



AUX005-1101

COMPARISON MATRIX BETWEEN SEMI S2-93A AND S2-0200

Foreword

Publication of this document as Auxiliary Information independent of any standards was authorized by a 2/3-majority vote of the North American Environmental Health and Safety (EHS) Committee at a meeting on July 19, 2001. This action was subsequently approved by the EHS Global Coordinating Subcommittee by email ballot on July 31, 2001 and by the NA Regional Standards Committee by electronic ballot on August 27, 2001.

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The comparison matrix between SEMI S2-93A and SEMI S2-0200 is a valuable tool to equipment suppliers, third parties and device manufacturers. It identifies the changes between S2-93A and SEMI S2-0200 and provides readers with insight as to the rationale behind some of the changes.

The SEMI S2 Comparison Matrix Task Force's objective is to compile a full comparison matrix of the official sections of SEMI S2-93A and SEMI S2-0200, soliciting input from the various S2 Working Groups where possible.

Limitation

This document is intended to be used as background information only. It is not the intent of this document to alter the criteria of SEMI S2.

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Comparison Matrix Between S2-93A and S2-0200

S2-93A	S2-0200	S2 WG Comments
1. Purpose These guidelines are intended as a minimum set of performance based environmental, health, and safety considerations for equipment used in semiconductor manufacturing.	1. Purpose 1.1 This safety guideline is intended as a set of performance-based environmental, health, and safety (EHS) considerations for semiconductor manufacturing equipment.	Note: “... minimum set...” is removed as it is a business issue.
2. Scope These guidelines apply to equipment used in the manufacturing, metrology, assembly, and testing of semiconductor products. This document contains the following: 1. Purpose 2. Scope 3. Safety Philosophy 4. General Guidelines 5. Safety-Related Interlocks 6. Chemicals 7. Ionizing Radiation 8. Non-Ionizing Radiation 9. Audio Noise 10. Ventilation and Exhaust 11. Electrical 12. Emergency Shutdown 13. Heated Chemical Baths 14. Ergonomics/Human Factors 15. Robotics and Automation 16. Hazard Warning 17. Earthquake Protection 18. Documentation 19. Fire Protection 20. Environmental Appendix 1 Terminology Appendix 2 Referenced Documents Appendix 3 Supplemental Information	2. Scope 2.1 <i>Applicability</i> — This guideline applies to equipment used to manufacture, measure, assemble, and test semiconductor products. 2.2 <i>Contents</i> — This document contains the following sections: 1. Purpose 2. Scope 3. Limitations 4. Referenced Standards 5. Terminology 6. Safety Philosophy 7. General Provisions 8. Evaluation Process 9. Documents Provided to User 10. Hazard Warning Labels 11. Safety Interlock Systems 12. Emergency Shutdown 13. Electrical Design 14. Fire Protection 15. Heated Chemical Baths 16. Ergonomics and Human Factors 17. Hazardous Energy Isolation 18. Mechanical Design 19. Seismic Protection 20. Automated Material Handlers 21. Environmental Considerations 22. Exhaust Ventilation 23. Chemicals 24. Ionizing Radiation 25. Non-Ionizing Radiation and Fields 26. Lasers 27. Sound Pressure Level 28. Related Documents	Note: SEMI S2-0200 has added eight new Sections: • Limitations • Evaluation Process • Hazardous Energy Isolation • Mechanical Design • Lasers • Terminology (originally in Appendix 1 in SEMI S2-93A) • Referenced Standards (originally Referenced Documents in Appendix 2 of SEMI S2-93A) • Related Documents Note: The titles of the twelve sections were revised: • “General Guidelines” to “General Provisions” • “Safety-Related Interlocks” to “Safety Interlock Systems” • “Non-Ionizing Radiation” to “Non-Ionizing Radiation and Fields” • “Audio Noise” to “Sound Pressure Level” • “Ventilation and Exhaust” to “Exhaust Ventilation” • “Electrical” to “Electrical Design” • “Ergonomics/Human Factors” to “Ergonomics and Human Factors” • “Robotics and Automation” to “Automated Material Handlers” • “Hazard Warning” to “Hazard Warning Labels” • “Earthquake Protection” to “Seismic

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	Appendix 1 — Enclosure Openings Appendix 2 — Design Principles and Test Methods for Evaluating Equipment Exhaust Ventilation Appendix 3 — Design Guidelines for Equipment Using Liquid Chemicals Appendix 4 — Ionizing Radiation Test Validation Appendix 5 — Non-Ionizing Radiation (Other than Laser) and Fields Test Validation Appendix 6 — Fire Protection: Flowchart for Selecting Materials of Construction 2.3 <i>Precedence of Sectional Requirements</i> — In the case of conflict between provisions in different sections of this guideline, the section or subsection specifically addressing the technical issue takes precedence over the more general section or subsection.	Protection”. • “Documentation” to “Documentation to User” • “Environmental” to “Environmental Considerations” Note: Six Appendices were added: • Appendix 1 – Enclosure Openings • Appendix 2 — Design Principles and Test Methods for Evaluating Equipment Exhaust Ventilation • Appendix 3 — Design Guidelines for Equipment Using Liquid Chemicals • Appendix 4 — Ionizing Radiation Test Validation • Appendix 5 — Non-Ionizing Radiation (Other than Laser) and Fields Test Validation • Appendix 6 — Fire Protection: Flowchart for Selecting Materials of Construction Note: Thirteen Related Information were added. Note: This section was added to promote continuity between the various sections where the criteria may not be completely align. Where the criteria are not aligned, the criteria specified in the section addressing the technical subject matter would take precedence over the more general section. For example: A section dealing with a specific technical issue may have criteria that are more limiting than the general section. For example: Section 12.2 includes an exception that permits safety-related devices (e.g., smoke detectors, gas/water leak detectors, etc.) to remain energized after an EMO condition. Section 14.4.4.9 specifies that fire detection system remains active following an EMO activation. The requirement for fire detection system to remain active following an EMO activation as stated in Section 14.4.4.9 will supercede the option for maintaining safety-related devices as stated in Section 12.2.
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	2.4 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 standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.	
	3. Limitations	Note: Section 3 has been added to SEMI S2-0200 to address “Limitations”.
	3.1 This guideline is intended for use by supplier and user as a reference for EHS considerations. It is not intended to be used to verify compliance with local regulatory requirements.	Note: Section 3.1 was added to the Limitation section to clarify that the SEMI S2 guideline is not intended to be used as a regulatory requirement. This note was added to SEMI S2-0200 as a result of certain authorities having jurisdiction (AHJ) who are requiring compliance with SEMI S2 (or relevant portions of SEMI S2) as a condition for their approval for the equipment to be use in their jurisdiction. The members of SEMI can create documents as needed to assist AHJ’s in their work by using relevant sections of the S2 document. See, for example, Auxiliary Information “SEMI AUX004-1100 - SEMI S2-0200 Evaluation Checklist for Semiconductor Hazardous Production Materials”
	3.2 It is not the philosophy of this guideline to provide all of the detailed EHS design criteria that may be applied to semiconductor manufacturing equipment. This guideline provides industry-specific criteria, and refers to some of the many international codes, regulations, standards, and specifications that should be considered when designing semiconductor manufacturing equipment.	Note: Section 3.2 was added to highlight the fact that this guideline does not contain all of the detailed EHS design criteria that may be applied to semiconductor manufacturing equipment and that it may be appropriate to reference relevant requirements specified in codes, regulations and standards as part of equipment design.
	3.3 Existing models and subsystems should continue to meet the provisions of SEMI S2-93A. Models with redesigns that significantly affect the EHS aspects of the equipment should conform to the latest version of SEMI S2. This guideline is not intended to be applied retroactively.	Note: Section 3.3 was added to promote a smooth transition between SEMI S2-93A and SEMI S2-0200. Note: SEMI S2-0200 does not explicitly explain how to determine if redesign significantly affects the EHS aspect of a piece of equipment.
	3.4 In many cases, references to standards have been incorporated into this guideline. These references do not imply applicability of the entire standards, but only of the sections referenced.	Note: Section 3.4 explains the areas that reference only parts of other standards.
3. Safety Philosophy	6. Safety Philosophy	Note: Section 3 has been renumbered to Section 6.

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3.1 Few safety standards exist that specifically address the design and construction of process equipment used in the manufacturing of semiconductors. Because of the expense and disruptive effects of safely retro-fitting equipment, these guidelines should be used, during design and construction of process equipment, to help eliminate known safety and health hazards inherent in operation and maintenance. Industry standards; building, electrical and fire codes; government regulatory requirements; and good practice should be considered in all equipment development programs.	6.4 This guideline should be applied during the design, construction, and evaluation of semiconductor equipment, in order to reduce the expense and disruptive effects of redesign and retrofit. 6.3 The following should be considered in the design and construction of equipment: • regulatory requirements; • industry standards; • this guideline; and • good engineering and manufacturing practices.	Note: 6.4 and 6.3 simplify the intent of 3.1 and list the references used in the design phase.
3.2 The safety philosophy set forth in these guidelines is that potential hazards in the operation and maintenance of equipment be identified and engineered out of equipment during the design and construction phases. Where identified hazards cannot be eliminated, no single point failure or operational error should allow immediate exposure of personnel, facilities, or community to hazards or directly result in injury, death, or equipment loss. All equipment should be fail-safe or of a fault-tolerant design.	6.1 A primary objective of the industry is to eliminate or control hazards during the equipment's life cycle (i.e., the installation, operation, maintenance, service, and disposal of equipment). 6.5 No reasonably foreseeable single-point failure condition or operational error should allow exposure of personnel, facilities, or the community to hazards that could result in death, significant injury, or significant equipment damage. NOTE 6: The intent is to control single fault conditions that result in significant risks (i.e., Critical, High, or Medium risks based on the example risk assessment matrix in SEMI S10). 6.6 Equipment safety features should be fail-safe or of a fault-tolerant design and construction.	Note: The objective has been expanded to include the entire equipment's life cycle (“cradle-to-grave”), not just operation and maintenance. Note: “reasonably foreseeable” has been added to the “single fault failure” concept to limit “what if” discussions to realistic scenarios. Note: S2-0200 attempts to incorporate a level of reasonableness into the guideline by stating an intent of controlling significant risks (namely, Critical, High and Medium risks as outlined in SEMI S10). Note: The criteria for “equipment” to be designed to be fail-safe and fault-tolerant has now shifted towards “equipment safety features”.
3.3 These guidelines define the minimum safety considerations for semiconductor manufacturing equipment. The areas of concern in the operation and maintenance of equipment are: - Chemical hazards - Radiation hazards - Electrical hazards - Physical hazards - Mechanical hazards - Environmental hazards - Fire and explosions - Seismic activity hazards	(Addressed in Section 2.2 – Scope)	Note: The concept is already captured in Section 2.2 of SEMI S2-0200.

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Ventilation Ergonomics		
	6.2 The assumption is made that operators, maintenance personnel, and service personnel are trained in the tasks that they are intended to perform.	
	6.7 Components and assemblies should be used in accordance with their manufacturers' ratings and specifications, where using them outside the ratings would create a safety hazard.	Note: Examples of components and assemblies used outside their ratings and specifications include, • use of 60 Hz components within products that are intended for world-wide 50/60 Hz installation, • use of AC rated components in a DC circuit, • use of components in excess of their current, voltage, or temperature ratings, • use of certified components not in accordance with their “conditions of acceptability” (e.g., Some certified power supplies may require external fuse protection of a specific current rating for a specific voltage source and installation clearance around the power supply chassis. Failure to provide the specific overcurrent protection or clearance would result in the certified component being used outside of its evaluated condition).
	6.8 A hazard analysis should be performed to identify and evaluate hazards. The hazard analysis should be initiated early in the design phase, and updated as the design matures. 6.8.1 The hazard analysis should include consideration of: • the application or process; • the hazards associated with each task; • anticipated failure modes; • the probability of occurrence and severity of a mishap; • the level of expertise of exposed personnel and the frequency of exposure; • the frequency and complexity of operating, servicing and maintenance tasks; and • safety critical parts. NOTE 7: EN 1050 contains examples of hazard analysis methods.	Note: Hazard analysis was originally covered in Section 4.2 of SEMI S2-93A but is now captured in Section 6.8 of SEMI S2-0200. Note: Section 6.8.1 of SEMI S2-0200 now specifies some content of the hazard analysis.

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	6.8.2 The risks associated with hazards should be characterized using SEMI S10. 6.9 The order of precedence for resolving identified hazards should be as follows: 6.9.1 <i>Design to Eliminate Hazards</i> — From the initial concept phase, the supplier should design to eliminate hazards. NOTE 8: It is recommended that the supplier continue to work to eliminate identified hazards. 6.9.2 <i>Incorporate Safety Devices</i> — If identified hazards cannot be eliminated or their associated risk adequately controlled through design selection, then the risk should be reduced through fixed, automatic, or other protective safety design features or devices. NOTE 9: It is recommended that provisions be made for periodic functional checks of safety devices, when applicable. 6.9.3 <i>Provide Warning Devices</i> — If design or safety devices cannot effectively eliminate identified hazards or adequately reduce associated risk, a means should be used to detect the hazardous condition and to produce a warning signal to alert personnel of the hazard. 6.9.4 <i>Provide Hazard Warning Labels</i> — Where it is impractical to eliminate hazards through design selection or adequately reduce the associated risk with safety or warning devices, hazard warning labels should be provided. See Section 10 for label information. 6.9.5 <i>Develop Administrative Procedures and Training</i> — Where hazards are not eliminated through design selection or adequately controlled with safety or warning devices or warning labels, procedures and training should be used. Procedures may include the use of personal protective equipment. 6.9.6 A combination of these approaches may be needed.	
4. General Guidelines	7. General Provisions	Note: Section 4 has been renamed and renumbered to Section 7.
4 General Guidelines This section describes the general safety guidelines for all semiconductor manufacturing process and test		

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equipment.		
4.1 Equipment should meet these general safety criteria. These guidelines should be incorporated by reference in all standard equipment purchase specifications (rather than rewriting the guideline for each piece of equipment). The intent is for the end user to buy a safe design, not design the equipment. The user and supplier should document when it is necessary to deviate from these guidelines.	7.1 This guideline should be incorporated by reference in equipment purchase specifications. The user and supplier should agree on deviations from this guideline. The intent is for the user to purchase equipment conforming with SEMI S2, not to design the equipment.	Note: The concept of “...purchase equipment conforming to SEMI S2...” rather than “... buy safe equipment” is important to the Working Group since the focus of this document is conformance to S2. Achieving a safe design is presumed if conformance is achieved.
4.2 The design of the completed equipment and its options should be examined and a risk analysis performed and documented by a qualified product-safety professional or other qualified engineering/technical professional. The risk analysis and documentation should be issued in the form of a report no later than 30 days prior to system shipment. This report should state that the equipment, including its components and sub-assemblies, conforms to applicable laws, regulations, and codes in effect at the time of purchase, and to the guidelines presented here or other applicable product safety standards. An independent laboratory or product safety consulting firm may be commissioned to supply additional testing, listings, or evaluations of conformance to this document. EXCEPTIONS: All hazards that cannot be engineered out of the product should be clearly identified and controlled to reduce personnel exposure and/or property damage. These hazards should be addressed specifically in the product operations and maintenance manual or in an accompanying notice. The manufacturer should continue to work to eliminate these hazards.	(Addressed in Section 6.8 – Safety Philosophy)	Note: The specification of performing hazard analysis, as well as the content of the hazard analysis, has now been considerably expanded in Section 6.8. Note: The specification of the issuance of the risk analysis report within 30 days prior to system shipment has been deleted from SEMI S2-93A as this is more appropriately addressed as a business decision. Note: The last sentence of the Exception to Section 4.2 of SEMI S2-93A suggests that all hazards should eventually be eliminated. While this is generally ideal, it may not always be practical or realistic to ‘eliminate the hazard’. For example, it may not be possible to eliminate all hazardous electrical voltage from a piece of equipment. A hierarchy for resolving hazards has, therefore, now been included in SEMI S2-0200. Refer to Section 6.9 of SEMI S2-0200 for details.
4.3 The equipment manufacturer should ensure that its equipment complies with laws and codes which are in effect at the time of purchase. All equipment requiring certification or approval by government agencies should have this certification or approval noted on the equipment or in the manuals as required by regulations.	7.2 The equipment must comply with laws and regulations that are in effect at the location of use. All equipment requiring certification or approval by government agencies must have this certification or approval as required by regulations. NOTE 10: It is recommended that the supplier request from	Note: There is a change in emphasis from “time of purchase” to “location of use.” Method of providing certification was deleted since manuals are often complete before approvals to laws and regulations at the location of use have been obtained. Note: NOTE 10 was added to suggest a method

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	the user information regarding local laws and regulations.	of obtaining local regulatory information.
4.4 The equipment manufacturer should maintain a program of quality assurance along with a safety, health, and environmental program to identify, correct, and inform the end user of potential hazards. Notification should be directed to the end user's equipment engineer, environmental health and safety officer, and purchasing agent.	7.3 The manufacturer should maintain an equipment/product safety program to identify and eliminate hazards or control risks in accordance with the order of precedence (see Section 6.9).	Note: Notifications of environmental health and safety are now addressed in Section 7.3.1 of SEMI S2-0200.
4.5 No single point failure or equipment operational error should allow exposure of personnel, facilities, or community to hazards or directly result in injury, death, or equipment loss.	(Addressed in Section 6.5 – General Philosophy)	Note: The concept of safeguarding against single point failure is now captured in Section 6.5 of SEMI S2-0200.
4.6 The equipment manufacturer should consider the type and quantity of hazardous process materials that may be used in the operation and maintenance of its equipment. The manufacturer should strive to avoid or minimize hazardous material use. If the end user's specific process chemistry is not defined, the equipment manufacturer's baseline process may be used for evaluation purposes.	(Addressed in Section 21.2.2.1 and 21.2.3.1 – Environmental Considerations) (Addressed in Section 23.1 – Chemicals)	Note: Minimization of the type and quantity of hazardous materials used is captured in Sections 21.2.2.1 and Sections 21.2.3.1 of SEMI S2-0200. Note: Discussions on the use of 'baseline' process is captured in Section 23.1 of SEMI S2-0200.
4.7 Equipment manufacturers who do not have an established and active product safety program and a comprehensive understanding of safety standards should obtain the services of a product safety professional during the development of the equipment.	Deleted.	Note: Deleted as this was regarded as a business issue.
	7.3.1 The supplier should provide the user's designated representative with bulletins that describe safety related upgrades or newly identified significant hazards associated with the equipment. This should be done on an ongoing basis as needed.	Note: This specification was originally addressed in Section 18.1 of SEMI S2-93A, but is now addressed here in the “General Provisions” Section.
	7.4 Model-specific tools and accessories necessary to operate, maintain, and service equipment safely should be provided with the equipment or specified by the supplier. NOTE 11: The official values in this guideline are expressed in The International System of Units (SI). Values that: are expressed in Inch-Pound (also known as “US Customary” or “English”) units,	Note: The specification for model-specific tools to be provided by the supplier is similar in philosophy to the criteria specified in Section 12.2.1 of EN/IEC 60204 for controlgear, “All controlgear shall be mounted so as to facilitate its operation and maintenance from the front. Where a special tool is necessary to remove a device, such a tool shall be supplied....” Note: The “NOTE 11” serves to establish one set of units as those required to measure conformance (i.e. SI unit) while allowing another set of units (i.e. “English”) to be used as a

