SEMI S12-0211
ENVIRONMENTAL, HEALTH AND SAFETY GUIDELINE FOR MANUFACTURING EQUIPMENT DECONTAMINATION

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1 Purpose

1.1 This document establishes guidance for decontaminating manufacturing equipment (ME) and parts that were or may have been exposed to hazardous materials and which are intended for further productive use. Equipment intended for further productive use includes that being offered for reuse, resale, repair, refurbishment, or relocation.

1.2 This Safety Guideline should be adopted at each site with proper consideration given to local, state, national, and international regulations and organization policies.

NOTE 1: It may be beneficial to seek professional support in implementing this Safety Guideline.

1.3 This Safety Guideline is intended to be used to ensure that decontamination prior to transportation occurs to the greatest extent possible, while acknowledging practical limitations that may exist in individual circumstances. It is recognized that, in many cases, complete chemical decontamination cannot be achieved without destruction of the ME. The ME transferor should ensure that all known remaining potential hazards are clearly identified to the transferee.

2 Scope

2.1 This Safety Guideline applies to the decontamination and handling of ME and parts that were or may have been exposed to hazardous materials and may pose a threat to human health or the environment. Handling activities include shutdown, dismantling, removing, labeling, and packaging prior to transport.

2.2 This Safety Guideline describes minimum criteria for documentation of decontamination and residual hazards associated with decontamination.

NOTICE: SEMI Standards and Safety Guidelines do not purport to address all safety issues associated with their use. It is the responsibility of the users of the documents to establish appropriate safety and health practices, and determine the applicability of regulatory or other limitations prior to use.

3 Limitations

3.1 This Safety Guideline is not intended to address criteria for the preparation of ME for final, (i.e., “end-of-life”) disposal. This Safety Guideline is limited to addressing the decontamination of ME or parts. Refer to SEMI S16 for guidance as related to the ME design as it is related to ME disposal.

NOTE 2: A summary of key considerations for “end of life” practices and disposal of ME is located in the Related Information 4 section of this document.

3.2 This Safety Guideline is not intended to address all decontamination measures associated with radioactive material or magnetic fields.

3.3 This Safety Guideline is not intended to supersede applicable international, governmental, site, or original ME manufacturer requirements.

4 Referenced Standards and Documents

4.1 *SEMI Standards and Safety Guidelines*

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

SEMI S16 — Guide for Semiconductor Manufacturing Equipment Design for Reduction of Environmental Impact at End of Life

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4.2 *NFPA Standard*[1]

NFPA 70E — Standard for Electrical Safety in the Workplace

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

5 Terminology

5.1 *Abbreviations and Acronyms*

5.1.1 *CDA* — clean dry air

5.1.2 *DIW* — deionized water

5.1.3 *HAZCOM* — hazard communication

5.1.4 *HEI* — hazardous energy isolation

5.1.5 *HEPA* — high efficiency particulate air

5.1.6 *ME* — manufacturing equipment

5.1.7 *MSDS* — material safety data sheet

5.1.8 *PBI/FR* — polybenzimidazoles/flame resistant

5.1.9 *PM* — preventative maintenance

5.1.10 *PPE* — personal protective equipment

5.1.11 *SCBA* — self contained breathing apparatus

5.2 *Definitions*

5.2.1 *assessment* — method of acquiring information related to a process that is intended to be performed or the effectiveness of an action that has been completed.

5.2.2 *blanking device* — a device used to seal flanged mating surfaces.

5.2.3 *by-products* — chemicals which are formed from reactions during the process.

5.2.4 *chemical health hazard* — the ability, for which there is process knowledge or verifiable evidence, based on established scientific principles, of a chemical to cause acute or chronic health effects in exposed persons. Health hazards include those of chemicals which are carcinogens, toxic or highly toxic materials, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, neurotoxins, agents which act on the hematopoietic system, and agents which damage the lungs, skin, eyes, or mucous membranes.

5.2.5 *consumables* — all parts of the ME that are worn out by the process operation and require periodic replacement.

