explosion Risk that exists:

R4-7.1.1 with all protective features operating (Category 1, 2 and 3),

R4-7.1.2 with a failure of one protective feature (Category 1 & 2 only), and



R4-7.1.3 with a failure of two protective features (Category 1 only).

NOTE R4-1: The equipment Categories are based on the intended conditions of use:

Category 1: explosive atmospheres are highly likely to occur and are present continuously frequently or for long periods

Category 2: explosive atmospheres are likely to occur

Category 3: explosive atmospheres are less likely to occur and, if they occur, do so infrequently and briefly

NOTICE: Paragraphs entitled "NOTE" are not an official part of this safety guideline and are not intended to modify or supersede the official safety guideline. These have been supplied by the committee to enhance the usage of the safety guideline.

SEMI makes no warranties or representations as to the suitability of the guideline set forth herein for any particular application. The determination of the suitability of the guideline is solely the responsibility of the user. Users are cautioned to refer to manufacturer's instructions, product labels, product data sheets, and other relevant literature respecting any materials mentioned herein. This guideline is subject to change without notice.

The user's attention is called to the possibility that compliance with this guideline may require use of copyrighted material or of an invention covered by patent rights. By publication of this guideline, SEMI takes no position respecting the validity of any patent rights or copyrights asserted in connection with any item mentioned in this guideline. Users of this guideline are expressly advised that determination of any such patent rights or copyrights, and the risk of infringement of such rights, are entirely their own responsibility.

SEMI S15-0200

SAFETY GUIDELINE FOR THE EVALUATION OF TOXIC AND FLAMMABLE GAS DETECTION SYSTEMS

This safety guideline was technically approved by the Global Environmental, Health, and Safety Committee and is the direct responsibility of the North American Environmental, Health, and Safety Committee. Current edition approved by the North American Regional Standards Committee on December 15, 1999. Initially available on www.semi.org January 2000; to be published February 2000.

1 Purpose

1.1 This guideline provides considerations for the evaluation of fixed gas detection systems used to monitor for safety of plant personnel, product and materials, the local environment and community. It provides an evaluation guide and reference sources appropriate to facilities and equipment where toxic and flammable gases are used and stored in gaseous or liquid form.

2 Scope

2.1 This guideline applies to toxic and flammable gas detection and addresses performance characteristics of gas detection systems.

2.2 It also describes several technologies available for detection of such gases and their performance characteristics.

2.3 This safety guideline does not purport to address all of the safety issues associated with its use. It is the responsibility of the users of this safety guideline to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

3 Limitations

3.1 This guideline does not include applicable fire and safety code regulations.

3.2 The gases or liquids which should be monitored are not listed.

3.3 This guideline does not suggest the appropriate levels of detectability. Such levels may be determined by reviewing accepted government and non-governmental agency standards, such as those promulgated by ACGIH, USEPA, and USOSHA.

3.4 Process related issues and corrective actions in the case of gas leaks are not discussed in this guideline.

3.5 This guideline makes no recommendation of any specific technology or manufacturer, nor does it provide installation and operation recommendations.

3.6 This guideline provides neither a comprehensive list of all gases, nor recommended areas for monitoring of toxic and flammable gases.

3.7 Not all known analytical methodologies for monitoring of toxic and flammable gases are described in this guideline.

4 Referenced Standards

4.1 SEMI Standard

SEMI E33 — Specification for Semiconductor Manufacturing Facility Electromagnetic Compatibility

5 Terminology

5.1 Abbreviations and Acronyms

5.1.1 *ACGIH* — American Conference of Governmental Industrial Hygienists

5.1.2 *EMI* — Electromagnetic interference

5.1.3 *EU* — European Union

5.1.4 *RFI* — Radio frequency interference

5.1.5 *USEPA* — United States Environmental Protection Agency

5.1.6 *USOSHA* — United States Occupational Safety and Health Administration

5.2 Definitions

5.2.1 *challenge gas* — a gas/chemical used to create a response in the gas detection system.

5.2.2 *conditioning* — the necessity to expose a gas/chemical sensor to the target gas/chemical to enable more rapid detection of that gas/chemical.

5.2.3 *fail-safe relay* — an alarm relay that is “fail-safe” returns to a safe operating condition when power is lost.