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	- are enclosed in parentheses, and - directly follow values expressed in SI units are not official, are provided for reference only, and might not be exact conversions of the SI values.	reference for those more familiar with the “English” system.
5 Safety-Related Interlocks	11 Safety Interlock Systems	Note: Section 5 has been renamed and renumbered to Section 11.
	11.1 This section covers safety interlocks and safety interlock systems. NOTE 21: If a fire detection or suppression system is provided with the equipment, see Section 14 for additional information.	Note: There has been confusion as to whether S2 is concerned about the switch on a mechanical guard (i.e. interlock switch) or the entire system of components that this switch (or other sensing device) may be connected to. This makes it clear the section addresses both concepts. Note: Note 21 was added to inform the reader that there may be additional interlock criteria within the fire protection section. The interlock criteria in that section will override any conflict in this section.
5.1 All equipment should use fail-safe hardware safety interlocks to protect against hazards inherent in the operation of the equipment. Hardware safety interlocks should back up the equipment's operating system to ensure that, upon activation, the equipment is brought to a safe standby condition automatically and the operator alerted immediately. The operator notification should provide an explanation of the cause.	11.2 Where appropriate, equipment should use safety interlock systems that protect personnel, facilities, and the community from hazards inherent in the operation of the equipment. NOTE 22: Safety critical parts whose primary function is to protect the equipment (e.g., circuit breakers, fuses) are typically not considered to be safety interlocks.	Note: “... operation of the equipment” is not intended to limit the use of interlocks to safeguard only operator tasks. The words “Where appropriate” were added to Section 11.2 to encourage the use of risk assessment in determining whether interlocks are appropriate. In some sections of S2-0200 interlock systems are explicitly called for (see, for example, Fire Protection, Ionizing Radiation and Exhaust Ventilation) Note: The operator notification statement in the last sentence of Section 11.4 of SEMI S2-93A is now addressed in NOTE 23 of Section 11.4. Note: The phrase “protect personnel, facilities, and the community” has now been included in this Section to bring alignment with the Safety Philosophy Section, Section 6.5, of SEMI S2-0200. Note: Circuit breakers and fuses, while they do serve to protect against fire, are not meant to be subjected to all of the criteria of Section 11. The

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	11.5 Safety interlock systems should be fault-tolerant and designed so that the functions or set points of the system components cannot be altered without disassembling, physically modifying, or damaging the device or component. EXCEPTION: When safety interlock systems having adjustable set points or trip functions are used, access should be limited to maintenance or service personnel by requiring a deliberate action, such as using a tool or special keypad sequences, to access the adjustable devices or to adjust the devices. NOTE 24: This subsection does not address the defeatability of safety interlocks. See Section 11.7 for additional information.	reason for the addition of the note is to distinguish circuit breakers, fuses, etc. from those of a traditional interlock or interlocking system. Note: The term ‘fail-safe’ has been replaced with ‘fault-tolerant’. The basis for the change from “fail-safe” to ‘fault tolerant’ was not to impose a stricter set of criteria for safety interlocks than those adopted by most S2 third parties for SEMI S2-93A. The S2 WG believes that the determination of compliance to the ‘fault tolerant’ criteria should be conducted with the appropriate level of the overall risk assessment in mind, and, where appropriate, taking into consideration factors such as 1) safety certification of the safety interlocks, 2) endurance testing (e.g. per Section 15.3 of EN/IEC 61010-1, Section 8.3.3.5.2 of EN 60947-5-1/IEC 947-5-1, or the equivalent), 3) reasonably foreseeable failure modes of the interlock circuit including disconnection of conductors, and 4) whether with interlock devices are used in accordance with the manufacturer’s ratings and specifications. Note: The exception has been added because a growing number of safety interlock systems (e.g., certain leak detectors, flow sensors, and exhaust detectors, GFCI circuits), are electronic in nature. It would not be realistic to prohibit their usage; however, a deliberate action (e.g., using a tool or special keypad) must be taken to alter adjustable set points or trip functions. Note: To avoid confusion, a Note has been added to clarify that Section 11.5 does not address the defeatability of safety interlocks and that there this is more appropriately addressed under 11.7.
	11.6 Electromechanical devices and components are preferred, but solid-state devices and components may be used, provided that the safety interlock system, or relevant parts of the system, are evaluated for suitability for use. The	Note: The criteria for interlocks have been rewritten to permit the use of solid-state (electronic) interlock circuits provided that certain additional conditions are met in order to

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	evaluation for suitability should take into consideration abnormal conditions such as overvoltage, undervoltage, power supply interruption, transient overvoltage, ramp voltage, electromagnetic susceptibility, electrostatic discharge, thermal cycling, humidity, dust, vibration, and jarring. EXCEPTION: Where the severity of a reasonably foreseeable mishap is deemed to be Minor per SEMI S10, a software-based interlock may be considered suitable. NOTE 25: Where a safety interlock is provided to safeguard personnel from a Severe or Catastrophic mishap as categorized by SEMI S10, consideration of positive-opening type switches is recommended. NOTE 26: Evaluation for suitability for use may also include reliability, self-monitoring, and redundancy as addressed under standards such as NEMA ICS 1.1 and UL 991. NOTE 27: Solid-state devices include operational amplifiers, transistors, and integrated circuits.	provide an equivalent level of safety as traditional "hardware" systems. Note: The list of abnormal conditions are taken from UL 991, “Tests for Safety-Related Controls Employing Solid-State Devices”. The use of solid-state devices that meets UL 991 is, therefore, one acceptable method of demonstrating that consideration has been given to the stated abnormal conditions, but it is not to be construed as the only method. Note: Exception has been added to permit software-based interlock for certain reasonably foreseeable mishap that is considered to be Minor severity as defined in SEMI S10. It should be noted that the Exception addresses only the “Severity” axis of the risk matrix and does not take into account the ‘Likelihood’ factor because the probability (or frequency) component is much more subjective. Note: To be more aligned with EN and IEC standards, the recommendation for positive-opening type switches is added as a NOTE 25. The S2 Safety WG does not, however, consider mandating safety interlocks to be ‘positive-opening’ to be consistent with our commitment to develop ‘value-added’ criteria. There is insufficient evidence to support that electromechanical interlocks alone isn’t already sufficient. The S2 Safety WG has, therefore, only mentioned the use of positive-opening switch a NOTE. Note: Note 26 has been added to clarify that evaluation for suitability of solid-state interlock circuits may also include reliability, self-monitoring and redundancy. Note: Note 27 has been added to provide several examples of solid-state devices. These examples are intended to clarify any ambiguity between solid-state device and electromechanical device.
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	11.4 Upon activation, the safety interlock should alert the operator immediately. EXCEPTION: Alerting the operator is not expected if a safety interlock triggers the EMO circuit (see Section 12) or otherwise removes power to the user interface. NOTE 23: An explanation of the cause is preferred upon activation of a safety interlock.	Note: If power is available, a message alert on a human-machine interface or alarm should be provided. But it was recognized that many interlocks shut down all power via the EMO circuit. In this case, "operator notification" was not thought to be practical or relevant. The requirement to "provide an explanation of the cause" has been relaxed to a recommendation since it was recognized that describing "the cause" is very subjective and it doesn't add much value with regard to essential safety; rather, it is a troubleshooting aid.
	11.9 Switches and other control device contacts should be connected to the ungrounded side of the circuit so that a short circuit to ground does not result in the interlocks being satisfied.	Note: This design-specific requirement was based on clause 9.1.4 of IEC 60204-1997 and clauses 9.3 and 9.4 of NFPA 79-1997.
5.2 The safety interlock scheme should be designed to minimize the need to override automatic fail-safe safety interlock systems during maintenance activities. Safety interlocks in conjunction with physical barriers that operate at the point of the hazard are preferred (for example, a safety interlocked cover over a laser beam). When access to hazards that cannot be eliminated is required during maintenance, defeatable safety interlocks should be provided. Upon exiting the maintenance mode, all safety interlocks should be automatically restored.	11.7 The safety interlock system should be designed to minimize the need to override safety interlocks during maintenance activities. 11.7.1 Safety interlocks that safeguard personnel during operator tasks should not be defeatable without the use of a tool. 11.7.2 When maintenance access is necessary to areas protected by interlocks, defeatable safety interlocks may be used, provided that they require an intentional operation to bypass. 11.7.2.1 Upon exiting or completing the maintenance mode, all safety interlocks should be automatically restored. 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.	Note: Physical barriers are now addressed in section 13.4.1. Note: This was added to prohibit the use of interlock switches that protect operator tasks that have a means of bypassing as a feature built into the switch (or system). There are, for example, spring return, normally open switches, that can be put in a static, closed circuit state by pulling the plunger out a bit. Note: The working group acknowledges that any interlock switch or system can be defeated. Therefore, the best practical design goal is that interlocks be designed to that they can not be defeated accidentally, (i.e. require an intentional act) Note: The basis of this requirement is to permit qualified personnel to defeat interlocks providing that they are automatically restored upon exiting or completing the maintenance mode. This is consistent with clause 6.2.2 (b) of IEC 60204-1997.
5.3 Each type of safety interlock and its operation	(Addressed in Section 9 - Documents Provided to User).	Note: The requirement for the description of

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should be fully explained in the operations and maintenance manuals.		safety interlocks is now addressed in Section 9.6.3, “Description of the emergency off and interlock functions.” and further expanded in SEMI S13 Section 8 - Hardware Safety Interlocks, “8.1 <i>The equipment supplier should describe the hardware safety interlocks provided for the equipment and their operation in a list or similar format in the operation and maintenance manuals. The interlock list should include, but not be limited to, hazards protected, detection methods, and equipment conditions after the interlock is activated.</i> 8.2 <i>The locations of hardware safety interlocks protecting personnel should be clearly indicated using a layout sketch.</i>”
5.4 Equipment using greater than 30 volts RMS or 42.2 volts peak, rf power, hazardous chemicals, lasers, and uv light, as well as radiation-generating equipment, should be provided with physical barriers (labeled as to the hazards they protect) or safety interlocks, at the point of hazard, which effectively protect from personnel exposure. If the physical barrier does not require a tool to obtain access, the interlock is mandatory.	11.10 Where a hazard to personnel is controlled through the use of an enclosure, the enclosure should either: require a tool to gain access and be labeled regarding the hazard against which it protects personnel; or be interlocked. In addition to enclosures, physical barriers at the point of hazard should be included where inadvertent contact is likely. NOTE 28: Where the removal of a cover exposes a hazard, consider additional labels. See Section 10 for guidance.	The concept of safeguarding personnel from hazards with either a tool accessed enclosure or interlock is consistent with clause 6.2.2 c) of IEC 60204, “Opening without the use of a key or a tool and without disconnecting of live parts shall be possible only when all live parts are protected against direct contact to at least IP2X or IPXXB (see IEC 60529). Where barriers provide this protection, either they shall require a tool for their removal or all live parts protected by them shall be automatically disconnected when the barrier is removed.”
5.5 All equipment using hazardous gas requiring detection should be able to interface with gas monitoring equipment. The output from gas monitoring equipment should initiate automatic shutdown of gas flows and place the equipment in a safe state.	(Addressed in Section 23 - Chemicals)	Note: The requirement is now addressed in Section 23.6,
5.6 When triggered, safety interlocks should place the point of hazard area in a safe state.	11.3 Safety interlock systems should be designed such that, upon activation of the interlock, the equipment, or relevant parts of the equipment, is automatically brought to a safe condition.	Note: This section has been reworded primarily for semantic reasons. For example, in SEMI S2-93A, it is unclear as to what is “triggered”?
5.7 When triggered, each affected safety interlock should require individual manual reset or restart before the equipment function can be restored.	11.8 The restoration of a safety interlock should not initiate equipment operation or parts movement where this can give rise to a hazardous condition.	Note: It was recognized that the S2-93A requirement might be overly restrictive in some cases (i.e. not value added) and so “where this can give rise to a hazardous condition” was added. For example, if a danger zone can develop behind a cover, and there is no reasonably foreseeable way that the cover could be closed with personnel in the potential danger

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		zone(s), then allowing the closed cover to reset the interlock system is acceptable. In such a case, the additional action of a manual reset is not required.
5.8 Computer hardware failure should automatically place the equipment in a safe standby mode. Software safety interlocks should be backed up by hardware safety interlocks in all cases.	Deleted.	Note: This requirement has been deleted as it did not satisfy the ‘value-added’ criteria. Two points were significant in this assessment. 1)computer hardware failure, by itself, does not necessarily give rise to hazardous conditions. 2) It is believed that software interlocks are acceptable provided they are used and designed as otherwise constrained by the S2 revision. The essence of the requirement is already addressed in Section 11.2 because where a computer failure would, indeed, give rise to a hazardous situation, this would be an “appropriate” scenario to provide safety interlocks. And it is addressed in the exception to section 11.6, which addresses software interlocks.
	8. Evaluation Process	Note: Section 8 was added to SEMI S2-0200 to address the Evaluation Process.
	8.1 This section describes the evaluation of equipment to this guideline, the contents of the evaluation report, and supporting information needed to perform the evaluation. 8.2 <i>General</i> — The evaluating party (see Section 8.4) should evaluate the equipment according to this guideline and create a written evaluation report. NOTE 12: The intent is that the “should” provisions of this guideline be used as the basis for evaluating conformance. The intent is also that the “may,” “suggested,” “preferred,” “recommended,” and “NOTE” provisions of this guideline not be used for evaluating conformance. 8.2.1 Conformance to specific sections of SEMI S2 may be achieved by instructions included in the supplier’s equipment installation instructions (reference SEMI E6) or other documentation.	Note: Section 8 addresses the realities of the change in application of S2. S2 was created as a guide for designers. However, the current use of S2 in the industry is more often as a review document for “conformance.” Thus the process of review and the resulting report is outlined in this section. Note: 8.2.1 notes that instructions included with the equipment are part of the design.
	8.3 <i>Evaluation Report Contents: General</i> — The evaluation report should include only the manuals (Section 9.6) and the design-specific sections (Sections 10 through 27). The Appendices should be used in the evaluation, and referenced	

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	in the report, only as they pertain to the specific application. 8.3.1 For each numbered section, the evaluation report should state one of the following, and provide supporting rationale: • “Conforms” — equipment conforms to the section or to the intent of the section. • “Does not Conform” — equipment conforms to neither the section nor to the intent of the section. • “N/A” — section is not applicable to equipment. 8.3.1.1 The results of a risk assessment indicating no significant risk may be used in determining that the equipment conforms to the intent of a section. 8.3.1.2 The evaluation report should include a determination per SEMI S10 of the level of risk associated with nonconformance findings. 8.3.1.3 Supporting rationale may include test data or documented engineering rationale.	Note: This classification of the clause-by-clause evaluation report was originally addressed in Section 18.3 of SEMI S2-93A, but is now addressed in a dedicated section dealing with Evaluation Process. Note: It should be noted that ‘conforms’ now includes conformance with the ‘intent’ of the section. This was added to allow certain features that may not meet the specific criteria stated in the guidelines, but nonetheless, still meets the intent of the guideline. This is not unlike Forward C of most UL standards. Note: Section 8.3.1.1 says that risk assessment results can be used to support a finding of “meets the intent”.
	8.4 <i>Evaluation Report Contents: Other Information</i> — The evaluation report should also include: • manufacturer’s model number; • serial number of unit(s) evaluated; • the date(s) that the equipment was evaluated; • a system/equipment description including configuration, options, and essential diagrams; and a statement of the qualifications of the evaluating party. An in-house body, independent laboratory, or product safety consulting firm (“third party”) meeting the provisions of SEMI S7 may be used to supply testing or evaluation of conformance to this document.	Note: The specification for the evaluation report content was originally addressed in Section 18.3 of SEMI S2-93A, but is now addressed in a dedicated section dealing with Evaluation Process.
	8.5 <i>Supporting Information Provided to Evaluator</i> — The following documentation should be provided to, or developed by, the evaluator, as necessary to demonstrate conformance to the provisions of this guideline. NOTE 13: It is recommended that the manufacturer’s typical	Note: “NOTE 13” and “NOTE 14” help clarify the

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	configuration and process be used for evaluation purposes. Alternatively, a process agreed upon between the user and the supplier may be used. NOTE 14: Special options or configurations that may pose additional hazards and are not included in the initial evaluation may need a separate review. It is recommended that upgrades, retrofits, and other changes that affect the safety design of the equipment be evaluated for conformance.	choice of processes and configuration of the equipment for evaluation purposes.
	8.5.1 General Information • Written system description, including hardware configuration and function(s), power requirements, power output, and other information necessary to understand the design and operation of the equipment. • Engineering data used to provide the rationale that the equipment and subassembly seismic anchorages are designed to satisfy the applicable design loads (see Section 19, Seismic Protection). • Descriptions of the purpose and function of safety devices, such as: emergency off devices (EMOs), interlocks, pressure relief devices, and limit controls. • A hazard analysis (see Section 6.8). • Ergonomics evaluation (see Section 16). • A list of safety critical parts and, for each one, evidence of certification, or documentation showing that the component is suitable for its application. • A residual fire risk assessment as described in Section 14.2. • Tests results, certifications, and design specifications that are necessary to evaluate the equipment with respect to fire safety. Descriptions of the fire detection and suppression equipment and controls should also be provided.	
	8.5.2 Industrial Hygiene Information 8.5.2.1 An industrial hygiene report, which should include, as applicable: • ventilation assessment (see Section 22); • chemical inventory and hazard analysis (see Section 23); • ionizing radiation assessment (see Section 24); • non-ionizing radiation assessment (see Section 25);	

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	- laser assessment (see Section 26); and - audio sound pressure level assessment (see Section 27).	Note: Refer to Sections 26.1.1 & 26.3 for details on laser assessment.
	8.5.3 <i>Environmental Information</i> (see Section 21) — Documentation substantiating the following: - consideration or inclusion of features that conserve resources (e.g., energy, water, deionized water, compressed gases, chemicals, and packaging); - consideration of features that would promote equipment and component reuse or refurbishing, or material recycling upon decommissioning; - consideration or inclusion of features for resource recycling or reuse; - chemical selection methods and criteria (see Section 21.2.3); - consideration of integrating effluent and emission controls into the equipment; and - efforts to reduce wastes, effluents, emissions, and by-products. NOTE 15: For purposes of Section 8.5.3, documentation may include design notes, metrics (whether normalized or not), meeting minutes, pareto evaluations, or other analyses.	
6. Chemicals	23. Chemicals	Note: Section 6 has been renumbered to Section 23.
6.1 Operation and maintenance manuals should contain descriptions or diagrams of potential key failure points and trouble spots in equipment that use hazardous process materials or contain hazardous by-products. Text should be highlighted with such words as CAUTION, WARNING, or DANGER. (The use of these words should conform to the requirements of 29 CFR 1910.144-147 [OSHA] and ANSI Standard Z535.)	23.1 The manufacturer should generate a chemical inventory identifying the chemicals anticipated to be used or generated in the equipment. At a minimum, this should include chemicals in the recipe used for equipment qualification or “baseline” recipe, as well as intended reaction products and anticipated by-products. Chemicals on this list that can be classified as hazardous production materials (HPMs), or odorous (odor threshold < 1 ppm) or irritant chemicals (according to their material safety data sheets), should also be identified.	Note: SEMI S2-0200 now specifies that chemical inventories include reaction products and by-products be generated. Chemicals that fall under certain hazard classifications must also be identified.
6.2 Equipment that uses hazardous production materials requiring detection based on regulations (such as federal, state, and local codes) should have sample points mounted in the equipment, or have recommended sampling points identified in the product literature. The equipment should be able to interface with an external monitoring device and shut down the supply of the hazardous process materials.	23.6 Equipment that uses hazardous gases may require continuous detection and, if so, should have sample points mounted in the equipment, or have recommended sampling points identified in the equipment installation instructions. Where the gas supply is part of or controlled by the equipment, the equipment should be able to accept a signal from an external monitoring device and shut down the supply of the gas.	Note: The phrase “may require continuous detection” does not burden the equipment manufacturer with providing the continuous detection, but rather alerts designers to the possibility that customers will need to perform this function. If this is true, then the manufacturer does have the burden of providing the appropriate sample points or sample point information.