5.2.6 *contaminated* — having come into contact with chemicals including greases/oils, gases, and water.

5.2.7 *dead zone* — areas within a component, system or ME that are inaccessible and where contaminants tend to collect.

5.2.8 *decommission* — to remove manufacturing equipment from active service.

5.2.9 *decontamination* — the reduction or elimination of hazardous materials from personal or real property.

5.2.10 *Hazard Communication (HAZCOM)* — communication of environmental and safety hazards for the chemicals present or potentially present on or adjacent to the ME and parts to all potentially affected employees, decontamination personnel, and ME owners before decontamination procedures are executed.

5.2.11 *hazardous material* — any chemical, substance, or compound which is defined or interpreted to pose risks or hazards to human health or the environment by applicable international, national, regional, or local laws or regulations.

[1] National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269, USA. Telephone: 617.770.3000; Fax: 617.770.0700; http://www.nfpa.org

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5.2.12 *maintenance* — planned or unplanned activities intended to keep equipment in good working order. (See also the definition for service.) [SEMI S2, SEMI S8, SEMI S10, SEMI S20]

5.2.13 *manufacturing equipment (ME)* — equipment used to manufacture, measure, assemble, or test products. It includes the equipment that processes substrates (e.g., silicon wafers, reticules), its component parts, and its auxiliary, support or peripheral equipment (e.g., chemical controllers, chemical delivery systems, vacuum pumps). ME also includes other items (e.g., piping, ductwork, effluent treatment systems, valve manifold boxes, filtration, and heaters) specific to and provided with the aforementioned equipment, but does not include such an item if the item is part of a facility and can support more than one piece of ME.

5.2.14 *owner* — the entity that has the highest level of access authority or legal right to a system or equipment.

5.2.15 *p-traps* — mechanical drain connections designed to prevent air transfer between drain systems and points of use.

5.2.16 *ring test* — a ring is placed around a gas or chemical supply line and traced along the entire length of line either from connection where the line starts to where connection to ME is performed or in the other direction.

5.2.17 *Supplier* — party that provides equipment to, and directly communicates with, the user. A supplier may be a manufacturer, an equipment distributor, or an equipment representative (see also the definition for user). [SEMI S2]

5.2.18 *service* — unplanned activities intended to return equipment that has failed to good working order. (See also the definition for maintenance.) [SEMI S2, SEMI S8, SEMI S10, SEMI S20]

5.2.19 *transferor* — the party with physical custody of the ME.

5.2.20 *transferee* — the party who will receive physical custody of the ME.

5.2.21 *user* — the organization(s) or persons within those organization(s) who will operate the system or equipment for its intended purpose.

5.3 *Symbols*

5.3.1 ¶ — a character used to identify a particular paragraph of the document. The identified portion includes the numbered paragraph identified by the number following the symbol and the Exceptions and lists (bulleted or numbered) embedded therein. It does not, however, include the subordinate headers and paragraphs. When duplicated, as ¶¶, it refers to more than one paragraph. For example, ¶ 8.5.3 refers to the text immediately following that number, the bulleted list, and the Exception. Contrarily, ¶ 8.5.1 refers to only that paragraph, but not to ¶ 8.5.1.1, 8.5.1.2, or 8.5.1.2.1.

5.3.2 § — a character used to identify a particular section or subsection of the document. The identified portion includes the numbered paragraph or header identified by the number following the symbol and all subordinate headers and paragraphs as well as the Exceptions and lists (bulleted or numbered) embedded therein. When duplicated, as §§, it refers to more than one section or subsection. For example, § 8.5 refers to ¶¶ 8.5, 8.5.1, 8.5.1.1, 8.5.1.2, 8.5.1.2.1, 8.5.2, and 8.5.3 (including the bulleted items and the Exception).

6 Responsibilities

6.1 The manufacturing equipment (ME) or component supplier should develop and document procedures required to decontaminate its products based on the ME use anticipated by the supplier.