5.2.4 *filter lag* — relative to gas/chemical sensors, the time delay in the detection of a challenge gas/chemical due to the incorporation of a chemical, mechanical or electrical filter.

5.2.5 *latching* — relative to discrete alarm contacts, the alarm relay will not reset when the alarm condition ceases to exist. The alarm must be manually or remotely reset by operator interface.

5.2.6 *poisoning* — the interaction of a gas/chemical other than the target gas/chemical that temporarily or permanently disables the sensor from reliably detecting the presence of the target gas/chemical, or otherwise renders the device inoperable.

5.2.7 *span drift* — the percentage change in a known calibration point or span of a sensor or gas detection system over time.

5.2.8 *surrogate gas/chemical* — a substitute gas/chemical that is more benign than the gas/chemical it is replacing. This concept is used in the calibration of gas/chemical sensors when a highly toxic or corrosive challenge gas is undesirable. The surrogate gas/chemical will simulate the interaction with the sensor of the gas/chemical for which it is substituted.

5.2.9 *target gas* — the specific gas intended to be detected.

5.2.10 *zero drift* — the percentage change in the zero point or baseline of a sensor or gas detection system over time.

6 Performance Characteristics

6.1 The performance characteristics (the test results of which should be reliable and repeatable) are as identified below. These are factors one should consider in the evaluation of a gas detection system (from the point of detection through the output signal) for a specific application. A form for compiling a comparison table is provided as Appendix 1.

6.2 *Accuracy* — What is the stated accuracy of the system? Over what time period will that accuracy be valid (before calibration of the gas detection system is necessary)?

6.3 *Alarms* — What is the range for setting the alarms for each gas detection point? Are the alarms user-adjustable for set and reset time delays, latching or non-latching, normally open or closed, fail-safe or non fail-safe? How many alarm levels are available per detection point? Is there a fail alarm and what conditions will activate that alarm? Are the alarms dedicated to each detection point or are they common to a group of monitoring points?

6.4 Calibration

6.4.1 Is calibration required? If so, how often? How is it accomplished? Can it be done away from the point of detection or must it be done on site? What equipment is needed to perform the calibration? Can a

surrogate gas be used for calibration? Can the calibration be accomplished by one individual? Is calibration accuracy affected by humidity?

6.4.2 During start-up, how much time must elapse before the gas detection system can be calibrated?

6.5 *Certifications and Classifications* — Does the gas detection system have the necessary performance or safety approvals for the specific application and location (e.g., UL, CE, SEMI S2)?

6.6 *Communications (serial)* — What types of serial communication are available from the gas detection system? What communication protocols are supported? Is it one-way or two-way communication?

6.7 *Conditioning Requirements* — Is the monitoring equipment always ready and able to detect a gas leak or must it be preconditioned on a periodic (regular) basis to ensure response times are achieved?

6.8 *Cost of Ownership* — What is the initial cost for the equipment and installation? What is the long-term cost of ownership of the system (consumables, calibration equipment, and labor)? What is the cost (hardware and installation) to expand the system (additional points of detection) and/or change the gas configuration?

6.9 *Data Archiving* — Are data documentation or data archiving system available as a part of the gas detection system?

6.10 *Diagnostics* — What system diagnostics are included? Can electrical or mechanical failures within the system be detected? Will a fault alarm be activated? Are diagnostics communicated over analog and/or digital outputs? Are faults archived by the gas detection system? Will an inoperative system be identified through a self-activated alarm (fail-safe)? Will the system alert the user that a calibration is required? Are communication outputs supervised?

6.11 *Display* — What local displays are available on the gas detection systems? Where is the display located? Does the display show gas concentration level with engineering units and identify active alarms with signal lights? Are other diagnostic and control functions displayed when activated? Is the display easy to read from a distance?

6.12 *Drift* — What is the zero and span drift over 30, 60, 90, and 180 days? Does the gas detection system compensate for drift?

6.13 *Environmental Conditions* — What are the temperature and relative humidity specifications for the gas detection system for normal operation as well as for storage of consumable parts? Could environmental changes such as quick humidity transients or temperature changes cause the gas detection system to spike or drift into an alarm condition?