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6.3 Equipment manufacturers should strive to use only compatible process chemicals in a single piece of equipment. If incompatible materials are present, a single device should not be the sole means of preventing their undesired mixing.	23.4 The design of engineering controls (e.g., enclosure, ventilation, interlocks) should include consideration of (see also Appendix 3): • pressure requirements; • materials incompatibility; • equipment maintainability; • chemical containment; and • provisions for exhaust ventilation (see Section 22).	Note: SEMI S2-0200 now includes engineering control design considerations. Appendix 3 provides design guidelines for equipment using liquid chemicals. S2-0200 Section 22 outlines exhaust ventilation requirements.
6.4 The equipment manufacturer should characterize process by-products and exhaust effluent and provide pertinent information necessary to address the best method of handling process by-products and exhaust effluent by the end user. This includes in-line filtration, recirculation traps, and pump oils which are part of the equipment. (For additional information, see SEMI F5.)		
6.5 Components used in systems designed to contain hazardous production materials under pressure should be rated for the service in which they are used. Mechanical connections are to be enclosed in such a way as to prevent exposure of personnel should a leak occur. (For additional information, see UFC Article 51.)		
6.6 If normal maintenance activities expose personnel to chemicals or process by-products, typical exposure levels and compound types should be available to end user.	23.5 During equipment development, the supplier should conduct an assessment that documents conformance to the following airborne chemical control criteria (see also Appendix 2). All measurements should be taken using recognized methods with documented sensitivities and accuracy. A report documenting the survey methods, equipment operating parameters, instrumentation used, calibration data, results, and discussion should be available.	Note: S2-93A Ventilation and Exhaust (Section 10) formerly outlined chemical exposure concentrations is now outlined in Section 23 of S2-0200. Appendix 2 provides test methods for evaluating equipment exhaust ventilation and Section 22 provides exhaust ventilation requirements. More comprehensive industrial hygiene documentation is now required.
6.7 A warning label should be placed at all chemical enclosure maintenance openings that reads “WARNING: Hazardous chemicals located within this enclosure.”	23.7 Appropriate hazard warning labels should be placed at all chemical enclosure access openings.	Note: The specific wording requirements from S2-93A have been removed. Section 10 of S2-0200 (Hazard Warning Labels) defines the requirements for hazard warning labels.
	23.2 A hazard analysis (see Section 6.8) should be used as an initial determination of chemical risk as well as to validate that the risk has been controlled to an appropriate level.	Note: A hazard analysis is now included in SEMI S2-0200.
	23.2.1 The hazard analysis, at a minimum, should address the following conditions: • potential mixing of incompatible chemicals; • potential chemical emissions during routine operation; • potential chemical emissions during maintenance activities; and • potential key failure points and trouble spots (e.g.,	Note: Section 23.2.1 of SEMI S2-0200 defines the minimum scope of the hazard analysis.



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	fittings, pumps).	
	23.2.2 All routes of exposure (e.g., respiratory, dermal) should be considered in exposure assessment.	
	23.3 The order of preference for controls in reducing chemical-related risks is as follows: 23.3.1 substitution or elimination (see also Section 21.2.2); 23.3.2 engineering controls (e.g., enclosure, ventilation, interlocks); 23.3.3 administrative controls (e.g., written warnings, standard operating procedures); 23.3.4 personal protective equipment.	Note: These sections were added to in an attempt to include traditional industrial hygiene hazard control hierarchy in controlling chemical-related risks. Subsection 6.9 of S2-0200 offers guidance.
	23.5.1 There should be no chemical emissions to the workplace environment during normal equipment operation. Conformance to this section can be shown by demonstrating ambient air concentrations to be less than 1% of the Occupational Exposure Limit (OEL) in the worst-case personnel breathing zone. Where a recognized method does not provide sufficient sensitivity to measure 1% OEL, then the lower detection limit of the method may be used to satisfy this criterion.	Note: S2-93A Ventilation and Exhaust (Section 10) formerly outlined chemical exposure concentrations that are now outlined in Section 23 of S2-0200. Reference to ACGIH TLV or PEL has been changed to recognize applicable occupational exposure limits (OELs). This section also identifies the worst case breathing zone as the area to sample.
	23.5.2 Chemical emissions during maintenance activities should be minimized. Conformance to this section can be shown by demonstrating ambient air concentrations to be less than 25% of the OEL, in the anticipated worst-case personnel breathing zone, during maintenance activities.	Note: S2-93A Ventilation and Exhaust (Section 10) formerly outlined chemical exposure concentrations that are now outlined in Section 23 of S2-0200. Reference to ACGIH TLV or PEL has been changed to recognize applicable OELs. This section also identifies the worst case breathing zone sample as being required to conform to this requirement.
	23.5.3 Chemical emissions during equipment failures should be minimized. Conformance to this section can be shown by demonstrating ambient air concentrations to be less than 25% of the OEL, in the anticipated worst-case personnel breathing zone, during a realistic worst-case system failure. NOTE 104: The use of direct reading instrumentation under simulated operating, maintenance, or failure conditions is the	Note: S2-93A Ventilation and Exhaust (Section 10) formerly outlined chemical exposure concentrations that are now outlined in Section 23 of S2-0200. Reference to ACGIH TLV or PEL has been changed to recognize applicable OELs. Changes criteria for conforming with this requirement from work room to worst case personnel breathing zone sample. Note: NOTE 104 was added to recommend the use of direct reading instrumentation, when possible. This allows one, for example, to better

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	preferred measurement method. Where used, it is recommended that the sample location(s) be representative of the worst-case, realistic exposure locations(s). It is recommended that the peak concentration be directly compared to the OEL to demonstrate conformance to Sections 23.5.1–23.5.3. NOTE 105: It is recommended that integrated sampling methods be used when direct-reading instrumentation does not have adequate sensitivity, or when direct-reading technology is not available for the chemicals of interest. Where integrated sampling is used, it is recommended that the sample duration and locations(s) be representative of the worst-case, realistic, anticipated exposure time and locations. The resulting average concentration is directly compared to the OEL to demonstrate conformance to Sections 23.5.1–23.5.3. NOTE 106: Tracer gas testing (see SEMI F15 for an acceptable method) may be used when direct-reading instrumentation does not have adequate sensitivity, or when direct-reading technology is not available for the chemicals of interest. Tracer gas testing should be used where testing conditions may be hazardous (e.g., system failure simulation with potential release of hazardous gas to atmosphere). It is recommended that tracer gas testing be used only when an accurate rate of chemical emission can be determined. Where used, it is recommended that the sample location(s) be representative of the worst-case, realistic exposure location(s).	characterize tasks that frequently take less than 8-hours where peak exposures potentially occur. Note: Integrated industrial hygiene sampling is recommended in NOTE 105 when direct reading instrumentation is not available or feasible. Note: Previously tracer gas testing was discussed in the Ventilation and Exhaust section of S2-93A, which specified it as the preferred test method. NOTE 106 of SEMI S2-0200 reiterates the recommendation to use direct read instrumentation as the preferred method when feasible and safe to do so. When this is not the case then tracer gas testing is the preferred method. Also, this note identifies the sample locations considered to be representative of worst case exposure potential.
	23.5.4 Chemical emissions outside the enclosure during a realistic worst-case system failure should be less than the lower of the following two values: 25% of the lower explosive limit (LEL), or 25% of the OEL.	Note: Failure mode chemical emissions were previously discussed in Ventilation and Exhaust section of S2-93A where it specifies conformance to <25% of TLV or PEL. S2-0200 now specifies that LEL be taken into account and the lower of 25% LEL or 25% OEL be chosen.
7. Ionizing Radiation	24. Ionizing Radiation	Note: Section 7 has been renumbered to Section 24.
7.1 Ionizing radiation emissions during operation and maintenance activities should be limited to the lowest practical level. Shielding, safety interlocks, and other safeguards should be used to ensure the lowest practical leakage level. Under normal operating conditions, the equipment should meet or exceed all	24.1 This section covers equipment that produces ionizing radiation (e.g., X-rays, gamma rays) or uses radioactive sources. 24.2 Accessible emissions of ionizing radiation should be designed as low as reasonably achievable. This criteria can	Note: References to National standards such as OSHA and NRC have been omitted from SEMI S2-0200 because of the task force’s commitment toward the development of a guideline that is internationalized.

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requirements of OSHA (29 CFR 1910), NRC, FDA (21 CFR 1000 through 1050), or local regulations, whichever is most stringent.	be met by demonstrating conformance to the provisions in Sections 24.2.1 and 24.2.2 and Appendix 4. 24.2.1 Accessible levels of ionizing radiation during normal operations should be less than 2 microsieverts (0.2 millirem) per hour above background. See also Table A4-1 of Appendix 4. 24.2.2 Accessible levels of ionizing radiation during maintenance and service procedures should be less than 10 microsieverts (1 millirem) per hour above background. See also Table A4-1 of Appendix 4. 24.2.3 Access to radioactive contamination or internal exposure (e.g., inhalation, ingestion) to radioactive materials should be minimized. The hazards and controls for the prevention of personnel contamination and internal exposures should be detailed in the operation and maintenance manuals. NOTE 107 The use of radioactive material is strictly regulated around the world. Import, export, and transportation of radioactive materials is also highly regulated. Licenses may be required to possess, use, and distribute radioactive materials. NOTE 108: Many regions require both user and import licenses, and the timely acquisition of these licenses depends on the information provided by the equipment supplier. NOTE 109: Radiation producing machines are also regulated around the world. Regulations and licensing requirements may cover activities such as importing, exporting, installing, servicing and using radiation producing equipment.	Note: Specific exposure limits to ionizing radiation are now provided for normal operations and service and maintenance procedures.
7.2 Suppliers of radiation-producing equipment should be registered with the NRC and the state (if an agreement state). If required by government regulations, documentation stating the type of ionizing radiation and levels of external radiation from the equipment at time of manufacture should be furnished to the user. (For additional information, see 29 CFR 1910.96.) Documentation that provides a performance guarantee may be submitted by the supplier, if based on established ratings for the same type of equipment	(Note: Refer to Section 24.5.3, Note 111 – Ionizing Radiation)	Note: Registration of products containing ionizing radiation is now captured in NOTE 111 of SEMI S2-0200.

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and allowed by regulations. 7.3 Where supplemental administrative controls are needed to limit radiation exposures, these procedures should be described in detail in the supplier's operation and maintenance manuals.	24.5.3 If supplemental administrative controls are recommended based on survey results or calculations, a discussion should be provided in the operations and maintenance manuals describing the source locations, radiation levels, and recommended control measures. NOTE 111: Ionizing radiation sources must be registered or licensed according to the regulations of the country of destination. These radiation sources must conform to the regulations of central or local government agencies, whichever is stricter. NOTE 112: It is recommended that equipment containing radioactive materials should demonstrate conformance to licensing with local regulatory agencies prior to shipment. NOTE 113: Equipment that uses particle acceleration in its process has the potential for generating ionizing radiation as a result of nuclear interactions between the accelerated particles and various materials. These materials can include materials of construction of the equipment, accumulated residual process materials in the equipment, and the target materials.	Note: Registration or license in accordance with regulations was previously addressed in Section 7.2 of SEMI S2-93A.
7.4 All point-of-hazard panels and shields, when removed or accessed, should be safety-interlocked to prevent operation of x-ray sources or exposures of personnel to sealed radioactive sources. These interlocks, by design, should not be defeatable.	24.3 Equipment should be designed to minimize access or exposure to ionizing radiation during normal operation, maintenance, and service. Potential exposures should be controlled in the following order of preference: 24.3.1 <i>Engineering Controls</i> — Engineering controls (e.g. shielding, interlocks) should be the primary mechanism to minimize emission of ionizing radiation or access to ionizing radiation. 24.3.1.1 Radiation shielding for the equipment facilities connections (e.g., gas and exhaust lines) should be designed such that removal and replacement of the shielding during installation is minimized. 24.3.2 Non-defeatable safety interlocks should be provided on barriers preventing maintenance access to radiation fields in excess of 10 microsieverts (μSv) or 1 millirem per hour.	

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	24.3.3 <i>Administrative Controls</i> — When administrative controls (e.g., distance, time, standard operating procedures, labeling) are to be used, the equipment supplier should provide detailed documentation explaining the use of the administrative controls.	
7.5 Labeling of radiation-producing equipment should be provided by the equipment manufacturer or supplier in accordance with 21 CFR 1020.40, NRC Part 20, 29 CFR 1910 or state and local regulations, whichever is most stringent.	24.4 Equipment utilizing or producing ionizing radiation should be labeled appropriately. NOTE 110: Label contents are typically controlled by regulation in the country in which the equipment is to be used.	
	24.2.4 The manufacturer should supply, in the user documentation, a contact phone number and address for the manufacturer's radiation safety support personnel. 24.5 The manufacturer should conduct an assessment to document conformance to the criteria specified in Sections 24.2.1 through 24.2.2 during normal equipment operation, maintenance, and service. 24.5.1 A radiation survey should be used to confirm design compliance and serve as a baseline survey (see also Table A4-1 of Appendix 4). 24.5.2 Measurements should be taken using recognized methods with documented sensitivities and accuracy. A report documenting the survey methods, equipment operating parameters, instrumentation used, calibration data, source locations, results, and discussion should be made available.	
8. Non-Ionizing Radiation	25. Non-Ionizing Radiation and Fields	Note: Section 8 has been renamed and renumbered to Section 25.
8.1 During operation or maintenance activities, exposure to non-ionizing radiation and fields (ranging from static electric and magnetic fields through	25.1 This section covers equipment that produces non-ionizing radiation, except laser sources, in the following categories: • static electric and magnetic (0 Hz), • sub-radio frequency electric and magnetic fields (< 3 kHz), • radio frequency (3 kHz - 300 GHz), • infrared radiation (700 nm - 1 mm), • visible Light (400 nm - 700 nm), and • ultraviolet Light (180 - 400 nm). 25.2 Potentially hazardous non-ionizing radiation emissions that are accessible to any personnel should be limited to the lowest practical level. This criterion can be met by	

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ultra-violet radiation, including: ultraviolet, infrared, visible light, radio frequency, laser, and microwave), should be limited to the lowest practical level and should not exceed applicable standards or guidelines. Shielding, safety interlocks, and other safeguards should be used to ensure the lowest practical leakage level. The equipment design should minimize potential non-ionizing radiation exposure to persons performing routine operations, maintenance, and service procedures. Under no circumstances should non-ionizing radiation levels exceed the maximum permissible exposure in the areas occupied by personnel. (For additional information, see ANSI Z-136.1 and C95.1 or OSHA 29 CFR 1046.10.)	demonstrating conformance to the following provisions: EXCEPTION: Emissions of non-ionizing radiation exceeding the cardiac pacemaker limits in Appendix 5 but less than the levels in Sections 25.2.1 and 25.2.2 should be identified with appropriate labeling. See also Section 25.5.1. 25.2.1 Accessible levels of non-ionizing radiation during normal operations are less than the Operator-Accessible Limit (see Appendix 5); 25.2.2 Accessible levels of non-ionizing radiation during maintenance and service procedures are less than the Maintenance- and Service-Accessible Limit (see Appendix 5).	
8.2 Documentation showing the frequency/wavelength and the energy level of non-ionizing radiation from the equipment and its fields should be available to the user for all portions of the equipment that contains sources of non-ionizing radiation. (For additional information, see ANSI Z-136.1 and C95.1.)	25.3 Sources of potentially hazardous non-ionizing radiation should be identified in the operation and maintenance manuals, and appropriate parameters listed. Parameters include frequency, wavelength, and power levels, continuous wave or pulsed (see also Appendix 5). If pulsed, parameters also include the pulse repetition rate, pulse duration, and description of the pulse waveform. EXCEPTION: Visible sources which are intended to be viewed or which provide illumination (e.g., display panels, visible alarm indicators), and are not lasers, do not need to be identified. NOTE 114: It is recommended that UV/IR generators that are part of fire protection test apparatus, and are provided with the equipment, be considered as possible sources of potentially hazardous non-ionizing radiation.	
8.3 Where supplemental administrative controls are needed to limit the non-ionizing radiation exposures, these procedures should be described in detail in the supplier's operation and maintenance manuals. A	25.6 The manufacturer should conduct an assessment to document conformance to the criteria specified in Sections 25.2.1 and 25.2.2. Engineering calculations may be used as part of this assessment. All measurements should be taken using recognized methods with documented sensitivities and accuracy. A report documenting the survey methods, equipment operating parameters, instrumentation used, calibration data, source location(s), and discussion should be provided. See Appendix 5. 25.6.1 If supplemental administrative controls are recommended based on survey results or calculations, a discussion should be provided in the operations and maintenance manuals describing the source location(s),	



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description of supplemental monitoring and alarms should also be required.	radiation levels, and recommended control measures. 25.6.2 Administrative control procedures recommended for operation, maintenance, or service activities should be documented in the operations and maintenance manuals.	
8.4 All equipment should conform with requirements of the FDA-CDRH. (For additional information, see Center for Device and Radiological Health, 21 CFR 1000 through 1050.)	(Refer to Section 26 – “Lasers”)	
8.5 All point-of-hazard panels and shields should be rigidly affixed and require a tool for removal and be labeled as outlined by the preceding standards.		
8.6 Removable shielding or filtering material (such as film shielding used on windows) should be designed or arranged to prevent reverse or faulty installation and labeled as outlined by ANSI Z-136.1, and C95.1, and Center for Device and Radiological Health, 21 CFR 1000 through 1050.	(Refer to Section 26 – “Lasers”) 25.5 Equipment utilizing or producing potentially hazardous non-ionizing radiation should be labeled. 25.5.1 Hazard warning labels should be provided by the manufacturer when emission levels are measured that may impact cardiac pacemakers or magnetizable prostheses. These warning labels should be located where the emissions exceed the pacemaker limit. (See Appendix 5 for pacemaker labeling levels and references.)	
	25.4 Equipment should be designed to minimize access or exposure to non-ionizing radiation during normal operation, maintenance, and service. Potential exposures should be controlled in the following order of preference: 25.4.1 engineering controls (e.g., enclosure, shielding, guarding, grounding, interlocks); 25.4.2 administrative controls (e.g., written warnings, standard operating procedures, labeling); and 25.4.3 personal protective equipment.	
9. Audio Noise	27. Sound Pressure Level	Note: Section 9 has been renamed and renumbered to Section 27.
9.1 The equipment should be designed to operate at the lowest practical dB(A) level but in no case greater than 80 dB(A). (For additional information, see 29 CFR	27.1 Equipment should be designed to control exposures to sound pressure levels equal to or greater than 80 dBA continuous or intermittent sound pressure level, and 120 dB	

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1910.95.) Test results indicating conformance to requirements should be available to the equipment user upon request.	instantaneous (impulse) sound pressure level. NOTE 1: NOTE 119: It is recommended that efforts be made to decrease sound pressure levels as they approach 80 dBA (i.e., 77 to 80 dBA), due to the additive sound pressure level effects of multiple pieces of equipment in the same vicinity. 27.3.2 If the measured sound pressure level is less than 70 dBA, the manufacturer should provide to the evaluator test data documenting sound pressure levels, survey equipment, equipment calibration, test conditions and results. 27.3.3 If the measured sound pressure level is greater than 70 dBA, the test data should include all of the information in Section 27.3.2, and should also include the expected duration of personnel exposure. 27.3.4 If measured sound pressure level is greater than 75 dBA, information should be provided in the equipment maintenance manual describing the sound pressure level(s) and location(s).	
9.2 Noise level tests, where required, should be conducted at the supplier's location or in an appropriate test room. The measurement technique should be ANSI S1.13 (R1976), Acoustical Society of America STD 4 (ANSI S3.17), or ANSI S1.4. The application should be checked with the ACGIH requirements. EXCEPTION: In lieu of an actual noise-level test report on the equipment being quoted, an alternative performance guarantee may be submitted if based on established noise ratings for the same type of equipment.	27.3 Sound level surveys should be conducted by the manufacturer during equipment development for equipment that may emit hazardous sound pressure levels. 27.3.1 The survey should be conducted in accordance with a recognized standard. In addition, the following test criteria should be applied: 27.3.1.1 The equipment mode of operation during the sound pressure level tests should simulate as closely as possible the actual modes and operating positions that may be experienced by the equipment user. 27.3.1.2 Measurements should be taken in locations that best simulate actual positions of operators relative to the equipment. As a general guideline, the microphone should be traversed 1 meter from the equipment, 1.2 meters above the ground to simulate seated operators, 1.5 meters above the ground to simulate standing operators, and 3.5 meters (or as	