6.2 Users should develop and document specific procedures based on chemistry used in ME.

6.3 The transferor should be responsible, unless otherwise negotiated, for preparing the documentation and certification for the ME (see § 11).

6.4 The transferor should be responsible, unless otherwise negotiated, for conducting a hazard assessment of the ME (see § 8.4 and § 8.5).

6.5 The ME transferor should be responsible for ensuring the removal or minimization of hazardous materials associated with the ME prior to transfer or relocation.

6.6 The ME transferor should be responsible for ensuring that residues, waste materials, and scrap parts/ME that are generated as part of the ME decontamination process are safely handled and appropriately disposed of in accordance with local, state, national, and international regulations or standards.

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6.7 The ME transferor and transferee should make every effort to ensure that their employees, third party representatives, and contractors are adequately trained in the proper identification, recognition, and treatment of all known hazards that can cause injury to personnel or contamination to the environment associated with the ME being transferred.

7 Training and Qualifications

7.1 Only properly trained and equipped personnel should perform assessment and decontamination activities. ME owner should ensure that the assessment and decontamination service provider is qualified to perform scope of work.

7.2 Decontamination activities should not begin until the specific procedures have been approved by the ME transferor.

7.3 Assessment and decontamination procedures should include criteria for appropriate personal protective equipment.

8 Project Planning for Decontamination

8.1 *General Criteria*

8.1.1 All activity-specific safety and health procedures, including hazardous energy control procedures, should be followed.

8.1.2 Equipment should be decontaminated prior to being moved. However, if movement of the ME is required prior to decontamination, precautions should be taken to remove potential sources of leakage, spillage, out-gassing, or hazardous material emissions. These precautions may include draining or purging followed by the use of appropriate barriers, covers, or containment devices. Such movement may be required to locate ME to temporary storage or alternate decontamination area onsite or within close proximity.

8.1.3 Chemical supply sources should be made safe prior to disconnection or removal from the ME and capped prior to the cleaning process. All chemical and gas supply lines may be ring tested to verify where the supply pipe connects to the ME or facility prior to disconnecting or cutting these lines. The supply end and the ME end of the line should be capped using the originally supplied caps or their equivalents. All chemical lines from the facility and internal to the ME should be handled with extreme care and considered as hazardous until determined safe for handling.

NOTE 3: The ring test is used to verify that each gas or chemical supply line is traced from its source to the point of connection to the equipment (or in the other direction) to ensure that the supply sources have been made safe prior to disconnecting or cutting each line.

8.1.4 All liquid and gas lines on the ME, including tanks for liquids, should be appropriately purged, drained, protected against corrosion and process contamination, and securely sealed with blanking plugs, caps, or similar devices. An exception may be made for closed loop systems (e.g., refrigeration), which cannot be removed. Where required, licensed technicians should be used for draining refrigeration systems. Residual amounts left inside the ME should be documented on the decontamination certificate.

8.1.5 When the intended use of the ME is known, the decontamination processes employed should not have a negative effect on the ability to reuse the ME as intended.

8.1.6 Exhaust ventilation to control exposures to, and the spread of, airborne contaminants should remain in service during ME decontamination or alternate exhaust provisions should be made. Where any flammable, reactive, corrosive, or toxic gases or gas compounds were used or may be potentially trapped in the ME, components, systems, or subsystems gas lines, safety controls should be implemented to protect the employee from any flashing or gas ignition and from a source releasing corrosive or toxic gases into the work area. These safety steps may include:

1. using snorkel devices attached to the facility exhaust system to capture flammable/reactive/corrosive/toxic gases being released when valves or ME is disassembled or opened during decontamination;
2. setting up a contained enclosure around the ME, component, system, or subsystem where the controlled release is conducted.

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3. the wearing of personal protective equipment (PPE) including a self-contained breathing apparatus (SCBA), flame retardant or corrosive resistant coveralls, head cover, and gloves. This is done to protect in the event of inadvertent release.