6.14 *Equipment Failure* — Is the gas detection system capable of reporting all single point failures that disable detection? What failure mode disables both detection of gas and reporting failure?

6.15 *Expansion Flexibility* — Is the gas detection system capable of expansion to accommodate additional detection points? How easy is it to integrate into the user's system (hardware, installation, programming, etc.)?

6.16 *Extraction Detection Systems*

6.16.1 *Sampling Distance* — What is the maximum sampling distance for the gas detection system? Will all the gas entering the sample line at the point of detection reach the central monitor? What is the sample loss due to the challenge gas absorbing onto the sample tubing walls?

6.16.2 *Sample Cycle Time* — How frequently, if multiple points are sampled, is the same detection point surveyed by the extraction detection system, at the desired alarm level?

6.16.3 *Sample Contamination* — What, if any, is the potential for contamination of the sample line tubing and manifolding equipment when multiple gases are monitored within the same extraction system? What combination of gases should be avoided due to chemical interaction on wetted materials?

6.17 *Filter Lag* — Does the gas detection system use any mechanical, chemical or electronic filters (for cross sensitivity, particles, etc.) which could slow the sampling response? If so, what lag time is expected for each gas type?

6.18 *Installation - Wiring Configuration* — How many wires are required per detection point? Can the system be wired in a highway configuration (bus, ring, star, etc.)? Are special barriers or grounds required to ensure no earth loop faults exist?

6.19 *Isolation* — Does the gas detection system require any special electrical isolation or grounding?

6.20 *Limits of Detection*

6.20.1 *Lowest Alarm Level* — What is the lowest alarm level setting for the gas detection system which will not activate due to sensor drift or insufficient signal to noise ratio?

6.20.2 *Limit of Detection* — What is the absolute lowest value that a sensor can detect, for each gas?

6.20.3 *Upper Limit of Detection* — What is the highest level of gas that can be quantified reliably by the gas detection system?

6.21 *Linearity* — What is the linearity over the full measuring range of the gas detection system output?

6.22 *Maintenance Interval* — What is the manufacturer's recommended maintenance frequency? What is involved to perform this maintenance? What items potentially require maintenance or periodic replacement (pumps, sensors, tapes, etc.)?

6.23 *Other Utilities* — In addition to electrical power, what other utilities are required to operate the system (e.g., compressed air, hydrogen, oxygen, etc.)?

6.24 *Outputs* — Does the gas detection system have analog, digital, and relay outputs? How many are available per system?

6.25 *Physical Size* — What is the physical size of the gas detection system for both the detection head (or sampling point) and the control systems or central monitor, including the required floor space?

6.26 *Poisoning* — Is the gas detection system susceptible to gases or vapors which would reduce the performance (ability to detect gas) of the system or render it contaminated and inoperative?

6.27 *Position Effect (Attitude Sensitivity)* — Is there a specific orientation of the sensor, detector, or sampling point required for the gas detection system to function optimally?

6.28 *Power Outage* — When system power is lost, what happens to the gas detection system? Once power is restored, what is the time lag before the system is fully functional?

6.29 *Power Requirements* — What are the power requirements (i.e., AC, DC, voltage, and amperage) of the system? What is the power draw of the total gas detection system?

6.30 *Recovery Time* — What is the amount of time it takes the gas detection system, once exposed to challenge gas, to recover to 10% of the original target gas concentration value?

6.31 *Repeatability* — What is the ability of the gas detection system to produce the same detection results within a certain percentage, when repeatedly exposed to the same gas concentration?

6.32 *Reliability* — What is the expected life of the various portions of the gas detection system (including the main unit, detection sensors, and consumables)?

6.33 *Replacement/Replenishment* — Does the system contain consumable items? How frequently must they be replaced? Can they be replaced by the user or is a factory person required for servicing?

6.34 *Resolution* — What is the level of resolution for changes in gas concentration? That is, to what extent can the gas detection system detect a changing challenge gas concentration? Is this user selectable?

6.35 *Response Time* — From the point of release of the challenge gas, how long does it take the gas detection system to reach 90% of the challenge gas concentration?

6.36 *RFI/EMI Susceptibility* — Does the gas detection system meet the requirements for CE Marking for RFI/EMI immunity and per SEMI E33?