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	far as possible) away from the nearest walls or sound-reflecting objects. Measurements are taken 360 degrees around the equipment wherever possible. Table 2 Sound Pressure Level Test Criteria Background level may be subtracted using an accepted method. If the sound pressure level difference is less than 3 dBA, the contribution of the source from the background cannot be adequately distinguished and the survey results would not be valid for values over 80 dBA. <table><tr><th><i>Difference between sound pressure level measured with noise source operating and background sound pressure level (dBA)</i></th><th><i>Correction to be subtracted from the sound pressure level measured with the noise source operating to level due to noise source alone (dBA)</i></th></tr><tr><td>3</td><td>3</td></tr><tr><td>4</td><td>2.5</td></tr><tr><td>5</td><td>1.7</td></tr><tr><td>6</td><td>1.3</td></tr><tr><td>7</td><td>1</td></tr><tr><td>8</td><td>0.8</td></tr><tr><td>9</td><td>0.6</td></tr><tr><td>10</td><td>0.4</td></tr></table>	<i>Difference between sound pressure level measured with noise source operating and background sound pressure level (dBA)</i>	<i>Correction to be subtracted from the sound pressure level measured with the noise source operating to level due to noise source alone (dBA)</i>	3	3	4	2.5	5	1.7	6	1.3	7	1	8	0.8	9	0.6	10	0.4	
<i>Difference between sound pressure level measured with noise source operating and background sound pressure level (dBA)</i>	<i>Correction to be subtracted from the sound pressure level measured with the noise source operating to level due to noise source alone (dBA)</i>																			
3	3																			
4	2.5																			
5	1.7																			
6	1.3																			
7	1																			
8	0.8																			
9	0.6																			
10	0.4																			
	27.2 The order of preference for controlling exposures is as follows: 27.2.1 <i>Engineering Controls</i> (e.g., source sound pressure level reduction, absorption, enclosures, barriers, acoustic dampening) — At a minimum, the design of the engineering controls should consider the sound pressure levels and type, the frequency, and the appropriate control technologies. 27.2.2 <i>Administrative Controls</i> — Acceptable administrative controls should be limited to supplemental hazard warning labels and operating procedures. NOTE 120: Noise labeling is typically implemented as signs located in the users facility.																			
10. Ventilation and Exhaust	22. Exhaust Ventilation	Note: Section 10 has been renamed and renumbered to Section 22.																		
10.1 Ventilation enclosures should be designed and test validated for efficient and safe control of chemical emissions during routine operation and maintenance, and during the failure of other control systems. These	22.2 Equipment exhaust ventilation should be designed and a ventilation assessment conducted (see Section 23.5, Appendix 2, and SEMI S6) to control, efficiently and safely, for potential worst-case, realistic employee exposures to	Note: Expands on the design and test requirements from S2-93A. Design and test criteria are outlined in Appendix 2 and section 22.3. S2-93A relied upon industrial hygiene																		

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systems should optimize the use of air flow, as far as practical, directing escaping chemicals so they do not impinge on the equipment. These means should be based on application-specific design principles as specified in the ACGIH Industrial Ventilation - A Manual of Recommended Practice, OSHA Regulations, 29 CFR 1910, SEMI S6 for ventilation, or the model mechanical codes applicable at the site of installation.	chemicals during normal operation, maintenance, or failure of other equipment components (hardware or software). All design criteria and test protocols should be based on recognized methods. See also Section 23.3.	testing to verify design conformance. S2-0200 requires that both industrial hygiene principles and design principles such as those found in Appendix 2 be applied in order to achieve conformance.
10.2 Equipment that uses hazardous materials or that generates hazardous chemical by-products should be designed to use local exhaust ventilation as the primary safety control. Exhaust loads that require continuous flow external treatment should be minimized. Supplementary exhaust to support maintenance should be used where appropriate to reduce the continuous exhaust requirements for the equipment.	22.1 Equipment exhaust ventilation should be designed to prevent potentially hazardous chemical exposures to employees as follows: 22.1.1 As primary control when normal operations present potentially hazardous chemical exposures to employees by diffusive emissions that cannot be otherwise prevented or controlled (e.g., wet decks, spin coaters). NOTE 98: In the context of this section, “primary control” means that it is the control of first choice (e.g., rather than personal protective equipment). 22.1.2 As supplemental control when intermittent activities (e.g., chamber cleaning, implant source housing cleaning) present potentially hazardous chemical exposures to employees which cannot reasonably be controlled by other means. Supplemental exhaust hoods or enclosures may be integrated into the equipment design, or supplied completely by the equipment user.	Note: Exhaust ventilation should be a supplemental control for tasks (i.e. maintenance tasks) that pose a threat of chemical exposure. The supplier can integrate supplemental exhaust into the equipment, or if the user is to supply the exhaust, provide the user with the recommended specifications outlined in Section 22.3 and Appendix 2.
10.3 Equipment that uses process materials with an NFPA 704 hazard rating in health, flammability, or reactivity of 3 or 4, should place non-welded connections handling such materials in an exhausted enclosure. The equipment supplier should document when external exhaust is required and specify the requirements.	22.1.3 As secondary control when a single-point failure presents the potential for employee exposures to hazardous materials, and this exposure cannot be controlled by other means (e.g., use of all welded fittings). EXCEPTION: Secondary exhaust control enclosures for non-welded connections (e.g., valve manifold boxes that enclose piping jungles) are not included in this guideline for those hazardous gases that are transported below atmospheric pressure (e.g., via vacuum piping systems) if it can be demonstrated that equivalent leak protection is provided. Equivalent protection may include such things as equipping the vacuum delivery system with a fail-safe (e.g., to close)	Note: An exception has been added allowing for non-welded connections for hazardous gases transported below atmospheric pressure, provided that equivalent leak protection is provided that includes a visual and audible alarm upon failure.

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	valve automatically activated by a loss of vacuum pressure. Loss of vacuum pressure should also activate a visual and audible alarm provided in visual or audible range of the operator.	
10.4 Secondary enclosure and exhaust systems for gas plumbing should be designed to ensure that a “realistic worst case” leak will be contained or captured.	(Refer to the Note in Section 10.1).	
10.5 During equipment development, the supplier should conduct testing to demonstrate conformance with these criteria. Documentation should be provided showing that the exhaust flow rates were determined by practical application testing. Tracer gas analysis, as described in SEMI F15, is the preferred testing method.	(Refer to the Note in 10.1 Section 23.5.3 – Chemicals)	
10.5.1 The goal is zero leakage, and under normal operating conditions, should not exceed 1% of ACGIH-recommended TLV, PEL, or the lower detectable limit.	(Refer to Section 23.5.1 – Chemicals)	
10.5.2 The secondary containment should control emissions into the work room air to less than 25% of ACGIH recommended TLV or PEL during a delivery system failure.	(Refer to Section 23.5.3 and 23.5.4 – Chemicals)	
10.5.3 Emissions from the equipment into the work area should not exceed 25% of TLV or PEL during maintenance activities.	(Refer to Section 23.5.2 – Chemicals)	
10.5.4 Any measurements of airborne concentrations in the work areas should be made using recognized methods with documented sensitivities and accuracy established by NIOSH, or other nationally recognized standard or test procedures.	(Refer to Section 23.5 – Chemicals)	
10.6 The size of the enclosure, the removable panels, and the openings should be minimized.		
10.7 The equipment supplier should specify static pressure, volumetric flow rate, the location where exhaust measurements should be made, and the duct material requirements for the user's exhaust systems.	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;	Note: This section expands on the design parameters the supplier was required to specify in S2-93A. Now additional exhaust parameters and test methods must be documented. Depending on the exhaust ventilation (design) type, some of the parameters may or may not be relevant. Appendix 2 provides design and test criteria.

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	- duct diameter at the point of connection to facilities; and - location(s) on the duct or hood where all ventilation measurements were taken.	
10.8 The equipment supplier should specify exhaust flow rates and differentiate among the types of exhaust required for various applications (heat, scrubbed, solvent, pyrophoric, etc.).	(Refer to Note in Section 10.7)	
10.9 Exhaust flow interlocks should be provided by the equipment manufacturer (but the actual exhaust system is part of the facilities, and its monitoring system should be supplied by the end user) on all equipment that use hazardous process materials. When the exhaust falls below the prescribed set point a visual and audible alarm should be provided in visual and audible range of the operator, and the process equipment should be placed in a safe stand-by mode.	22.4 Exhaust flow interlocks should be provided by the manufacturer on all equipment that uses hazardous production materials (HPMs) where loss of exhaust may create a hazard. Flow (e.g., pitot probe) or static pressure (e.g., manometer) switches are the preferred sensing methods. NOTE 99: Sail switches (switches that are connected to a lever that relies upon air velocity to activate) are generally not recommended. NOTE 100: It is recommended that the pressure or flow measuring point be located upstream of the first damper. NOTE 101: Section 11 contains provisions for safety interlocks. 22.4.1 When the exhaust falls below the prescribed set point, an alarm should be provided within audible or visible range of the operator, and the process equipment should be placed in a safe stand-by mode. A time delay and exhaust setpoint for the equipment to go into standby mode may be allowable, based on an appropriate risk assessment. The system should be capable of interfacing with the facility alarm system. NOTE 102: It is recommended that non-HPM chemical process exhaust be equipped with audible and visible indicators only.	Note: This section is similar to Section 10.9 of S2-93A but adds a preference towards the use of flow and static pressure sensing methods. Note: Note 99 of SEMI S2-0200 was added advising against the use of sail switches. Note: Note 100 of SEMI S2-0200 identifies accepted ventilation design principles. Note: New allowance for a time delay before putting system into stand-by mode if an appropriate risk assessment has been performed. Subsection 6.8.2 refers to SEMI S10 for characterizing risk. Note: Note 102 of SEMI S2-0200 recommends that even non-HPM exhaust be equipped with audible and visible alarms.
	22.4.2 Exhaust flow interlocks and alarms should require manual resetting.	Note: Refer to Section 5 – Safety-Related Interlocks. No change from Section 5.7 of S2-93A.
	22.4.3 Exhaust flow interlocks should be fault-tolerant.	Note: SEMI S2-0200 now specifies exhaust flow interlocks to be fault tolerant.
	22.1.2.1 When a procedure (e.g., cleaning) specified by the	

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	supplier requires exhaust ventilation, the supplier should include the minimum criteria for exhaust during the procedure.	
	22.5 Equipment and equipment components should be designed using good ventilation principles and practices to ensure chemical capture and to optimize exhaust efficiency (see Appendix 2). NOTE 103: It is recommended that exhaust optimization be achieved with total equipment static pressure requirements of –1 to –38 mm (–0.05 to –1.5”) H₂O (see also Section A2-1 of Appendix 2, and Section 8.3.6.1 of SEMI S6-93).	Note: Section 22.5 of SEMI S2-0200 captures a similar concept as Section 10.1 of SEMI S2-93A but in SEMI S2-0200, Appendix 2 has been added to provide exhaust design and test criteria. Note: Note 103 was added to recommend static pressure requirements be between –1 to –38mm H₂O (–0.05 to –1.5” H₂O).
11 Electrical	13. Electrical Design	Note: Section 11 has been renumbered to Section 13.
	13.1 This section covers electrical and electronic equipment that use hazardous voltages.	Note: This introductory requirement was provided to clarify when the criteria of section 13 should be applied to equipment with electrical circuits.
11.1 Energized Electrical Work (“Hot Work”) - The supplier should design the equipment to minimize the need to conduct calibration, testing, or maintenance on equipment that may be energized and to minimize work that must be performed on components near exposed energized circuits. The supplier is expected to move as many tasks as possible from the “Hot Work” categories type 3, 4, and 5 to type 1 or 2. This can be accomplished through such hardware changes as remote safe testing points for high-voltage measurements. Work in types 3, 4, and 5 should have specific written instructions in the maintenance manuals. The following are the five types of energized electrical work: Type 1 - Equipment is fully de-energized (electrically “cold”). Type 2 - Equipment is energized. Live circuits are covered or insulated. Work is performed at a remote location to preclude accidental shock.	13.3 Energized Electrical Work— The supplier 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. The supplier should move as many tasks as practical from category Type 4 to Types 1, 2, or 3. Routine Type 4 tasks, excluding troubleshooting, should have specific written instructions in the maintenance manuals. 13.2 <i>Types of Electrical Work</i> — The following are the four types of electrical work defined by this guideline: <i>Type 1</i> — Equipment is fully deenergized. <i>Type 2</i> — Equipment is energized. Energized circuits are covered or insulated. NOTE 32: Type 2 work includes tasks where the energized circuits are or can be measured by placing probes through suitable openings in the covers or insulators.	Note: A note has been added to Type 2 task to clarify that electrical measurement tasks through a barrier with properly sized probe opening is considered to be Type 2 task.

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Type 3 - Equipment is energized. Live circuits are exposed and accidental contact is possible. Potential exposures are less than 30 volts RMS, 42.2 volts peak, 240 volt-amperes, and 20 Joules. (See NFPA 79-14.3, IEC 204, UL 1950 & 1262, IEC 950.) Type 4 - Equipment is energized. Live circuits are exposed and accidental contact is possible. Voltage potentials are greater than 30 volts RMS, 42.2 volts peak, 240 volt-amperes, 20 Joules, or radio frequency (rf) is present. Type 5 - Equipment is energized and measurements and adjustment require physical entry into the equipment, or equipment configuration will not allow the use of clamp-on probes. The supplier should list type 3 or higher electrical hazard tasks by their type (as defined in Section 11.1) in its equipment operation and maintenance manuals.	<i>Type 3</i> — Equipment is energized. Energized circuits are exposed and inadvertent contact with uninsulated energized parts is possible. Potential exposures are no greater than 30 volts rms, 42.4 volts peak, 60 volts dc or 240 volt-amperes in dry locations. <i>Type 4</i> — Equipment is energized. Energized circuits are exposed and inadvertent contact with uninsulated energized parts is possible. Potential exposures are greater than 30 volts rms, 42.4 volts peak, 60 volts dc, or 240 volt-amperes in dry locations. Potential exposures to radio-frequency currents, whether induced or via contact, exceed the limits in Table A5-1 of Appendix 5.	Note: Type 3 is generally considered by product safety standards such as IEC 1010-1, UL 1244, UL 3101 and IEC 950 to be below the threshold voltage level for risk of electric shock. The requirement has, therefore, been revised to permit tasks to be within either category types 1, 2, or 3. Note: The voltage cutoff of 42.2 volts peak has been corrected to 42.4 volts peak (30 Vrms X square root of 2) to bring it in line with IEC/EN and UL standards. Note: The 240 VA threshold is based on IEC 950, Section 1.2.8.7; UL 1012, Section 3.8. Note: Type 5 work has now been integrated into Type 4. Note: Refer to last sentence of Section 13.3. To be more in line with IEC/EN and UL's threshold levels, it is now only necessary to list type 4 hazards.
11.2 Equipment should be provided with means to allow the user to comply with OSHA 29 CFR 1910.147 (Control of Hazardous Energies, Lockout/Tagout) and 29 CFR 1910.331-335 (Electrical Safety-Related Work Practices) as related to lockout/tagout. Recommended lockout/tagout procedures should be supplied and installation instructions for user-supplied lockout devices provided as part of the maintenance/installation instructions.	(Addressed in Section 17, Hazardous Energy Isolation)	Note: This requirement is now expanded in Section 17, Hazardous Energy Isolation
11.3 Electrical Design - The supplier should meet the following electrical design guidelines. (See NFPA 79 for specific detail of design.)	13.4 <i>Electrical Design</i> — Equipment should conform to the appropriate international, regional, national or industry product safety requirements.	Note: Reference to NFPA 79 has been removed to bring SEMI S2-0200 into a more internationalized status. No other international standard(s) is listed in its place because of the wide diversity of tools within the semiconductor industry.
11.3.1 The equipment manufacturer should provide non-conductive and/or grounded conductive physical barriers on all areas where exposed circuits are greater than 30 volts RMS or 42.4 volts peak. Barriers	13.4.1 Nonconductive or grounded conductive physical barriers should be provided: Where it is necessary to reach over, under, or around,	

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concealing hazards should be labeled identifying the hazards concealed. Visual hazard alerts should be in accordance with SEMI S1, ANSI Z535, or an equivalent.	or in close proximity to hazards. • Where dropped objects could cause shorts or arcing. • Where failure of liquid fittings from any part of the equipment would result in the introduction of liquid into electrical parts. • Over the line side of the main disconnect. • Where maintenance or service tasks on equipment in dry locations are likely to allow inadvertent contact with uninsulated energized parts containing either: potentials greater than 30 volts rms, 42.4 volts peak, or 60 volts dc; or power greater than 240 volt-amps. NOTE 33: A dry location can be considered to be one that is not normally subject to dampness or wetness. NOTE 34: Removable nonconductive and noncombustible covers are preferred.	Note: It is not the S2 Safety WG's intent to limit this bullet to equipment used in dry locations. The term 'Dry location' was added to the bullet to address the fact that the threshold for 'hazardous voltage' assumes dry location uses. Wet locations may require the threshold voltage levels to be lowered.
11.3.2 The equipment design should minimize the probability of electrical shock during maintenance, repair, modification, calibration, or adjustment. Exposed energized circuits, components, and terminal strips should have removable non-conductive and non-combustible covers to protect personnel from incidental contact. EXCEPTION: Covers are not required for enclosures which require a tool to open and are properly labeled and designed to minimize accidental contact with energized circuits.	13.4.2 Where test probe openings are provided in barriers, the barriers should be located, and the probe openings should be sized, to prevent inadvertent contact with adjacent energized parts, including the energized parts of the test probes. 13.4.7 Enclosure openings should safeguard against personnel access to uninsulated energized parts. (Refer to Appendix 1 for examples of openings for protection against access from operators.) 13.4.8 Top covers of electrical enclosures should be designed and constructed to prevent objects from falling into the enclosures. (Refer to Appendix 1 for examples of acceptable top enclosure openings.)	Note: Issues related to the combustibility of materials of construction as stated in the last sentence of Section 11.3.2 of SEMI S2-93A are now addressed in Section 14, Fire Protection. Note: Section 13.4.8 addresses openings to top covers. For openings other than top covers, refer to Section 13.4.7 and Appendix 1.
11.3.3 The equipment should not exhibit surface leakage current greater than 3.5 milliamperes (mA) measured from any point on the surface of the equipment covers and associated controls to earth ground. Equipment grounding circuits within a machine	13.6 <i>Electrical Safety Tests</i> 13.6.1 Equipment connected to the facility branch circuit with a cord and plug should not exhibit surface leakage current greater than 3.5 milliamperes (mA) measured from any point	Note: The leakage current limit remains the same; however, the requirement has now been limited to cord-and-plug connected equipment