8.1.7 Where ME parts (e.g., those used in ion implanters, photoresist spinners/developers, and metal deposition chambers) are removed from the ME for scheduled cleaning, normal maintenance, service or refurbishment, these parts should be cleaned prior to ME transfer. Parts that are removed for additional cleaning, on-site or at vendors, should be double wrapped or bagged and a tag detailing the type of chemicals of concern expected should be attached.

8.1.8 Where ME parts (e.g., filters, o-rings, and oil traps) are routinely removed and replaced, these parts should be removed and replaced with clean parts or an appropriate blanking device prior to ME transfer. If any such parts are removed but not replaced, this fact should be noted in the documentation provided to the transferee. If contaminated consumable parts are removed, ensure they are disposed of in an appropriate hazardous waste stream system.

8.1.9 Thorough decontamination may not be achieved within component systems or ME due to inaccessibility (e.g., "dead zone") or to physical characteristics of materials. ME with such zones requires additional cycle purges or disassembly for access and proper cleaning. If complete decontamination cannot be achieved, follow the guidance outlined in § 11.

8.1.10 While disconnecting ME or removing components, exposure monitoring appropriate to the hazard should be performed. Monitoring techniques to be considered include use of toxic or flammable gas detection systems, industrial hygiene sampling, wipe sampling and pH measurements.

8.1.11 Prior to transfer, the transferor should ensure that any remaining hazards are clearly identified.

8.1.12 A signed acknowledgement of receipt, by the transferee, of all documentation and certifications specified in § 11 should be obtained before transfer of contaminated ME.

8.1.13 It is recognized that, in some cases, complete chemical decontamination cannot or will not be desired or achieved for various reasons (e.g., it will destroy the ME (e.g., pumps) or there is a need for failure analysis). Equipment that is not completely decontaminated may be classified for transportation as a hazardous material. Transfer of this ME, including transportation, should be in accordance with all applicable local, state, national, and international regulations and organization policies.

8.1.14 Table 1, Planning by ME Disposition, is intended to be used as a quick guide to determine basic assessment and other items prior to decontamination and evaluation. This chart should be used only as a method to determine items and criteria that could need additional research and investigation. The ME or part transferor should validate that ME manufacturer and owner decontamination procedures are available prior to transfer.

Table 1 Planning by ME Disposition

	Disposition				
	Move Within Facility	*Move from One Facility to Another on Same Site*	*Move from One Site to Another*	*Storage*	*End of Life Disposal*
EHS or designated equivalent perform hazard and contamination assessment to determine decontamination criteria	✓	✓	✓	✓	✓
Refer to SEMI S16 for all end of life disposal (see ¶ 3.1 of this document)					✓
Documentation	✓	✓	✓	✓	
Communication between ME owner and contractors	✓				
Package to eliminate leakage of residual materials	✓	✓	✓	✓	
Communication between Site Owners, ME owner, and contractors		✓			

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	Disposition				
	Move Within Facility	*Move from One Facility to Another on Same Site*	*Move from One Site to Another*	*Storage*	*End of Life Disposal*
Decontaminate ME per § 9			✓	✓	
Transport ME in accordance with local/regional regulatory requirements			✓	✓	✓
Communication and documentation review by receiving organization prior to ME being shipped			✓	✓	

8.1.15 Table 2, EHS Planning Considerations, is intended to be a quick guide to determine the basic EHS planning consideration for the four listed areas. Table 2 is not intended to be inclusive of all planning activities for all situations before decontamination is conducted.