6.37 *Self-Test* — Does the gas detection system have an automatic or user initiated self-test routine? How is it accomplished? What is the interval for the self-test? Can the operator override the self-test? Is the self-test just an electrical check or is gas actually generated? Is the generated gas the target gas?

6.38 *Sensor Exchange* — Do sensors require on-site calibration only or can they be factory calibrated? Are additional adjustments or programming operations required when replacing a sensor? Is there a warm-up period for the sensors before they are functional (for calibration purposes)? If so, how long?

6.39 *Sensor Specificity* — Are gas specific sensors available for every gas that must be monitored? What are the known interferences to the gas detection system that could cause a false alarm or mask a real alarm?

6.40 *Service & Support* — What is the manufacturer's capabilities to service and support their equipment once it is has been installed? Does the manufacturer have a 24 hour/7 day service support program in place?

6.41 *Spare Parts Availability* — What is the availability of spare parts from the manufacturer? Are emergency spare parts always available?

6.42 *Special Handling Considerations* — Are there items that require special handling, storage, or disposal? If so, what are the considerations?

6.43 *Storage and Shelf-Life Requirements* — What are the storage (environmental) requirements for the consumable items (e.g., electrochemical sensors and paper tapes)? Do these items have a shelf-life and if so how long?

6.44 *System Check* — Does the gas detection system have a system check facility? If so, is this done on a continuous or interval basis? What is the interval?

6.45 *System Expandability & Flexibility* — Is the gas detection system universal, in the sense that the user can change from one gas sensor to another by only exchanging the sensing elements? How much modification is required? Can this be done in the field by the user or must the detection system be returned to the manufacturer for service?

6.46 *Wake Up Requirement* — Does the gas monitor's sensor require periodic doses of challenge gas or electrical charges to ensure the sensor will continually operate? If so, what is the interval required for each gas type or electrical challenge?

6.47 *Warm Up Period* — Upon installation or sensor replacement, how long does it take for the gas detection system's sensor to stabilize after power is applied?

6.48 *Warranty* — What is the warranty period of the gas detection system?

7 Gas Detection Technologies Available

7.1 Several gas detection technologies are described in the following paragraphs. As additional technologies become available, they should be considered, using the performance characteristics described above.

7.2 *Acoustic (Hydrogen Gas Measurement Only)* — Piezoelectric crystals send and receive pulsed ultrasound. These sound waves travel through two tubes of air, one tube filled with sample air, the other with reference air. The returned pulses are counted, normalized for temperature, and compared. Through mathematical calculations the result represents the concentration of hydrogen gas present in percent by volume or percent LEL.

7.3 *Catalytic* — Catalytic gas sensors measure flammable gases by comparison of the change in resistance across a Wheatstone bridge. The sensor contains two resistive elements (beads), one active which increases its resistance when exposed to gas, and the other which maintains a constant resistance. The sensor output is then conditioned by the gas detection system and generates a current output proportional to the gas concentration in percent of lower explosive limit (LEL).

7.4 Electrochemical — Electrochemical gas sensors measure toxic gases and contain components (electrodes and electrolyte) designed to react when exposed to a specific toxic gas or a family of gases; the reaction generates a current which is measured and conditioned by the gas detection system and represents an output which is proportional to the concentration of gas, measured in parts per million (ppm) or parts per billion (ppb).

7.5 FTIR — Fourier-transform infrared (FTIR) gas detection systems use spectrophotometric techniques to detect and measure gas. Infrared light is passed through a gas sample, and the resulting absorbency spectrum is analyzed to determine its constituents. A current output is generated which is proportional to the concentration of gas present.

7.6 Infrared — Monochromatic infrared gas detection systems measure the absorption of radiation (light) by a gas sample. The absorption is translated into a current output which is proportional to concentration. Each gas has a unique absorption wavelength which the system must be tuned to make an accurate measurement.

7.7 Ion Detection — Ion detection is useful for detecting SiO₂ particles which are created by the burning of certain gases such as silane, TEOS and TEOA. SiO₂ “smoke” is created when these gases are burned, and this can be detected with an ionization detector chamber, which operates similarly to a smoke detector. SiO₂ particles entering the chamber create a signal that is calibrated to represent the presence of a known concentration of the target gas. A gas detection system using this method is typically used in a sample draw system and can be used either by itself or in conjunction with a pyrolyzer to condition (burn) the gas entering the detection head.