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must have a measured resistance of one tenth ohm or less between any measured points and the main equipment grounding conductor. Grounding conductors and connectors should be compatible in current rating to the associated ungrounded conductors and connectors as specified in the National Electrical Code.	on the surface of the equipment covers and associated controls to earth ground. (Refer to SEMI S9 or other appropriate standards for recognized test methods.) EXCEPTION: Equipment with leakage current exceeding 3.5 mA is acceptable if documentation is provided to substantiate that the equipment is fully compliant with an applicable product safety standard that explicitly permits a higher leakage current. 13.6.2 Equipment grounding circuits should have a measured resistance of one-tenth (0.1) ohm or less between the main equipment grounding conductor terminal and any accessible metal surfaces that are: accessible to operator without the use of tools; and likely to become energized in a single-point failure condition. Refer to SEMI S9 or other appropriate standards for recognized test methods. 13.4.5 Grounding (earthing) conductors and connectors should be sized to be compatible in current rating with their associated ungrounded conductors according to appropriate standard(s) per Section 13.4.	similar to that of many UL, CSA standards. In addition, the test methodology is now specified per SEMI S9 or other appropriate standards. Note: An exception was added primarily to align S2-0200 with certain IEC standards that explicitly permit certain equipment to have leakage current in excess of the specified limit. However, the Working Group felt that if a manufacturer elects to invoke the leakage current limit exception in a product safety standard, the product safety standard must be considered to be ‘applicable’ to that product and that the product must also fully comply with all other provisions of that standard. Note: To promote consistency in test methodology, equipment grounding continuity test in SEMI S2-0200 now references SEMI S9 or other appropriate standards for recognized test methods in performing grounding continuity test.
11.3.4 All electrical components and wiring should be designed to conform with the most recent electrical code for the country of use at the time of the equipment's assembly. United States; NEC/NFPA 70, NFPA 79 Japan; JIS Europe; IEC 950, IEC 204 Critical electrical/electronic components (whose failure could increase the risk of electrical shock, fire, or personnel injury) should be listed or recognized by a nationally recognized testing laboratory, or otherwise enclosed and protected by a protection device which is listed or recognized by a nationally recognized testing	13.4.3 Where failure of components and assemblies could result in a risk of electric shock, fire, or personal injury, those components and assemblies should be certified by an accredited testing laboratory and used in accordance with the manufacturer's specifications, or otherwise evaluated to the applicable standard(s).	Note: References to country specific codes and standards has been removed to bring SEMI S2-0200 into a more internationalized status. The phrase “listed or recognized by a nationally recognized testing laboratory” has been replaced by “certified by an accredited testing

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laboratory.	NOTE 35: With the exception of implementation of ground fault protection, shunt trip units that require power to trip (actuate) are not recommended to be used in a safety control circuit, because they are not fail-safe.	laboratory”. While many certified electrical components (e.g., circuit breakers, relays, switches, filters, etc.) are commercially available, there are many state-of-the-art designs in assemblies, where it may not always be feasible to obtain certification. The words, “or otherwise evaluated to the applicable standard(s)” have been added to Section 13.4.3 of S2-0200 to enable manufacturers and third parties to evaluate these assemblies to the appropriate standard(s) themselves rather than requiring certification for such assemblies.
11.3.5 Electrical wiring should be color coded or labeled for easy identification of the wiring's origin and termination according to international or appropriate (country of use) national standard.	13.4.4 Electrical wiring for power circuits, control circuits, grounding (earthing) and grounded (neutral) conductors should be color coded according to appropriate standard(s) per Section 13.4, or labeled for easy identification at both ends of the wire. Where color is used for identification, it is acceptable to wrap conductor ends with appropriate colored tape or sleeving; the tape or sleeving should be reliably secured to the conductor. EXCEPTION 1: Internal wiring on individual components, e.g., motors, transformers, meters, solenoid valves, power supplies. EXCEPTION 2: Flexible cords. EXCEPTION 3: Nonhazardous voltage multi-conductor cables (e.g., ribbon cables). EXCEPTION 4: When proper color is not available for conductors designed for special application (e.g., high-temperature conductors used for furnaces and ovens).	Note: The exceptions are based on clause 16.1.3 of NFPA 79-1997 and 14.2.4 of EN/IEC 60204-1997.
11.3.6 Electrical enclosures should be constructed to National Electrical Manufacturers Association (NEMA) standards or equivalent.	13.4.6 Electrical enclosures should be suitable for the environment in which they are intended to be used.	Note: The NEMA requirement for enclosure has been removed to meet the “Internationalization” filter and has now been replaced with a more performance-based requirement.
11.3.7 The minimum over-current ratings for components used as main disconnects should be identified in the facility installation and maintenance manual. (For additional information, see NEC 110-9 and 110-10.) The end user should require the following as a minimum:	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.	Note: The reference to NEC has been removed to satisfy the “Internationalization” filter.

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All 208/120 volt main circuit protection devices should be rated to withstand the available short circuit current of at least 10,000 rms symmetrical amperes at 208/120 volts at their incoming terminals. For all 480/277 volt circuits, protection devices should withstand a minimum of 14,000 rms symmetrical amperes. EXCEPTION: Over-current protection devices need not have 10,000 AIC (or 14,000 AIC) if they are located on the load side of another over current protection device, mentioned above, with the proper AIC rating. This over-current protection device shall be mounted in close proximity to the equipment.	13.4.10 The equipment should be provided with main overcurrent protection devices and main disconnect devices rated for at least 10,000 rms symmetrical amperes interrupting capacity (AIC). NOTE 36: Some facilities may require higher AIC ratings due to electrical distribution system design. EXCEPTION: Cord- and plug-connected single phase equipment, rated no greater than 240 volts line-to-line/150 volts line-to-ground and no greater than 2.4 kVA, may have overcurrent protection devices with interrupting capacity of at least 5,000 rms symmetrical amperes interrupting capacity (AIC).	Note: The Working Group discussed the benefit of maintaining different AIC ratings for overcurrent protective devices of different voltage circuits and a consensus was reached to simplify this section by standardizing towards 10,000 AIC rating independent of voltages. The basis is for this decision was that even 14,000 AIC rated overcurrent protective devices may not be adequate if the available fault current at the facilities exceeds 14,000 AIC. Instead, a NOTE has been added to clarify that depending on the specific end-user location, the AIC rating of the overcurrent protective device may need to be increased. Note: Note 36 of SEMI S2-0200 was intended to alert manufacturers that the minimum 10,000 AIC interrupting capacity requirement specified in section 13.4.10 may not be sufficient at fabs where the available fault current exceeds 10,000 amperes.
11.3.8 Incoming electrical power from the facility to the process equipment should come from a single feed location and should terminate at the main disconnect defined in 11.3.7. This disconnect should have the lockout capabilities specified in 11.2. (For additional information, see OSHA 29 CFR 1019.147.) EXCEPTION 1: Internal power distribution to support modules and sub-panels is acceptable. EXCEPTION 2: Equipment with more than one feed should be provided with provisions for lockout and be marked with the following text, “DANGER, RISK OF ELECTRIC SHOCK. DISCONNECT ALL (number of	13.4.11 Equipment should be designed to receive incoming electrical power from the facility to a single feed location that terminates at the main disconnect specified in Section 13.4.9. This disconnect, when opened, should remove all incoming electrical power in the equipment from the load side of the disconnect. The disconnect should also have the energy isolation (“lockout”) capabilities specified in Section 17. EXCEPTION 1: Equipment with more than one feed should be provided with provisions for energy isolation (lockout) for each feed and be marked with the following text or the equivalent at each disconnect: “WARNING: Risk of Electric Shock or Burn. Disconnect all [number of feed locations] sources of supply prior to servicing.” It is preferred that all of	

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feed locations) SOURCES OF SUPPLY PRIOR TO SERVICING” at each disconnect. EXCEPTION 3: A second power feed may be used when power is supplied from a facilities UPS system to maintain critical equipment system, but not the entire system. Power supplied from an external UPS will be removed when the emergency off circuit is activated or the main equipment breaker is opened.	the disconnects for the equipment be grouped in one location. EXCEPTION 2: Multiple units mounted separately with no shared hazards and without interconnecting circuits with hazardous voltages, energy levels or other potentially hazardous conditions may have: • separate sources of power and separate supply circuit disconnect means, if they are clearly identified; or • separate EMO circuits, if they are clearly identified.	Note: Provisions have now been added to allow a separately mounted unit (such as Heat Exchangers, Chillers, etc.) to have its own power source and disconnecting means and its own EMO circuit. Also refer to Exception 4 of Section 12.2.1.
11.3.9 All equipment should be provided with a nameplate, located adjacent to the input power connection, containing, as a minimum, the manufacturer's name, model number, serial number, and electrical ratings (voltage, current, frequency, and, for multi-phase systems, the number of phases and number of wires. For more information, see NEC 670-3 and NFPA 79, Chapter 2-7.)	13.4.12 A permanent nameplate listing the manufacturer's name, machine serial number, supply voltage, phase, frequency and full-load current should be attached to the equipment where plainly visible after installation. Where more than one incoming supply circuit is to be provided, the nameplate should state the above information for each circuit. NOTE 37: Additional nameplate information may be required depending on the location of use.	Note: The criteria for nameplate data have been reduced to be more consistent with other product safety standards. Note: Note 37 has been added to alert manufacturers that the nameplate data in Section 13.4.12 may not be sufficient in certain locations of use. Country specific requirements for nameplate data beyond that noted in Section 13.4.12 are outlined in Related Information 12, “Other Requirements By Region of Use”.
11.4 UPS, Uninterrupted Power Supplies - Applies to UPS with outputs greater than 30 volts ac or dc or energy level in the excess of 500 volt-amperes and integrated inside equipment footprint. (For additional information, see NFPA 110A.)	13.5 <i>Uninterruptable Power Supplies (UPSs)</i> — This section applies to UPSs with outputs greater than: 30 volts rms, 42.4 volts peak; 60 volts dc; or 240 volt-amps.	Note: The 500 VA cutoff level has been lowered to 240 VA to keep consistent with the definition of hazardous energy.
	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.	
11.4.1 Output of the UPS should be removed when the emergency off circuit is activated or the main equipment breaker is opened. The emergency off circuit or the main equipment breaker should be a hardware-based fail-safe circuit.	13.5.2 Power from the UPS should be interrupted when any of the following events occur: • the emergency off actuator (button) is pushed; or • the main equipment disconnect is opened; or • the main circuit breaker is opened. EXCEPTION: Upon EMO activation, the UPS may supply power to the EMO circuit, safety related devices, and data/alarm logging computer systems as described in the exception clauses of Section 12.2.	Note: The exception is added to bring it more in line with Exception 1 of Section 12.2.

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11.4.2 UPS should be located within the main power enclosure. If not, it must be physically isolated from other equipment systems.	13.5.3 The UPS may be physically located within the footprint of the equipment provided that the UPS is within its own enclosure and is clearly identified.	Note: It was recognized that equipment may contain many hazardous energy UPSs integrated in commercial components such as magnetic bearing turbo pumps. It is not feasible to require them to all be located in the main power enclosure.
11.4.3 The UPS should be listed or recognized by a nationally recognized testing lab.	13.5.4 The UPS should be certified by an accredited testing laboratory and be suitable for its intended environment (e.g., damp location, exposure to corrosives).	Note: The phrase “listed or recognized by a nationally recognized testing lab” has been replaced with “certified by an accredited testing laboratory” to satisfy “Internationalization” filter.
11.4.4 The UPS wiring shall be separate and identified at termination points as “UPS SUPPLY OUTPUT”.	13.5.5 The UPS wiring should be identified as “UPS Supply Output” or equivalent at each termination point where the UPS wiring can be disconnected.	
	13.7 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 38: NFPA 497 and EN 1127-1 provide methods for making this assessment.	
12 Emergency Shutdown	12. Emergency Shutdown	
12.1 The equipment should have an “emergency off” (EMO) circuit which, when activated, places the equipment into a safe shutdown condition. A safe shutdown should not increase the level of hazard in the system. EXCEPTION: Components which are not intended to be used as stand-alone equipment, but rather within an overall end-use system (and receive their power from the end-user system), need not be provided with an emergency off circuit. The component installation manual, however, should need to provide clear instruction to the end-user system manufacturer to connect the component to the end-user system's emergency off circuit.	12.1 The equipment should have an “emergency off” (EMO) circuit. The EMO actuator (e.g., button), when activated, should place the equipment into a safe shutdown condition, without generating any additional hazard to personnel or the facility. EXCEPTION 1: An EMO circuit is not needed for equipment rated 2.4 kVA or less, where the hazards are only electrical in nature, provided that the main disconnect meets the accessibility provisions of Section 12.5.2 and that the effect of disconnecting the main power supply is equivalent to activating an EMO circuit. EXCEPTION 2: Assemblies that are not intended to be used as stand-alone equipment, but rather within an overall integrated system, and that receive their power from the user's system, are not required to have an emergency off circuit. The assembly's installation manual should provide clear instructions to the equipment installer to connect the assembly to the integrated system's emergency off circuit. NOTE 29: It is recommended that the emergency off function not reduce the effectiveness of safety devices or of devices with safety-related functions (e.g., magnetic chucks or braking devices) necessary to bring the equipment to a safe	Note: Certain assemblies are intended to be mounted within an overall integrated system (such as many rack-mounted units). It does not seem to be value-added to require that each assembly be provided with an EMO button, if it is expected that the end-user system will provide a system EMO button.

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	shutdown condition effectively.	
	NOTE 30: If a fire detection or suppression system is provided with the equipment, see Section 14 for additional information.	
	12.1.1 If the supplier provides an external EMO interface on the equipment, the supplier should include instructions for connecting to the interface.	
12.2 The emergency off circuit (EMO) should be a fail safe circuit that shuts off all electrical power to the equipment so that only the safe voltage EMO circuit (typically 24 volts) and its supply may be energized. The EMO should be designed to ensure that it cannot be disabled without causing the main power circuit to open. The EMO should be hardwired to the equipment's operating system. The EMO circuit should require manual resetting so that power cannot be restored automatically. Resetting of the EMO switch should not re-energize the equipment.	12.2 Activation of the emergency off circuit should deenergize all hazardous voltage and all power greater than 240 volt-amps in the equipment beyond the main power enclosure. EXCEPTION 1: A non-hazardous voltage EMO circuit (typically 24 volts) and its supply may remain energized. EXCEPTION 2: Safety related devices (e.g., smoke detectors, gas/water leak detectors, pressure measurement devices, etc.) may remain energized from a non-hazardous power source. EXCEPTION 3: A computer system performing data/alarm logging and error recovery functions may remain energized, provided that the energized breaker(s), receptacle(s), and each energized conductor termination are clearly labeled as remaining energized after EMO activation. Hazardous energized parts that remain energized after EMO activation should be insulated or guarded to prevent inadvertent contact by maintenance personnel. EXCEPTION 4: Multiple units mounted separately with no shared hazards and without interconnecting circuits with hazardous voltages, energy levels or other potentially hazardous conditions may have: • separate sources of power and separate supply circuit disconnect means if clearly identified, or • separate EMO circuits, if they are clearly identified. 12.2.2 The EMO circuit should consist of electromechanical components.	Note: Additional exceptions have now been introduced in Section 12.2 permitting sub-circuits to be energized after EMO. Note: Exception 2 limits the use of safety related devices to hazardous power (i.e. 240VA). What is not explicitly stated is whether this power may be delivered at hazardous voltage levels. This will require clarification in the next revision. Note: Due to increasing requests for critical computer systems to remain energized to prevent lost of critical data, an exception has been added to permit certain computer systems to remain energized after the EMO activation. Note: Parallel to Exception 2 of clause 13.4.1, provisions have now been added in Exception 4 to allow separately mounted units (such as remote display monitors, vacuum pumps, etc.) to have its own power source and disconnecting means, or its own EMO circuit, providing that there is no shared hazard between the unit(s) and the system.

NOTE: The EMO should perform its function by de-energizing rather than energizing control

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components.	12.2.3 Resetting the EMO switch should not re-energize circuits, equipment, or subassemblies.	Note: The requirement is consistent with that of clause 9.2.5.4.2 of IEC 60204-1997, “reset shall not initiate a restart”.
	12.2.4 The EMO circuit should shut down the equipment by deenergizing rather than energizing control components.	Note: The NOTE in SEMI S2-93 has converted into a requirement.
	12.2.5 The EMO circuit should require manual resetting so that power cannot be restored automatically.	
	12.2.1 The EMO circuit should not include features that are intended to allow it to be defeated or bypassed.	Note: This requirement was added to prohibit a switch, key or other control circuit that would bypass EMO circuit. However, this section does NOT require an EMO system to be non-defeatable by any conceivable means.
12.3 The emergency off function and hardware configuration should be clearly described in the facilities installation instructions and maintenance manuals.	(Addressed in Section 9.6.3 - Documents Provided to User)	Note: The requirement for description of emergency off function is now addressed in Section 9.6.3, “ <i>Descriptions of the emergency off and interlock functions.</i> ”
12.4 All emergency off buttons should be clearly labeled and easily accessible from operating and maintenance locations. Multiple emergency off buttons should be provided where necessary to assure ready access from any location on the equipment or remote components. The emergency off circuit should disable any UPS outputs to the point where only safe EMO control voltage is available. (For additional information, see NFPA 79 7-2.)	12.4 All emergency off buttons should be clearly labeled as “EMO,” “Emergency Off,” or the equivalent and should be clearly legible from the viewing location. The label may appear on the button or on the yellow background. 12.5 Emergency off buttons should be readily accessible from operating and regularly scheduled maintenance locations and appropriately sized to enable activation by the heel of the palm. 12.5.2 No operation or regularly scheduled maintenance location should require more than 3 m (10 feet) travel to an EMO button.	Note: The requirement now addresses guards and shrouds for EMOs, and clarifies that the EMO button needs to be accessible by the ‘heel’ of the palm. The ‘heel’ of the palm is also mentioned in the pushbutton section of the “Human Factors Design Handbook, Second Edition” by Wesley E. Woodson, Barry Tillman and Peggy Tillman, “<i>The push button is an effective emergency control device for shutting off machines in a hurry. In such applications, the button should be larger so that the operator does not have to be so accurate, i.e., so that the button can be operated either with the end of a finger or with the heel of the hand.</i>” Note: The basis of this requirement is taken from a SEMI Yellow Ballot Draft Document 2322, “Safety Guidelines for Emergency Shutdown Design” which was withdrawn during the balloting process.
	12.5.3 The person actuating or inspecting the EMO button should not be exposed to serious risks of tripping or falling or of coming in contact with energized electrical parts, moving	

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	machinery, surfaces or objects operating at high temperatures, or other hazardous equipment.	
	12.6 See Section 13.5 for additional EMO guidelines when EMOs are used with UPSs.	Note: This is simply a pointer to advise the reader that additional EMO criteria are located in the UPS section.
12.5 The emergency off button should be red, palm or mushroom shaped, and located to minimize accidental activation. Lockable types should be considered at the rear of the equipment and maintenance access areas.	12.3 The emergency off button should be red and mushroom shaped. A yellow background for the EMO should be provided. NOTE 31: Non-lockable self-latching (i.e., twist- or pull-to-release) EMO buttons may be required by regulations. 12.5.1 Emergency off buttons should be located or guarded to minimize accidental activation.	Note: The yellow background requirement has been added to bring harmonization with U.S. (NFPA 79, ANSI/RIA R15.06) and International standards (e.g. EN 418, EN 60204, etc.) Note: Lockable type EMO is discouraged in the revised version because of its common misuse as a means of energy isolation (lockout/tagout).
12.6 Buttons used for other purposes should follow the guidelines in NFPA 79, Chapter 11. NOTE: When a machine has both an emergency off and an emergency stop, etc., the EMO should be red, with the other button colored different within the guidelines of NFPA 79, Chapter 11.		Note: This requirement has been removed because: 1) NFPA 79 is a U.S. based standard and as such does not conform with the “Internationalization” filter. 2) The NOTE is in direct conflict with Section 12.6 because NFPA 79 requires Stop and OFF buttons to be RED.
13. Heated Chemical Baths	15. Heated Chemical Baths	Note: Section 13 has been renumbered to Section 15.
Use SEMI S3 as the minimum safety design considerations. All baths should have the following: Grounded or GFCI heaters Power interrupt Manual reset Automatic temperature controller Liquid level sensor Fail-safe over-temperature protection Proper construction materials Exhaust failure interlock Overcurrent protection	15.1 Refer to SEMI S3 for the minimum safety design considerations for heated chemical baths. Each heated chemical bath should have the following: - grounded or GFCI-protected heater; - power interrupt; - manual reset; - automatic temperature controller; - liquid level sensor; - fail-safe over-temperature protection; - proper construction materials; - exhaust failure interlock; and - overcurrent protection. NOTE 63: See Section 14 for fire protection risk assessment considerations for baths using combustible or flammable chemicals.	
14. Ergonomics/Human Factors	16. Ergonomics and Human Factors	Note: Section 14 has been renamed slightly and