Table 2 EHS Planning Considerations

EHS Planning Considerations	
Hazard and Contamination Assessment	Historical chemical use (includes process, auxiliary (e.g., heat transfer fluid), and maintenance chemicals.) HAZCOM Electrical Hazardous Energy Isolation Chemical exposure Radioactive Magnetic Sampling and analysis for external contaminants from other sources or from spill events
PPE	Clothing Respiratory Hand Head Eye Face Feet Fall protection
Facility and Utility Requirements	Communication with responsible facility parties Electrical Clean dry air (CDA) Gas and chemical delivery systems Equipment (ME) exhaust House ventilation and exhaust House vacuum systems Facility chill water and de-ionized water (DIW) systems
Waste	Determine owner of waste system Control (handling, storage and packaging) wastes Regulated vs. non-regulated Hazardous vs. non-hazardous

8.1.16 In situ decontamination in a running cleanroom requires very strict cleanliness protocols in comparison to fab closures. All support equipment should meet the ME owner's cleanroom protocol and activities should not contaminate other processes.

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8.2 The following items should be identified prior to decontamination:

8.2.1 the location of the eyewash and safety showers,

8.2.2 the area to be barricaded if a potential for exposure to others exists,

8.2.3 the availability and familiarity with the MSDS for the chemicals to which the ME or parts have been exposed,

8.2.4 the points in piping that may contain chemicals (e.g., p-traps and dead zones), and

8.2.5 isolation of all energy sources.

8.3 *Documentation*

8.3.1 The maintenance and operations instructions for the ME and other supplier and user documentation, including that described below, that addresses the following hazards should be considered prior to developing the decontamination procedure.

8.3.1.1 General EHS hazards specific to the ME, part or component.

8.3.1.2 HAZCOM written program and applicable training records.

8.3.1.3 *Hazardous Energy Control* — Refer to SEMI S2 section on Hazardous Energy Isolation.

8.3.1.4 *Electrical Safe Work Practices* — Refer to NFPA 70E.

8.3.1.5 *Radiation* — Refer to SEMI S2 section on Ionizing Radiation.

8.3.1.6 Fire safety hazards.

8.3.1.7 *Waste Handling and Disposal* — Refer to SEMI S2 section on Environmental Considerations and to the site waste disposal procedures to address the waste handling/disposal hazards for the ME. The party responsible for waste disposal, waste generation assignment, and party responsible for signing any manifests or waste documentation should be determined before decontamination is initiated.

8.3.2 Occupational exposure monitoring performed during decontamination processes should be documented.

8.4 *Hazard and Contamination Assessment*

8.4.1 An assessment, as shown in Figure 1, should be performed on all ME prior to transfer. The initial assessment of ME should consider the history of the ME, visual inspection, and results of samples taken of external surfaces and areas of the ME exposed to hazardous gases or chemicals during processing. Some disassembly may be required to complete this assessment. If the assessment shows that the ME may have come into contact with hazardous materials during processing, or if sample results indicate that contamination exists, further assessment should be performed.

8.4.2 Prior to decontamination, the ME should be evaluated for both abnormalities and non-functionality that may affect the assessment and decontamination efforts.

NOTE 4: Visible residues on ME surfaces (e.g., liquids, powders, flakes, or films) should be assumed to be hazardous unless otherwise determined and documented by appropriate test, analysis, and evaluation. Wipe sampling and chemical testing verifying the absence of materials posing physical and health hazards is recommended for all ME that may have been exposed to hazardous materials regardless of the presence of visible residues. Appropriate sampling methods and procedures will vary depending on the ME model and processing. In order to make a determination as to the number of samples and locations sampled, it is recommended that professional guidance be obtained. Reference to the ME manufacturers recommended procedures should be made prior to the start of any testing and sampling.

8.4.3 If results of activities in § 8 indicate that ME should be decontaminated prior to transfer, refer to § 9 of this document. If results of activities in § 8 indicate that ME requires decontamination but will not or cannot be decontaminated prior to transfer, see § 11. If results of activities in § 8 indicate that ME does not require decontamination prior to transfer, this remainder of this Safety Guideline is not applicable to the ME.

8.5 *Elements of the Assessment*

8.5.1 *Chemical Used* — All chemicals used in the ME and support equipment (pumps, cooling systems, etc.), both currently and at any time in its history, including proprietary chemicals, should be identified to the personnel planning and implementing the decontamination of ME and parts. In addition, Material Safety Data Sheets from the

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