7.8 Molecular Emission Spectrometer — Sample air is injected into a reaction chamber. In the reaction chamber, a flame, fed by hydrogen and sample air, is the activating reaction. When a sample gas enters the flame, reactions of the target gas result in additional light emissions. The resulting light passes through two optical filters and is converted to electronic signals in a dual photomultiplier tube. The signals are combined to produce a linear, quantitative output.

7.9 Paper Tape — Paper tape systems use the color change of a chemically impregnated tape to detect toxic gases. The tape changes color when exposed to a challenge gas; the color change is then detected by a photocell, analyzed, and converted into a concentration value (ppm or ppb).

7.10 Solid State — One type of solid state sensor is made of a metal oxide (typically tin-oxide) material that changes resistance in response to the presence of a toxic gas; the gas detection system measures this resistance change and converts it into a concentration value. Thin film semiconductor sensors absorb the target gas onto the semiconductor, resulting in a transfer of electrons which causes a measured change in the resistance of the semiconductor and reported as a ppm or ppb concentration.

8 Related Documents

8.1 SEMI Documents

SEMI S2 — Environmental, Health, and Safety Guideline for Semiconductor Manufacturing Equipment

8.2 American Conference of Governmental Industrial Hygienists (ACGIH)¹ — *Threshold Limit Values for Chemical Substances in the Work Environment*

8.3 Uniform Fire Code²

UFC Article 51 — Semiconductor Fabrication Facilities

UFC Article 80 — Hazardous Materials

8.4 National Fire Protection Association³

NFPA 49 — Hazardous Chemical Data

NFPA 70 — National Electric Code

NFPA 72 — National Fire Alarm Code

NFPA 318 — Protection of Cleanrooms

8.5 International Fire Code⁴

8.6 Santa Clara, California Uniform Fire Code,⁵ Amendments 1998 Edition

8.7 Southern Building Code Congress International⁶

Standard Building Code — Chapter 22: Hazardous Materials, 1994 Edition

¹ American Conference of Governmental Industrial Hygienists (ACGIH), 1330 Kemper Meadows Drive, Cincinnati, OH 45240-1634

² Published by International Conference of Building Officials and Western Fire Chiefs Association, 5360 South Workman Mill Road, Whitter, CA 90601

³ National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269

⁴ International Fire Code Institute, 9300 Jollyville Road, Suite 105, Austin, TX 78759

⁵ Santa Clara Fire Department, 777 Benton Street, Santa Clara, CA 95050

⁶ Southern Building Code Congress International (SBCCI), 900 Montclair Road, Birmingham, AL 35213



8.8 *US Government*

Occupational Safety and Health Organization (OSHA)⁷
29 CFR - Sections 1910.119 and 1910.1000

US Environmental Protection Agency (EPA)⁸ *40 CFR*
68.13, Subpart C

⁷ US Government Printing Office, Washington, D.C. 20402
⁸ Superintendent of Documents, US Government Printing Office,
Washington, D.C. 20402

APPENDIX 1

TABLE FOR COMPARISON OF PERFORMANCE CHARACTERISTICS

NOTE: The material in this appendix is an official part of SEMI S15 and was approved by full letter ballot procedures on December 15, 1999 by the North American Regional Standards Committee.

Table A1-1

<i>Performance</i>	<i>Manufacturer/Technology</i>				
<i>Characteristics</i>	<i>A.</i>	<i>B.</i>	<i>C.</i>	<i>D</i>	<i>E.</i>
Accuracy					
Alarms					
Calibration					
Certifications and Classifications					
Communications (Serial)					
Conditioning Requirements					
Cost of Ownership					
Data Archiving					
Diagnostics					
Display					
Drift					
Environmental Conditions					
Equipment Failure					
Expansion Flexibility					
Extractive Systems: Sampling Distance Sample Cycle Time Sample Contamination					
Filter Lag					
Installation (Wiring Configuration)					
Isolation					
Limits of Detection: Lowest Alarm Level Limit of Detection Upper limit of Detection					
Linearity					
Maintenance Interval					
Other Utilities					
Outputs					
Physical Size					
Poisoning					
Position Effect (Attitude Sensitivity)					
Power Outage					
Power Requirements					
Recovery Time					
Repeatability					