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		renumbered to Section 16.
14.1 General - Process equipment should be designed to prevent personal injury and equipment damage and to minimize procedural errors. Equipment design features should ensure that operator workload, information processing requirements, and physical demands do not exceed user capabilities or compromise safety. The following sections provide general guidelines that are further explained or detailed in SEMI S8 and applicable references in Appendix 2.	16.1 General - Ergonomics and human factors design principles should be incorporated into the development of equipment to identify and eliminate or mitigate ergonomics- and human factors-related hazards. 16.2 Provisions for Conformance - Equipment should be assessed to the guidelines set forth in SEMI S8. The Supplier Ergonomic Success Criteria (SESC; see SEMI S8), or the equivalent, should be used to document the assessment.	Note: SEMI S2-0200 simply references SEMI S8 and the use of the SESC
14.2 Ergonomic Hazards - Ergonomic hazards should be designed out or otherwise reduced to the maximum extent practicable. Ergonomic hazards exist whenever the system design or installation results in task demands that exceed the information processing and/or physical capabilities of trained personnel. Hazards may result from: (a) controls that are confusing to operate; (b) displays that are difficult to read or understand; (c) lifting of heavy or bulky components; (d) repetitive motion; (e) static and/or awkward postures; (f) poor access, inadequate clearance, and excessive reaching, bending, or stooping.	(Deleted. Refer to SEMI S8)	
14.3 Human Characteristics - Equipment should be designed to fit the physical characteristics of 90 percent of the user population (from 5th percentile Asian female through 95th percentile American male). User population design considerations include: (a) ensuring that frequently performed physical task requirements are located within the functional reach envelope of small operators; (b) providing sufficient access and clearance for large operators; (c) ensuring that manual handling requirements are within the strength capability of all operators; (e) locating displays for ease of viewing. Control and display operation should be compatible with user expectations (e.g., behavioral stereotypes).	(Deleted. Refer to SEMI S8)	
14.4 Operability 14.4.1 System controls and displays should promote ease of use. Equipment design should consider both routine and non-routine (e.g., emergency or fault) operation. Risk to operators should be minimized by decreasing both the likelihood and consequence of procedural errors.	(Deleted. Refer to SEMI S8)	
14.4.2 Visual and/or auditory signals should alert	(Deleted. Refer to SEMI S8)	

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operators to conditions that are unsafe or require immediate intervention.		
14.4.3 Prompt and consistent feedback should be provided to indicate system status, control inputs, and changes in system condition.	(Deleted. Refer to SEMI S8)	
14.5 Maintainability/Serviceability - Equipment design and installation should facilitate maintenance and service. Specific considerations should include: (a) design for positive malfunction detection and isolation of faulty components; (b) unit packaging of component parts for ease of removal and replacement; (c) access to components that require testing, servicing, maintenance, or replacement; (d) lifting aids for heavy or bulky components.	(Deleted. Refer to SEMI S8)	
14.6 Training - System design should minimize personnel and training requirements considering time, cost, and performance trade-offs.	(Deleted. Refer to SEMI S8)	
14.7 Documentation - Documentation should describe and validate the ergonomics/human factors design features of the equipment. Accepted methods and practices should be used when evaluating the human-machine interface.	(Deleted. Refer to SEMI S8)	
15. Robotics and Automation	20. Automated Material Handlers	Note: Section 15 has been renamed and renumbered to Section 20.
	20.1 This section covers automated material handlers, which include: • substrate handlers; • industrial robots and industrial robot systems; and • unmanned transport vehicles (UTVs). NOTE 84: Substrate handlers typically handle a single substrate at a time, and are distinguished from industrial robots by their small load capacity.	Note: The Working Group recognizes that there are really three general types of automated material handlers and that in many cases, it would not be appropriate to apply the requirements of ANSI/RIA R15.06 to wafer handlers or unmanned transport vehicles, as inferred in Section 15 of SEMI S2-93A. This Section and NOTE 84, therefore, defines three categories (substrate handlers, industrial robots and industrial robot systems, and unmanned transport vehicles) and outlines evaluation criteria for each of them.
	20.2 <i>General</i> — The means of incorporating personnel safeguarding into automated material handlers should be based on a hazard analysis. The hazard analysis should include consideration of the size, capacity, speed, and spatial operating range of the handler. 20.2.1 <i>Subsystem Stops</i> — If a separate stop button is used for the automated material handler, it should be differentiated	

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	from the EMO button.	
	<i>20.3 Substrate Handlers — See Section 20.2, General.</i>	
ANSI/RIA R15.06 should be used as the minimum safety design considerations. Robotics and automation should not add to the overall degree of hazard presented by the equipment and should be designed in a manner that minimizes pre-existing procedural, chemical, electrical, and mechanical	<i>20.4 Industrial Robots and Industrial Robot Systems —</i> Industrial robots and industrial robot systems should meet the requirements of appropriate national or international standards, e.g., ANSI/RIA R15.06, ISO 10218, EN 775. If there are deviations from these standards because of semiconductor applications of the robot, these deviations may be found acceptable based on risk assessments.	
	<i>20.5 UTVs</i> NOTE 85: There are two basic types of UTVs: (1) the floor-traveling (including both rail-guided and rail-independent) UTV, that automatically travels on the floor to a specified destination where it is unloaded or loaded; and (2) the space-traveling UTV, which automatically travels without resting on the floor (e.g., in the space below the ceiling) to a specified destination where it is loaded or unloaded. UTVs do not include rail-guided mechanisms that are attached to equipment (such as in wet benches). <i>20.5.1 Collision Avoidance —</i> UTVs generally travel in wide areas and are used in a system rather than stand alone operation. UTVs should be equipped with a non-contact approach sensing device so that they do not inadvertently contact people or other objects. <i>20.5.2 UTVs: Loading and Unloading Equipment</i> 20.5.2.1 UTVs should be interlocked with equipment such as semiconductor process equipment, automated load ports, stockers, ground-based conveyors, and automated warehouses as needed to ensure that the load remains secure and that the UTV and transfer components are not in conflict with one another. 20.5.2.2 If loading results in an unsafe condition, the equipment should detect and indicate the condition, and movement of all loading equipment should stop immediately. The system should not reset or restart automatically.	
16 Hazard Warning	10. Hazard Warning Labels	Note: Section 16 has been renamed and renumbered to Section 10.
16 Hazard Warning	10. Hazard Warning Labels	
All electrical, chemical, thermal, and mechanical	10.1 Where it is impractical to eliminate hazards through	Note: SEMI S1 and ANSI Z535 were undergoing

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hazards should be identified on the equipment. All chemical hazards should be identified by descriptive labels. All other hazard labels should conform with SEMI S1 or ANSI Z535, IEC 417, or an equivalent. All hazards should also be identified in the operation and maintenance manuals. The use of the words CAUTION, WARNING, and DANGER should conform to the requirements of 29 CFR 1910.144-147 and ANSI Z535.	design selection or to adequately reduce the associated risk with safety or warning devices, hazard warning labels should be provided to identify and warn against hazards. 10.2 Labels should be durable and suitable for the environment of the intended use. 10.3 Labels should conform to SEMI S1. EXCEPTION: Some hazard label formats and content are dictated by law (e.g., laser labeling and chemical hazard communication labeling in certain countries of use) and may not conform to SEMI S1.	rewrite at the time of this S2 rewrite process., However, he decision was made to direct the reader to SEMI S1. This way, we minimize creating potential conflicts in criteria between SEMI S1 and SEMI S2. Note: Refer to SEMI Document 2781 for draft revision update to SEMI S1. Note: To avoid conflicts between SEMI S1 and the labeling text requirements of certain product specific regulations and code, an exception has been added.
17. Earthquake Protection	19. Seismic Protection	Note: Section 17 has been renamed and renumbered to Section 19.
17.1 The equipment and its sub-assemblies should have protection from movement during earthquakes.	NOTE 74: Users have facilities located in areas that are susceptible to seismic activity. The end user may require more stringent design criteria because of increased site vulnerability (e.g., local soil conditions and building design may produce significantly higher accelerations) and local regulatory requirements. Certified drawings and calculations may be required in some jurisdictions. 19.1 General - The equipment should be designed to control the risk of injury to personnel, adverse environmental impact, equipment and facility damage due to movement, overturning, or leakage of chemicals (including liquid splashing), during a seismic event. The design should also control equipment damage due to failure of fragile parts (e.g., quartzware, ceramics) during a seismic event. NOTE 75: These criteria are intended to accomplish two things: (1) allow equipment suppliers to correctly design the internal frame and components to withstand seismic forces; and (2) allow equipment designers to provide end-users with the information needed to appropriately secure the equipment within their facility.	

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	19.1.1 Because preventing all damage to equipment may be impractical, the design should control the failure of parts that may result in increased hazard (e.g., hazardous materials release, fire, projectile). NOTE 76: It is recommended that the hazard analysis described in Section 6.8 be used to evaluate both the risk of part failure and the effectiveness of control measures. 19.1.1.1 These parts should be accessible for evaluation of damage. NOTE 77: SEMI S8 contains guidelines for maintainability and serviceability; these may be used to determine accessibility.	
17.2 All tie-ins and attachments to equipment should be able to accommodate the expected displacement of the equipment and surrounding structure in an earthquake. These locations should be clearly identified on the equipment frame.	19.4 The locations of the tie-ins, attachments, or seismic anchorage points should be clearly identified. NOTE 82: It is not the intent of SEMI S2 that the supplier provide the seismic attachment point hardware. Such hardware may be provided as agreed upon between supplier and user. NOTE 83: It is the responsibility of the user to verify that the vibration isolation, leveling, seismic reinforcing, and load distribution is adequate.	
17.2.1 Equipment design and method of installation should provide for the following acceleration:	19.2 Design Loads - The equipment, subassemblies, and all devices used for anchoring the equipment should be designed as follows: 19.2.1 For equipment containing hazardous production materials (HPMs), the equipment should be designed to withstand a horizontal loading of 94% of the weight of the equipment, acting at the equipment's center of mass. 19.2.2 For equipment not containing hazardous production materials (HPMs), the equipment should be designed to withstand a horizontal loading of 63% of the weight of the equipment, acting at the equipment's center of mass. NOTE 78: Subassemblies may include transformers, vessels, power supplies, vacuum pumps, monitors, fire suppression components, or other items of substantial mass that are attached to the equipment.	Note: The seismic requirements in SEMI S2-0200 are more detailed than that of SEMI S2-93A. The seismic requirements are based on the 1997 version of the Uniform Building Code. The derivation of these requirements is shown in section R5-2 of Related Information 5.

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- 4.0 m/sec² (0.4 G (gravity)) simultaneous on the X and Y axes and 2.5 m/sec² (0.25 G (gravity)) simultaneous on the Z axis. - Frequency of acceleration applied should be in the 0 - 30 Hz range.	19.2.3 Horizontal loads should be calculated independently on each of the X and Y axes, or on the axis that produces the largest loads on the anchorage points. 19.2.4 When calculating for overturning, a maximum value of 85% of the weight of the equipment should be used to resist the overturning moment. NOTE 79: Because equipment may be placed into service anywhere in the world, it is recommended that the seismic protection design of the equipment be based upon requirements that allow the equipment, as designed, to be installed in most sites worldwide. The above loads are based on 1997 Uniform Building Code (UBC) requirements for rigid equipment in Seismic Zone 4, and are assumed to satisfy most design situations worldwide. NOTE 80: If the equipment or internal component is flexible as defined by the UBC, is located above the midheight of the building, or is within 5 km of a major active fault, the horizontal design loadings in Sections 19.2.1 and 19.2.2 may not be conservative. Likewise, there are several conditions for which the horizontal design loadings are overly conservative (e.g., rigid equipment with rigid internal components located at grade, or sites with favorable soils conditions). For these conditions, designing based on the more detailed approach in the UBC may result in a more economical design. It is recommended that the user engage a professional mechanical, civil, or structural engineer to make these determinations.	
17.2.2 Supplier should provide the following data for end user: - A complete base frame plan with isometric views, sections, and intersections details of framing members - A three-dimensional drawing of the skeleton framing - The type of feet used and their location on the base frame plan drawing - The weight distribution on each foot - Center of gravity location for each module	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 Section 9. • A drawing of the equipment, its support equipment, its connections (e.g., ventilation, water, vacuum, gases) and the anchorage locations identified in Section 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.	



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- A statement of the qualification of the reviewing party. (See Section 4.2.) - The date that the equipment was last evaluated and serial number of unit evaluated - All modifications made since the evaluation - A list of the safety-related tests the equipment will be subjected to during the final test and prior to its shipment to the end user.		
18.4 Upon the request of the end user, the equipment supplier should provide all of the following documentation: - A by-product analysis and information normally required by the end user to obtain necessary environmental permits and determine appropriate handling and disposal requirements. (See Section 20.2.)	9.1 This section describes the documents that the supplier provides to the user. 9.2 <i>Evaluation Report</i> — Upon request by the user, the supplier should provide the user with a summary of the SEMI S2 evaluation report (see Section 8) or the full report. 9.2.1 Nonconformances noted in the report should be addressed by the supplier, by providing either an action plan or a justification for acceptance. The justification should include countermeasures in place and a risk characterization per SEMI S10. 9.3 <i>Seismic Information</i> — Refer to Section 19 of this document. 9.4 <i>Environmental Documentation</i> — The manufacturer should provide the user with the following environmental documentation as applicable: 9.4.1 Energy consumption information, including idle, average, and peak operating conditions, for the manufacturer’s most representative (“baseline”) process. 9.4.2 Mass balance, including idle, average, and peak operating conditions, for the manufacturer’s most representative (“baseline”) process. NOTE 16: 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. 9.4.3 Information regarding routes of unintended release (of effluents, wastes, emissions, and by-products) and methods	Note: Section 9.2 “Evaluation Report” has now been created to promote consistency of the information in an S2 evaluation report. The Working Group balanced the minimum report outline and the business need of reviewers to provide value-additions in their reports. Note: Environmental information was added by the Environmental Working Group.

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- A system safety analysis or an OSHA hazard analysis as outlined in 29 CFR 1910.119. - A list of all hazardous materials which may be used. - An industrial hygiene evaluation to NIOSH standards or equivalent which should include, as applicable: - External leakage of ionizing radiation. (See Section 7.2.) - Frequency and level of non ion-ionizing radiation. (See Section 8.2.) - Noise test report or statement. (See Section 9.2.) - Ventilation testing report. (See Section 10.5.) - Ergonomics evaluation. (See Section 14.7.) - MSDS for hazardous materials supplied by or available directly from the equipment supplier.	and devices to monitor and control such releases. This should include information on features to monitor, prevent, and control unintended releases (see Section 21.2.4). 9.4.4 Information regarding routes of intended release (of effluents, wastes, and emissions) and features to monitor and control such releases (see Section 21.2.5). 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). (Addressed in Section 9.6.3 – Manuals) 9.5 <i>Industrial Hygiene Information</i> — Refer to Sections 22–27 of this document. 9.6 <i>Manuals</i> 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. 9.6.2 The manuals should conform to SEMI S13. NOTE 17: 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	Note: The reason for consolidating the criteria for documentation in Section 9.6 is to better enable the equipment supplier’s technical publication department to quickly identify all of the necessary documentation needed to be assembled in manuals. Note: Several SEMI S2-93 documentation-related criteria were removed from SEMI S2-0200 if these criteria were already captured in SEMI S13. Designers should, therefore, reference SEMI S13 to ensure that they have
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	the equipment. NOTE 18: 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. 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 Section 13.3); • instructions for energy isolation (“lockout/tagout”) (refer to Section 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). 9.6.4 Information should be provided regarding potential routes of unintended releases (see Section 21.2.4). 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 Section 8.5.3); and	captured all of the information specified for manuals. Note: At first glance, the fifth bullet in Section 9.6.3 of SEMI S2-0200 duplicates the criteria specified in Section 9.4.5. The Environmental Working Group clarified that while these two sections are quite similar, they are not duplicates as one deals with documentation that is to be provided to the user, while the other deals information to be included in manuals. Note: The Environmental Working Group clarifies that while Section 9.6.4 of SEMI S2-0200 appears to duplicate Section 9.4.4, they are not duplicates as one deals with documentation that is to be provided to the user, while the other deals information to be included in manuals.
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	- residual hazardous materials, or parts likely to become contaminated with hazardous materials, that may be in the equipment prior to decommissioning. NOTE 19: It is recommended that the manual state that changes to the typical process chemistry or to the equipment could alter the anticipated environmental impact. <i>9.6.6 Maintenance Procedures with Potential Environmental Impacts</i> — 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. <i>9.7 Fire Protection Documentation</i> — The equipment supplier should provide: - a summary fire protection report as described in Section 14.3; - descriptions of optional fire risk mitigation features (see Section 14.3.2); - NOTE 20: It is recommended that this be provided prior to purchase. - fire detection system operations, maintenance, and test manuals; - fire suppression system operations, maintenance, and test manuals; - acceptance documents provided by licensed designers and installers (see Sections 14.4.4.12 and 14.4.5.16); and - a list of any special apparatus needed to test the fire detection or suppression features of the equipment. The list should note whether the apparatus is included with the equipment, or is sold separately.	
19. Fire Protection	14. Fire Protection	Note: Section 19 has been renumbered to Section 14.
	14.1 Overview - This section applies to fire hazards that are internal to the equipment. 14.1.1 This section provides minimum safety considerations for fire protection designs and controls on the equipment. 14.1.2 This section also provides minimum considerations for	

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	fire detection and suppression systems when provided with the equipment. NOTE 39: Detailed guidance on fire risk assessment and mitigation for semiconductor manufacturing equipment is provided in SEMI S14. 14.2 Risk Assessment 14.2.1 A documented risk assessment should be performed or accepted by a party qualified to determine and evaluate fire hazards and the potential need for controls. The risk assessment should consider normal operations and reasonably foreseeable single-point failures within the equipment. It should not consider exposure to fire or external ignition sources not within the specified use environment. NOTE 40: This risk assessment can be combined with the overall hazard analysis performed for this guideline, provided the risk assessor has the required professional expertise to perform risk assessments for fire hazards. SEMI S7 describes qualifications for such an assessor. 14.2.2 If an accurate risk assessment depends on the user's adherence to specified procedures or conditions of use, the supplier should describe such procedures or conditions and state their importance. 14.3 Reporting 14.3.1 A summary report should be provided to the user. The summary should include the following characterizations, per SEMI S10, for each residual fire hazard identified: • the assigned Severity; • the assigned Likelihood; and • the resulting Risk Category. 14.3.2 Optional fire risk reduction features should be described in the pre-purchase information provided to the user. 14.3.3 The scope and effectiveness of the means of fire risk reduction should also be identified and reported, including the expected risk reduction (as described in Section 14.3.1).	Note: Note 39 was updated in the SEMI S2-0200^E version to reference the recently released SEMI S14. Note: SEMI S2-0200 includes criteria for performing a fire protection risk assessment.
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	14.3.4 If, due to fire hazards within the equipment, thermal or non-thermal (e.g., smoke) damage is possible outside of the equipment, then this possibility should be reported to the user. This report should include a qualitative description of the foreseen scenario.	
19.1 The use of combustible and smoke-generating materials in the construction of the process equipment should be limited. No flammable or combustible material should come in contact with potential ignition sources such as electrical components or heated surfaces. 19.2 A materials flammability test report should be available upon request. The use of combustible plastics, rated less than UL 94V-0, should be limited to less than 20% of the surface area and protected from such sources of ignition. (For additional information, see Flame Spread per ASTM E-84, Limited Oxygen Index per ASTM D-2863 and Heat Deflection Temperature per ASTM D-648 or other technical reference which address combustible plastics.)	14.4 Fire Risk Reduction 14.4.1 Materials of Construction - Equipment should be constructed of noncombustible materials wherever reasonable. If process chemicals do not permit the use of noncombustible construction, then the equipment should be constructed of materials, suitable for the uses and compatible with the process chemicals used, that contribute least to the fire risk. NOTE 41: Some regional codes (e.g., Uniform Fire Code) may require construction with noncombustible materials. 14.4.1.1 The flowchart in Appendix 6 may be used for the selection of materials of construction for equipment. 14.4.1.2 Any portion of equipment that falls within the scope of SEMI F14 (Guide for the Design of Gas Source Equipment Enclosures) should be designed in accordance with that guide. 14.4.2 Elimination of Process Chemical Hazards - The option of substituting non-flammable process chemicals for flammable process chemicals should be considered. 14.4.3 Engineering Controls 14.4.3.1 Fire risks resulting from process chemicals may be reduced using engineering controls (e.g., preventing improper chemical mixing, preventing temperatures from reaching the flash point). 14.4.3.2 Fire risks resulting from materials of construction may be reduced using engineering controls (e.g., non-combustible barriers that separate combustible materials of construction from ignition sources, installing a fire suppression system that extinguishes ignited materials).	Note: In contrast to SEMI S2-93A which outlines a specific flammability rating of plastic material, SEMI S2-0200 includes a hierarchy for fire risk reduction.

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19.2.1 Circuit boards should be UL 94V-1 rated or better.	14.4.3.3 Equipment power and chemical sources that present unacceptable fire risks should be interlocked with the fire detection and suppression systems to prevent start-up of the equipment or delivery of chemicals when the fire detection or suppression is inactive. NOTE 42: Some jurisdictions require interlocking. NOTE 43: Refer to Section 6.5 for criteria for acceptability. 14.4.3.4 Shutdown or failure of a fire detection or suppression system need not interrupt the processing of product within the equipment by immediately shutting down the equipment, but should prevent additional processing until the fire detection or suppression is restored. Software or hardware may be used for this function. 14.4.3.5 Controlling smoke by exhausting it (using the supplier-specified equipment exhaust) from the cleanroom may be used to reduce fire risks from the generation of products of combustion. When used, this reduction method should be combined with detection or suppression when flames can be propagated. NOTE 44: Controlling smoke may be sufficient when smoke is the only consequence (e.g., smoldering components that generate smoke). NOTE 45: For controlling smoke to be effective, the smoke must be removed not only from the equipment, but also from the cleanroom. This is typically accomplished by using ducted exhaust. NOTE 46: The use of exhaust to remove smoke may be subject to regulations, such as building and fire codes. NOTE 47: The use of exhaust to remove smoke may create hazards within the exhaust system. Therefore, a description of the expected discharge (i.e., anticipated air flow rate, temperature, and rate of smoke generation) into the exhaust system may be important information for installation of equipment.	
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19.3 Equipment with enclosures greater than 1.4 m³ (50 ft³) should be evaluated for fire detection system. All fire detection systems should be listed or recognized by a nationally recognized testing lab. The supplier should consider fire suppression systems. 19.3.1 The fire detection systems should be capable of interfacing with the user's facility alarm systems.	14.4.4 Fire Detection - The following criteria apply to any fire detection system determined to be appropriate for fire protection by the fire risk assessment: NOTE 48: Heat detectors, smoke sensing devices, and other devices used solely for monitoring equipment status may not need to meet these requirements. Some local jurisdictions, however, may require that all smoke detectors be connected to building systems and be compliant with all applicable fire alarm codes. 14.4.4.1 The fire detection system, which includes detectors, alarms and their associated controls, should be certified by an accredited testing laboratory and suitable for the application. NOTE 49: Such certifications typically require that the components of fire detection systems are readily identifiable and distinguishable from other components in the equipment. 14.4.4.2 The fire detection, alarm and control system should be installed in accordance with the requirements of the certification in Section 14.4.4.1, and in accordance with requirements of the appropriate international or national codes or standards (e.g., NFPA 72). 14.4.4.3 The fire detection system should be capable of interfacing with the facility's alarm system. It may be preferable for the equipment supplier to specify the location and performance of detectors, but not provide them, so that the user may better integrate the detection in the equipment with that in the facility. This alternative should be negotiated explicitly with the user. 14.4.4.4 The fire detection system should activate alarms audibly and visually at the equipment. 14.4.4.5 Manual activation capability for the fire detection system should be considered, for the purpose of providing notification to a constantly attended location. 14.4.4.6 Activation of trouble or supervisory conditions should result in all of the following: • notification of the operator; • allowing the completion of processing of substrates in the	Note: Instead of fire detection being listed or recognized by nationally recognized testing laboratories, SEMI S2-0200 specifies that fire detection systems shall be “certified by an accredited testing laboratory” in order to meet the internationalization goal.
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	equipment; • prevention of processing of additional substrates until the trouble or supervisory condition is cleared; and • providing, through an external interface, a signal to the facility monitoring system or a constantly attended location. 14.4.4.7 The fire detection system should be capable of operating at all times, including when the equipment is inoperable (e.g., equipment controller problems) or in maintenance modes (e.g., some or all of the equipment's hazardous energies are isolated ("locked out")). EXCEPTION: Operability is not required during maintenance of the fire detection system. NOTE 50: For the purposes of this section, "inoperable" includes the equipment state after an EMO is activated, and during maintenance of a duration less than the battery life expectancy of the fire detection system. Therefore, it is recommended that the detection system not require hazardous energies (e.g., line alternating current) to operate following an EMO activation. 14.4.4.8 A back-up power supply, capable of sustaining the detection system for 24 hours, should be provided. NOTE 51: Back-up power must be provided in accordance with local regulations. The requirements for back-up power vary among jurisdictions. 14.4.4.9 The fire detection system should remain active following EMO activation. 14.4.4.10 There may be cases where the internal power supply for a detection system cannot supply power for the full length of extended maintenance procedures (i.e., procedures longer than the expected duration of the back-up power supply). In such cases, the supplier should provide written procedures for either removing the fire hazard or safely supplying power to the fire detection system. 14.4.4.11 Activation of the fire detection system should shut down the equipment within the shortest time period that allows for safe equipment shutdown. This includes shutdown	
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	of any fire-related hazard source that could create additional fire risks for the affected module or component. NOTE 52: See Sections 14.4.3.3 and 14.4.3.4 for related provisions. EXCEPTION 1: A non-recycling, deadman abort switch is acceptable on detection systems that are used for equipment shutdown, but not on those used for activation of a suppression system. EXCEPTION 2: Activation of the fire detection system should not remove power from fire and safety systems. 14.4.4.12 The equipment design and configuration should not prevent licensed parties from certifying the design and installation of fire detection systems. NOTE 53: This is not meant to suggest installation by licensed parties; however, some jurisdictions require fire detection and suppression system installers to be licensed as specified by the jurisdiction. 14.4.5 Fire Suppression - The following criteria apply to any fire suppression system determined to be appropriate by the fire risk assessment. NOTE 54: As a fire detection system is generally required to provide the initiating sequence for the suppression system, it is the intention of this guideline that this be the same fire detection system described in Section 14.4.4. 14.4.5.1 The fire suppression system, which includes nozzles, actuators, and their associated controls, should be certified by an accredited testing laboratory and suitable for the application. NOTE 55: Such certifications typically require that the components of fire suppression systems are readily identifiable and distinguishable from other components in the equipment. This includes adequate labeling of piping. 14.4.5.2 The fire suppression agent should be accepted for the application by an accredited testing laboratory. The suppression agent selection process should include an evaluation of potential damage to a cleanroom, and the least	
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	damaging effective agent should be selected. If more than one agent is effective, the options should be specified to the user so that the user may specify which agent should be provided with the equipment. The supplier should also specify if the user may provide the agent. 14.4.5.3 The fire suppression agent and delivery system should be designed and installed in accordance with the appropriate international or national standard (e.g., NFPA 12, NFPA 13, NFPA 2001). It may be preferable for the equipment supplier to specify the location and performance of suppression system components, but not provide them, so that the user may better integrate the suppression in the equipment with that in the facility. This alternative should be negotiated explicitly with the user. 14.4.5.4 Activation of the fire suppression system should alarm audibly and visually at the equipment. This may be done by the same system that initiates activation. 14.4.5.5 If the discharge is likely to present a risk to personnel, the alarm should provide adequate time to allow personnel to avoid the hazard of the agent discharge. 14.4.5.5.1 If there is a confined space in the equipment, the asphyxiation hazard posed by the suppression system should be assessed. 14.4.5.6 The fire suppression system should be capable of operating at all times, including when equipment is inoperable and during equipment maintenance. NOTE 56: For the purpose of this section, "inoperable" includes the equipment state after the EMO is activated. EXCEPTION: Most suppression systems contain sources of hazardous energy. These sources should be capable of being isolated (i.e., "locked out") to protect personnel. 14.4.5.7 The fire suppression system should remain active following EMO activation. 14.4.5.8 There may be cases where the internal power supply for a suppression system cannot supply power for the full length of extended maintenance procedures (i.e., procedures longer than the expected duration of the back-up	
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	power supply). In such cases, the supplier should provide written procedures for either removing the fire hazard or safely supplying power to the fire suppression system. 14.4.5.9 Allowances can be made to provide for the deactivation of an automatic discharge of the suppression system when in the maintenance mode. Such deactivation switches should be supervised (i.e., if the suppression system is deactivated, there should be an indication to the user and the resumption of production in the equipment should be prevented.) NOTE 57: Hazardous energies associated with the fire suppression system may be isolated (i.e., "locked out") using an energy isolation procedure (see Section 17) during equipment maintenance. NOTE 58: The permissibility of deactivation of suppression systems varies among jurisdictions. 14.4.5.10 A back-up power supply, capable of sustaining the suppression system for 24 hours, should be included where the suppression system requires independent power from the detection system used to activate the suppression. NOTE 59: The requirements for back-up power vary among jurisdictions. 14.4.5.11 The fire suppression system should be capable of interfacing with the facility's alarm system. This may be done via the fire detection system. 14.4.5.12 Activation of the fire suppression system should shut down the equipment within the shortest time period that allows for safe equipment shutdown. NOTE 60: See Sections 14.4.3.3 and 14.4.3.4 for related provisions. EXCEPTION: Activation of the fire suppression system should not remove power from fire and safety systems. 14.4.5.13 The fire suppression system should be capable of manual activation, which should shut down the equipment and activate an alarm signal locally and at a constantly attended location.	
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	14.4.5.14 The fire suppression system should be tested on a representative sample of the equipment. The test procedure should include a suppression agent discharge test, unless precluded for health or environmental reasons. This test may be performed at the equipment supplier's or other similar facility, but should be performed under conditions that adequately duplicate any factors (e.g., equipment exhaust) that may reduce the effectiveness of the suppression. This representative sample need not be fully operational, but should duplicate those factors (e.g., exhaust, air flow) that could negatively affect the performance of the system. 14.4.5.15 Procedures for controlling access to the suppression agent source (e.g., protecting agent cylinders from disconnection by unauthorized personnel) should be provided. 14.4.5.16 The equipment design and configuration should not prevent licensed parties from certifying the design and installation of fire suppression systems. NOTE 61: This is not meant to suggest installation by licensed parties; however, some jurisdictions require fire detection and suppression system installers to be licensed as specified by the jurisdiction. 14.4.5.17 Installation of Piping for Fire Suppression Agent - The fire suppression piping system should be: • made from corrosion-resistant components, • designed to minimize water accumulation around components and control other conditions that promote corrosion, and • designed so mechanical inspections are easily performed. 14.4.5.18 Piping should be designed, installed, and tested to ensure that it is capable of containing the high pressures generated by the discharge of the suppression agent. 14.4.5.19 The supplier should provide information necessary for proper field installation of piping. 14.5 Warnings and Safe Work Practices - Warnings and safe work practices related to fire detection and suppression	
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	features of the equipment (e.g., restrictions on using open flames within range of active fire detection systems, hazardous stored energy in pressurized suppression systems) should be part of the documentation provided by the supplier. 14.6 Maintenance and Testing of Fire Detection and Suppression Systems - The equipment supplier should provide detailed maintenance and testing procedures for the fire systems provided with each piece of equipment. These procedures should include testing frequency, as well as details of special equipment required for testing. 14.6.1 Chemical generating test apparatus (e.g., canned smoke) should be avoided for cleanroom applications. NOTE 62: Information about UV/IR generating sources used for testing fire detection systems may require consideration of Section 25 (Non-Ionizing Radiation). 14.6.2 The maintenance testing procedure should include testing of the facility interface and verifying that all the equipment fire detection and suppression systems are functional. 14.6.3 The detection and suppression systems should be designed so that preventative maintenance of components does not degrade their performance (e.g., by resulting in displacement or destruction of sensors). 14.6.4 Supplier should document the sound pressure level generated during suppression agent discharge, if the test is performed. 14.6.5 Materials or procedures used for testing and maintenance of the fire detection and suppression system should not degrade the equipment's ability to perform its intended function. 14.6.6 Suppliers should describe hazardous energies present in fire detection and suppression systems, and provide instructions for their proper isolation (see Section 17.2). 14.7 Environmental - Suppliers should provide guidance to users regarding the impact on emissions of any fire	
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	suppression agents used in the equipment.	
20. Environmental Considerations	21. Environmental Considerations	Note: Section 20 has been renumbered to Section 21.
20.1 Introduction - The end user has a responsibility to employees and the community to minimize the environmental impact of processes and operations. The equipment suppliers have a responsibility to assist the end users in achieving this goal. Minimization of chemical consumption, characterization of air emissions and waste water effluent, minimization of waste, and control of chemical spills should be addressed during equipment design. If the end user's specific process chemistry is not defined, the equipment manufacturer's baseline process may be used for evaluation pursuant to this guideline.	21.1 This section covers environmental impacts throughout the life of the equipment. NOTE 86: It is recommended that environmental impacts be balanced against other factors, including safety and health, legal, and regulatory requirements. NOTE 87: It is recommended that the manufacturer maintain awareness of relevant environmental regulations, either internally or through the user. NOTE 88: The user is responsible for providing the manufacturer with information regarding any environmental restrictions that are specific to a given site and that may impact equipment design (e.g., cumulative emissions limits, permit requirements, site-specific programs). NOTE 89: See Section 14 for fire suppression emission issues. NOTE 90: References to “process” in this section are meant to refer to the baseline process.	Note: The Environmental Section in SEMI S2-0200 now specifically covers the life of the equipment. Environmental impacts throughout the life of the equipment need to be addressed to meet the intent of this section. Note: NOTE 87 and 88 were added to inform designers that global environmental requirements for semiconductor processing equipment are being established and that many countries have conflicting environmental regulations. It is important to create dialog with the end user at the location where equipment will be installed to ensure that local issues are addressed in a timely manner. The manufacturer is encouraged to make every effort to know as much as possible about the jurisdictions into which their equipment are sold; however, it cannot be accomplished without the end user's input and expertise regarding their own local conditions. In S2-93A the manufacturers were required to “magically” know all conditions and all regulations; SEMI S2-0200 recommends a more positive approach early on to achieve the best solutions.
	21.2 Design	

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	21.2.1 The following design guidelines apply to all phases of equipment life, from concept to decommissioning and disposal. NOTE 91: The documentation described in Sections 8.5.3 and 9.4 provide information that can be used for evaluating conformance to this section.	Note: Refer to the comments in Section 21.1 for intent. This addition reflects current concerns over environmental sustainability and product stewardship. Note: NOTE 91 was inserted to provide a performance-oriented solution to the evaluation of this section. When the documentation in Section 8.5.3 and 9.4 are evaluated and are deemed satisfactory, the intent of Section 21 has been met. All documentation criteria of this section were consolidated and moved to the Section 9 “Documents Provided to User”.
20.2 General Requirements 20.2.1 Upon request, the equipment manufacturer should supply information to the customer's environmental engineer as soon as is possible for the development of necessary permit applications. This information should include raw material chemical consumption requirements, wastewater effluent quality, hazardous waste generation and collection quantities, solid waste generation, exhaust effluent characterization, on-board control technologies, chemical process efficiencies, and a chemical mass balance.	(See Sections 9.4 - Environmental Documentation)	Note: Documentation related guidelines are now captured in Section 9, “Documents Provided to User”. Note: While the user needs this information, it was deemed in SEMI S2-93A the responsibility of the user to request it when necessary.
20.2.2 The equipment supplier should identify spill prevention features of the equipment.	(See Section 21.2.4 – “Prevention and Control of Unintended Releases)	Note: S2-0200 describes greater details on design features for preventing releases.
20.2.3 The equipment supplier should identify any maintenance, ancillary equipment, or peripheral operations that require chemicals (e.g., lubricants, cleaners, coolants). The supplier should specify anticipated change-out frequency, quantity, and potential for contamination by process.	(See Section 9.6.6 – “Maintenance Procedures with Environmental Impact”)	Note: Documentation-related guidelines are now captured in Section 9, “Documents Provided to User”.
20.2.4 Using the baseline process, supplier should notify end user of environmental regulatory restrictions (current and potential future) on chemicals used in the equipment.	See Note 87.	Note: See comments on SEMI S2-0200, Section 21.1 regarding the dialog suggested for end user and supplier. It was considered unreasonable for suppliers to know all restrictions of their equipment in a global economy. Instead a dialog is now suggested with the end user having the responsibility to notify the supplier of

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		specific restrictions in specific localities. It is not the intent that suppliers have no responsibility. The supplier is encouraged to make every effort to identify environmental issues related to their equipment at the regional level (for example, European Union restrictions, US EPA restrictions, Pacific Rim restrictions, but not necessarily each country).
20.2.5 Upon receipt of the supplier's evaluation, a qualified end user environmental engineer should complete the environmental component of an Environmental/Health/Safety Impact Appraisal. This appraisal should determine if the equipment meets or exceeds the environmental guidelines presented here, considering specific process chemistries which will be used and site-specific requirements. Information from the evaluation should be used to negotiate any design changes necessary to provide the end user with environmentally acceptable equipment. The supplier should consider integrating these modifications into future units of the model in question.	See Note 88.	Note: This Section was deleted because it places expectations on the end user, which is outside the scope of S2. Instead, discussions of responsibilities of user and supplier with regard to equipment meeting site-specific needs have now been incorporated into NOTE 88.
20.3 Hazardous Materials Use - Use of hazardous materials should be kept to a minimum or eliminated wherever possible.	(See Section 21.2.3.1)	Note: “Minimization” has been replaced with more specific features that should be considered. This is now discussed in Section 21.2.3.1.
20.3.1 Prior to final design, chemicals used with the equipment should be reviewed jointly by the supplier and end user to determine if specific regulatory restrictions exist. As part of the evaluation process, a Materials Safety Data Sheet (MSDS) for each of the chemicals should be available.	(See Section 9.6. “Manuals”)	
20.3.2 Chemical delivery to the equipment and use of chemicals in the equipment should be carefully controlled to avoid excess chemical consumption, waste generation, and chemical losses to the exhaust system. The equipment and process should have provisions to minimize chemical usage when no processing is occurring.	(See Section 21.2.3 – “Chemical Selection”) (See Section 21.2.2 – “Resource Conservation”)	
20.3.3 A less hazardous chemical should be used wherever possible for process chemistries, equipment maintenance, and utility uses (cleaners, lubricants, and coolants).	(See Section 21.2.3 – “Chemical Selection”)	
	21.2.2 <i>Resource Conservation</i>	Note: Section 21.2.2 addresses resource conservation during design, which replaces the