<i>Performance</i>	<i>Manufacturer/Technology</i>				
<i>Characteristics</i>	<i>A.</i>	<i>B.</i>	<i>C.</i>	<i>D</i>	<i>E.</i>
Reliability					
Replacement/ Replenishment					
Resolution					
Response Time					
RFI/EMI Susceptibility					
Self-test					
Sensor Exchange					
Sensor Specificity					
Service and Support					
Spare Parts Availability					
Special Handling Considerations					
Storage and Shelf-life Requirements					
System Check					
System Flexibility					
Wake Up Requirements					
Warm Up Period					
Warranty					

NOTICE: SEMI makes no warranties or representations as to the suitability of the guidelines set forth herein for any particular application. The determination of the suitability of this guideline is solely the responsibility of the user. Users are cautioned to refer to manufacturer's instructions, product labels, product data sheets, and other relevant literature respecting any materials mentioned herein. This guideline is subject to change without notice.

The user's attention is called to the possibility that compliance with this guideline may require use of copyrighted material or of an invention covered by patent rights. By publication of this guideline, SEMI takes no position respecting the validity of any patent rights or copyrights asserted in connection with any item mentioned in this guideline. Users of this guideline are expressly advised that determination of any such patent rights or copyrights, and the risk of infringement of such rights, are entirely their own responsibility.

SEMI S16-0600

ENVIRONMENTAL, HEALTH AND SAFETY GUIDELINES FOR SEMICONDUCTOR MANUFACTURING EQUIPMENT DISPOSAL

These guidelines were technically approved by the Global Environmental, Health and Safety Committee and are the direct responsibility of the Japanese Environmental, Health and Safety Committee. Current edition approved by the Japanese Regional Standards Committee on April 28, 2000. Initially available on www.semi.org June 2000; to be published June 2000.

1 Purpose

1.1 This document provides guidelines to minimize hazards to workers and impacts to the environment during equipment and component disposal.

2 Scope

2.1 These guidelines apply to the disposal of semiconductor manufacturing equipment, its materials and components and equipment design consideration to facilitate disposal.

2.2 These guidelines are intended to be voluntary best practices for this industry. These guidelines apply to disposal parties, equipment designers, equipment manufacturers, equipment suppliers and equipment owners. The information should be provided to the disposal party by the equipment owner prior to contract negotiations.

2.3 These safety guidelines do not purport to address all of the safety issues associated with its use. It is the responsibility of the users of these guidelines to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

3 Limitation

3.1 These guidelines are not intended to supersede the applicable codes and regulations of the region where the equipment is disposed.

3.2 Section 6 in these guidelines should be applied not to existing models and subsystems but to newly designed models and subsystems after publication of these guidelines.

4 Referenced Standards

4.1 SEMI Standards

SEMI S1 — Safety Guidelines for Visual Hazard Alerts

SEMI S2 — Environmental, Health, and Safety Guideline for Semiconductor Manufacturing Equipment

SEMI S10 — Safety Guideline for Risk Assessment

SEMI S12 — Environment, Health and Safety Guidelines for Equipment Decontamination

SEMI S13 — Safety Guidelines for Operation and Maintenance Manuals Used with Semiconductor Manufacturing Equipment

4.2 ISO Documents¹

ISO11469 — Plastics; Generic Identification and Marking of Plastic Products

ISO14001 — 1996 Environment Management Systems, Specifications with Guideline for Use

4.3 CEN² / CENELEC³ Document

EN1050 — Safety of Machinery—Principles for Risk Assessment

4.4 OSHA Document⁴

29 CFR 1910. 1200 — Labor

NOTE 1: As listed or revised, all documents cited shall be the latest publications of adopted standards.

5 Terminology

5.1 Terminology defined in SEMI S1, S2, S12, and S13 should be referred to except if otherwise specified below.

5.1.1 *decontaminate* — to remove all known hazards from equipment, including chemical, physical, electrical, to a level that will not pose a threat or harm to humans or the environment. This level may be set by each country, state and local regulations or industry practice.

5.1.2 *decontamination* — the process required to remove hazards to an acceptable level of risk (see Section 5.1).

1 International Standards Organization, 1, rue de Varembe, Case postale 56, CH-1211 Geneve 20, Switzerland.

2 European Committee for Standardization, 36, rue de Stassart, B-1050 Brussels, Belgium

3 European Committee for Electrotechnical Standardization, Rue de Stassart, 35, B-1050 Brussels, Belgium

4 US Government Printing Office, Washington, D.C. 20402

5.1.3 *disposal* — to dispose of equipment and/or component/material based on legislation or industry/regional standard practices.

5.1.4 *disposal party* — a party who disposes of equipment and its components.

5.1.5 *EMAS* — Eco-Management and Audit Scheme which came into force in July, 1993 and operational in the EU Member States in April, 1995.

5.1.6 *equipment owner* — a party who surrenders equipment to a disposal party or disposals of potentially contaminated materials or components.

5.1.7 *hazardous energy* —energy with the potential to affect human health or the environment.

5.1.8 *hazardous material* — materials including chemicals (solid, liquid or gas) that pose a threat to the environment or human health as defined by international, each country and local regulations.

5.1.9 *Material Safety Data Sheet (MSDS)* —written or printed material concerning chemical elements and compounds, including hazardous materials, prepared in accordance with applicable standards such as the International Labor Convention (ILC) No. 170, provisions of USA government regulation 29 CFR 1910.1200, or Canadian WHMIS (Workplace Hazardous Material Information System).

6 Equipment Design for Disposal

6.1 The equipment design should comply with environment section of SEMI S2.

6.2 The equipment design should consider the following regarding disassembly prior to waste treatment:

6.2.1 The equipment design should encourage refurbishing, reuse or recycling.

6.2.1.1 The equipment design should enable disassembly down to the component or subassembly size to facilitate refurbishing or recycling.

6.2.1.2 The equipment design should provide for the ability to appropriately decontaminate all components.

6.2.2 The equipment design should consider enabling all hazardous energies in/on the equipment to be reduced to a non-hazardous level upon equipment disassembly. If a hazardous energy still remains, see Section 7 of this document.

6.2.2.1 This includes the ability to release or remove any trapped materials.

6.2.3 The equipment design should avoid mixing of incompatible chemicals upon equipment disassembly.

If this is not feasible, an appropriate hazard alert label based on SEMI S1 should be affixed at each applicable position (see Section 7 of this document).

6.2.4 The equipment design should prevent release of hazardous materials to the environment upon equipment disassembly. If this is not feasible, see Section 7 of this document.

6.3 Chemicals used to maintain the equipment or chemicals used in the baseline process should comply with following sub-sections.

6.3.1 Materials for which special disposal procedures are required, such as batteries (lithium, ni-cad, mercury and silver), mercury and fluorescent lamps, and other potentially hazardous material should be accompanied by material safety data sheet (MSDS) or other document describing necessary information for disposal and instructions for safe handling and disposal.

6.3.2 Additional information on proper disposal of materials, designed into the equipment with the intent of being contaminated but disposable, but not hazardous themselves until contaminated, such as absorbents and adsorbents, should also be provided with disposal procedures which minimize environmental impact and personnel effect.

6.3.3 Equipment containing ionizing radiation sources subject to licensing by federal or local agencies should be constructed so as to allow the easy removal of ionizing radiation sources. Disposal of ionizing radiation sources must be in compliance with applicable each country, state and local regulations.

6.4 Construction materials and components of equipment should be selected by considering their environmental impacts based on the supplier's environment management program. Environment management programs should be constructed based on ISO14001, EMAS or other environment management system.

6.5 The hazardous and primary construction materials of equipment should be provided in document such as operation and/or maintenance manuals based on the supplier's environment management program.

6.5.1 Recycling category identification should be molded as part of the material or labeled on the material. This requirement should only be applied to non-metallic materials which are capable of being molded or labeled.

6.5.2 Identification and marking of plastics should comply with ISO11469 unless local regulations differ. This requirement should be applied to only materials which are able to be molded or labeled.