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20.3.4 Recycling or reusing chemicals in the equipment, rather than consuming only virgin materials, should be evaluated.	21.2.2.1 The manufacturer should consider resource conservation (i.e., reduction, reuse, recycling) during equipment design, for example: • water reuse or water recycling within the equipment; • reduced chemical consumption, energy use, and water use (e.g., reducing resource use when no process is occurring); • reduced use of resources during maintenance procedures (e.g., parts cleaning procedures could include minimum rinse rates and rinse times); • recycling or reusing chemicals in the equipment, rather than consuming only new materials; • reducing volume of packaging, increasing recycled content of packaging, and/or designing reusable packaging.	“minimization” wording of the former 20.1 and provides greater clarity. Note: Specific resource conservation considerations have been added. These are expanded from only the use of new vs. recycled chemicals. Resource conservation was considered by the Environmental Working Group to be a cornerstone of any environmental design program.
20.4 Air Emissions 20.4.1 Process by-products, fugitive emissions, and exhaust effluent should be characterized. The equipment manufacturer should provide the end user with pertinent information necessary to address the best method of handling (controlling or treating) process by-products and exhaust effluent.	21.2.5 <i>Effluents, Wastes, and Emissions</i> NOTE 93: It is recommended that the manufacturer document its efforts to minimize the equipment's generation of hazardous wastes, solid wastes, wastewater, and air emissions. NOTE 94: It is recommended that SEMI F5 be used for guidance in gaseous effluent handling. (See Section 9.4.2 – “Mass Balances”)	Note: Effluents, wastes and emissions were included to consider not only air emissions, but also solid waste, hazardous waste, and wastewater. Note: Criteria on characterization information have now been moved to Section 9.4.2. Note: Sections that were duplicate of other sections, such as chemical, or ventilation were deleted from this section.
20.4.2 The equipment supplier should specify exhaust flow rates and differentiate among the types of exhaust required for various applications (heat, scrubbed, solvent, pyrophoric, etc.).	(See Section 22 - Exhaust Ventilation and Appendix A 2)	
20.4.3 The manufacturer should evaluate on-board controls for process chamber exhaust effluent treatment or external point-of-use abatement methods and provide alternatives to the equipment end users.	21.2.5.3 The manufacturer should evaluate the feasibility of including integrated controls for effluent and emission treatment.	Note: As effluent treatment regulations become more stringent, point-of-use abatement - as an option – is becoming increasingly important to the design of any tool creating emissions.
20.4.3.1 In the case of volatile organic compound (VOC) emissions, on-board controls, such as thermal destruction or physical capture should be evaluated and the possible abatement alternatives described to the equipment end user for their choice on implementation.	(See Section 21.2.5 – “Effluents, Wastes and Emissions”)	
20.4.3.2 The equipment, equipment maintenance, and process should be designed to operate without the use of Ozone Depleting Substances (ODS), such as chlorofluorocarbons (CFC), methylchloroform, and carbon tetrachloride.	21.2.3 <i>Chemical Selection</i> 21.2.3.1 Chemical selection for process, maintenance, and utility uses (e.g., gases, etchants, strippers, cleaners, lubricants, and coolants) should take into account	Note: S2-0200 further defines hazardous materials and expands the scope of concern beyond process use. It acknowledges the need to weigh many factors in selecting chemicals, including toxicity, by-products, recyclability.

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	effectiveness, environmental impacts, volume, toxicity, by-products, decommissioning, disposal, and recyclability; use of the least hazardous chemical is preferred. To the extent practicable, the utilities, maintenance, and process should be designed so that the equipment operates without the use of: - ozone depleting substances (ODSs) as identified by the Montreal Protocol, such as chlorofluorocarbons (CFCs), methylchloroform, hydrochlorofluorocarbons (HCFCs), and carbon tetrachloride, or - perfluorocompounds (PFCs), including CF₄, C₂F₆, NF₃, C₃F₈, and SF₆, and CHF₃ due to their global warming potential.	Specific reference to the elimination of CFCs, HCFCs and PFCs is in line with EU directives and the Montreal and Kyoto Protocols.
20.4.3.3 In the case of emissions of toxic compounds, on-board controls such as physical capture should be evaluated and the possible abatement alternatives described to the end user.	(See Section 21.2.5.3)	
20.5 Wastewater Effluent - Contaminant concentrations in the waste water discharges from the equipment should be as low as practical and controlled as to terms of contaminant type.	(See Section 21.2.5 – “Effluents, Waste and Emissions”)	
20.5.1 Discharge of regulated substances, such as organic compounds and heavy metals, should be avoided or minimized through waste stream segregation or by-product reduction. Reduction activities may include process changes, such as lower chemical concentrations in the process and mechanical separation methods, such as diverter valves and increased dwell time over chemical baths prior to rinsing.	21.2.5.5 Segregation of effluents, wastes, and emissions should be provided in the following cases: - where chemically incompatible; - where segregation facilitates recycling or reuse; or - where separate abatement or treatment methods are required. NOTE 96: It is recommended that the equipment design documentation show evidence of consideration of by-products generated during equipment operation, clean-up, maintenance, and repair. By-products can include deposits in drains or ducts, and replaceable parts (e.g., batteries, vapor lamps, contaminated parts). (See Section 21.2.5 – “Effluents, Waste, and Emissions”)	Note: S2-0200 is more general and less prescriptive than S2-93A. The ability to support stricter environmental requirements and to support recycling possibilities is enhanced when waste streams are segregated as much as possible. By-product generation was an important consideration added throughout this section that was not considered explicitly in S2-93A.
20.5.2 Methods to minimize the amounts of corrosive materials entering the waste water effluent should be evaluated and alternatives described to the equipment end user for potential implementation.	(See Section 21.2.5, NOTE 93)	Note: S2-0200 is more generic and less specific than S2-93A.
20.5.3 Dilution with water or other dilute stream, in the excess of process requirements, solely to meet any categorical pretreatment limits as set by EPA or local sanitary sewer ordinances, is not acceptable.	21.2.5.4 Dilution in excess of process or safety requirements should not be used to reduce contaminant discharge concentrations.	Note: Optimization criteria stay the same. However, S2-0200 has removed references to country specific requirements (such as EPA or local ordinances) as part of the Task Force's

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	(See Section 8.5.3 - “Environmental Information”)	“Internationalization” objective.
20.5.4 The equipment/process should avoid unnecessary deionized water use when no processing is occurring.	(See Section 21.2.2.1 – “Resource Conservation”)	
20.6 Waste Generation - Solid and hazardous waste generation should be kept to a minimum, and dissimilar waste chemicals should not be mixed.	21.2.5.2 Equipment should use partitions, double-contained lines, or other similar design features to prevent the mixing of incompatible waste streams (See Section 21.2.5.5)	Note: Specific consideration should be given to waste generation and the reactions that may occur.
20.6.1 Methods of collection of chemical wastes generated in the form of liquids and solids should be designed into the equipment for temporary accumulation within the unit, or connections should be provided to permit central collection (dependent on facility installation).	21.2.5.1 Equipment design that allows connection to a central waste collection system is preferred, except where collection at the equipment may facilitate recycling or reuse opportunities or otherwise reduce environmental impacts. NOTE 95: It is recommended that individual drains and exhausts be kept separate (e.g., separate outlets for acid drain, solvent drain, deionized (DI) water drain; acid exhaust, solvent exhaust). 21.2.5.1.1 Point-of-use collection containers should be designed for accessibility as well as the possible reuse and recycling of the collected materials.	Note: Revises preference to central waste collection systems, but provides guidance on point-of-use collection if used.
20.6.2 In-equipment collection should be designed to avoid evaporative or spill-over losses or mixing of dissimilar waste streams.	(See Section 21.2.5.5 – “Segregation of effluents, wastes, and emissions”) (See Section 21.2.4 – “Prevention and Control of Unintended Releases”)	
20.6.3 Provisions should be made to allow operators to determine the collection containers' remaining available capacity conveniently without having to open the containers. Collection containers should be readily accessible and designed to allow their contents to be transferred to another container or to allow them to be disposed of and replaced. Level detectors and alarms should be considered for in-equipment collection containers.	21.2.4.5 Equipment design should allow personnel to determine all in-equipment container levels conveniently without having to open the containers, where ignorance of the level could result in an inadvertent release 21.2.4.6 Overfill level detectors and alarms should be provided for in-equipment containers.	Note: Effort was made here to make criteria more performance oriented.
20.6.4 The equipment should be designed such that any clean-up, maintenance, and repair generates the least amount of by-products possible. This requirement should include deposits in drains, ducts (which may be minimized by equipment design), and on replaceable parts.	(See Section 21.2.5.5, Note 96)	Note: The criteria in Section 20.6.4 of SEMI S2-93A have now been captured into NOTE 96 as a recommendation.
	21.2.6 <i>Decommissioning and Disposal</i> 21.2.6.1 Equipment design should address (see Section 8.5.3	Note: Guidelines addressing decommissioning and disposal, including recycling concerns, have now been expanded into its own subsection in

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20.6.5 The equipment should be designed to facilitate machine clean up or disposal after its useful life has expired. Parts which become contaminated with hazardous materials should be kept to a minimum. Use of removable liners or modular parts should be considered.	for documentation provisions) construction material and component reuse, refurbishment, and recycling. 21.2.6.2 The equipment should be designed to facilitate equipment decontamination and disposal, e.g., by use of removable liners or replaceable modules. This includes minimizing the number of parts that become contaminated with hazardous materials. NOTE 97: It is recommended that SEMI S12 “Guidelines for Equipment Decontamination” be used for guidance during equipment decontamination	SEMI S2-0200.
20.7 Secondary Containment - All equipment feed, storage, and waste collection systems should be protected against an unwanted chemical release.	21.2.4 <i>Prevention and Control of Unintended Releases</i> 21.2.4.1 Equipment design, including feed, storage, and waste collection systems, should prevent potential unintended releases. At a minimum: 21.2.4.3 Chemical storage containers and secondary containment should be designed for accessibility and easy removal of collected material.	Note: This section has been expanded in an effort to make criteria more performance oriented.
20.7.1 Secondary containment should be provided to collect releases (110% of capacity) and to allow any material released in the secondary containment to be easily removed.	21.2.4.2 Secondary containment for liquids should be capable of holding at least 110% (see first row of Table A3-1 of Appendix 3) of the volume of the single largest container, or the largest expected volume for any single point failure. NOTE 92: In some circumstances secondary containment may be specified by the equipment supplier, but provided by the user. 21.2.4.7 Secondary containment and other control systems should be designed to ensure that chemicals cannot be combined, where the combination could result in an inadvertent release.	Note: Table A3-1 was added in an effort to make criteria more performance oriented. Note: The scope of secondary containment has now been clarified from “any material” as stated in SEMI S2-93A, to “liquids”. The application of containment requirements of water and DI water is a topic open for discussion.
20.7.2 Detection and alarm systems should be incorporated into units that use automated or pressured chemical feeds to provide automated shutdown of the unit if an unwanted release occurs and should be capable of providing alarms.	21.2.4.4 Secondary containment should have alarms and gas detection or liquid sensing, as appropriate, or have recommended sensing points identified in the equipment installation instructions. 21.2.4.10 Chemical distribution systems should be capable of automatic shutoff and remote shutdown 21.2.4.9 Equipment should be able to accept a signal from a	Note: Effort to make criteria more performance oriented.

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	monitoring device and stop the supply of chemical, at the first non-manual valve within the affected system	
20.7.3 Equipment design should eliminate potential direct unwanted release routes to the environment, or cross contamination of waste streams due to an emergency condition or a control failure. Recommendations for mitigating emergency releases should be provided to the end user if applicable.	(See Sections 9.4.3 and 9.4.4 – “Environmental Documentation”)	Note: The guideline in Section 9.6.4 appears to be fully captured in Section 9.4.3.
	21.2.4.8 Equipment components should be compatible with chemicals used in the manufacturing process. Chemical systems should be designed for the specified operating conditions, and have sufficient mechanical strength and corrosion resistance for the intended use.	Note: This is related to SEMI S2-93A, Section 20.7, but goes beyond to address releases caused by incompatible equipment/chemical reaction.
	17. Hazardous Energy Isolation	Note: Section 17 has been added to SEMI S2-0200.
	17.1.1 Lockable energy isolation capabilities should be provided for tasks that may result in contact with hazardous energy sources.	Note: This section has been added to address proper hazardous energy isolation. Unlike S2-93A, which only addressed energy control in the electrical section, this section applies to all hazardous energy isolation.
	17.1.2 Where service tasks may be safely performed on subassemblies, energy isolation devices (e.g. circuit breakers, disconnect switches, manual valves) may be provided for the subassemblies for use as an alternative to shutting down the entire equipment system. The isolation devices should isolate all hazardous energy to the subassemblies and be capable of being locked in the position in which the hazardous energy is isolated.	Note: This section allows for, but does not require, energy isolation at the subassembly level where it can be performed safely. This could apply to both electrical energy isolation for subassemblies as well as isolation of other hazardous energies at the subassembly level. Note: OSHA Title 29 Part 1910.147’s definition for Energy isolating device is “A mechanical device that physically prevents the transmission or release of energy, including but not limited to the following: A manually operated electrical circuit breaker; a disconnect switch; a manually operated switch by which the conductors of a circuit can be disconnected from all ungrounded supply conductors and, in addition, no pole can be operated independently; a line valve; a block; and any similar device used to block or isolate energy. <i>Push buttons, selector switches and other control circuit type devices are not energy isolating devices.</i>” Note: In most cases, the sensors used in an interlock system (i.e. guard switches) do not themselves directly interrupt supply power to

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		potentially hazardous device. Usually they interact with a control circuit that trips a relay or contactor that interrupts the power feed. Hence, OSHA would consider these types of interlocks to be ‘control circuit type devices’ and are, therefore, not considered as energy isolation devices.
	17.1.3 The person actuating or inspecting an energy isolating device should not be exposed to serious risks of tripping or falling or of coming in contact with energized electrical parts, moving machinery, surfaces or objects operating at high temperatures, or other hazardous equipment. NOTE 64: Hazardous energies include electrical, stored electrical (e.g., capacitors, batteries), chemical, thermal/cryogenic, stored pressure (e.g., pressurized containers), suspended weight, stored mechanical (e.g., springs), generated pressure (e.g., hydraulics and pneumatics), and other sources that may lead to the risk of injury. NOTE 65: In order to minimize down-time and provide ease of use, it is preferred to have energy isolation devices located in the areas where maintenance or service is performed. NOTE 66: Energy isolation devices for incompatible hazardous energy sources (e.g., electrical and water, incompatible gases) are recommended to be separated. NOTE 67: Isolation of hazardous energy may include: deenergizing of hazardous voltage; stopping flow of hazardous production material (HPM); containing HPM reservoirs; depressurizing or containing HPM and pneumatic lines; deenergizing or totally containing hazardous radiation; discharging of residual energy in capacitors; stopping of hazardous moving parts; and shutting off hazardous temperature sources.	Note: This section provides consideration of location of isolation devices so that they can be accessed safely. Note: NOTE 64 was added to provide examples of typical energies that may need to be controlled on semiconductor manufacturing equipment. Note: During the S2 revision effort, a number of users proposed to add a specification to have energy isolation devices located in the areas where maintenance or service are performed. While the Safety Working Group considered the proposal feature to be more related to up-time, it was agreed that there would be value-added to incorporate this feature as a NOTE for designers to consider during their design. Note: NOTE 67 provides examples of means to isolate hazardous energies.

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	NOTE 68: Energy isolation devices with integral locking capabilities are preferred, but may not be feasible or commercially available, in which case detachable lockout adapters may be used. NOTE 69: See Section 14 for information on fire protection hazardous energies.	Note: Note 68 has been added to clarify the confusion that some of the safety professionals have regarding the suitability of detachable lockout devices (e.g., clamshell devices) as a means of satisfying OSHA's requirement for 'capability of being locked out'. In reading OSHA's interpretative response, http://www.osha-slc.gov/OshDoc/Interp_data/19940707B.html, it is fairly clear that detachable lockout devices are permitted.
	17.2 <i>Installation and Maintenance Manuals</i> 17.2.1 Installation and maintenance manuals should identify the types of hazardous energies within the equipment. 17.2.2 Installation and maintenance manuals should provide specific instructions for the equipment on how to: • shut down the equipment in an orderly manner; • locate and operate all the equipment's energy isolating devices; • affix energy isolating (“lockout/tagout”) devices; • relieve any stored energies; • verify that the equipment has actually been isolated and deenergized; and • properly release the equipment from its isolated state. 17.2.3 Where the manufacturer provides written maintenance procedures for tasks within subassemblies, and intends that these tasks be performed without controlling hazardous energies at the entire equipment level, the installation and maintenance manuals should provide appropriate energy isolation procedures at the subassembly level.	Note: Section 17.2.2 of SEMI S2-0200 is derived from 29 CFR 1910.147 (OSHA).
	17.3 <i>Electrical Energy Isolation</i> 17.3.1 The main energy isolation capabilities (equipment supply disconnect) should be in a location that is readily accessible and should be lockable only in the deenergized position.	

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	NOTE 70: For equipment with multiple incoming supply sources, it is recommended that all of the energy isolation devices be located in one area.	
	17.4 Non-Electrical Energy Isolation 17.4.1 The equipment should include provisions and procedures so that hazardous energy sources, such as pressurized systems and stored energy, can be isolated or reduced to a zero energy state prior to maintenance or service work. 17.4.2 The hazardous energy isolation devices should be in a location that is readily accessible. 17.4.3 The hazardous energy isolation devices should be capable of being locked in the position in which the hazardous energy is isolated.	
	18. Mechanical Design	Note: Section 18 has been added to SEMI S2-0200.
	18.1 This section covers hazards due to the mechanical aspects of the equipment. NOTE 71: This is similar to the essential requirements of European Union directives. The supplier has the option of demonstrating compliance by choosing standards that are appropriate to the machine and application. NOTE 72: Pressurized vessels must meet applicable codes and regulations. 18.2 <i>Machine Stability</i> — Equipment, components, and fittings should be designed and constructed so that they are stable under reasonably foreseeable shipping, installation, and operating conditions. The need for special handling devices and anchors should be indicated in the instructions. Unanchored equipment in its installed condition should not overbalance when tilted in any direction to an angle of 10 degrees from its normal position. NOTE 73: See IEC 61010-1 for an example of stability tests.	Note: Engineers are encouraged to reference Simple Pressure Vessel Directive, ASME specifications, etc. as applicable. Note: Stability of products to prevent tipover at an angle of 10 degrees is incorporated in many product safety standards including IEC/EN 61010-1, IEC/EN 60950, etc.
	18.3 <i>Break-up During Operation</i> — The various parts of the equipment and its linkages should be able to withstand the stresses to which they are subjected when used as designed. Precautions should be taken to control risks from falling or	Note: Section 18.3 through 18.3.3 parallels the requirements outlined in the Machinery Directive's Essential Health and Safety Requirements (Annex I), Section 1.3.2.

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	flying objects. 18.3.1 The potential effects of fatigue, aging, corrosion, and abrasion for the intended operating environment should be considered as part of the mechanical hazards risk assessment. 18.3.2 Where a risk of rupture or disintegration remains despite the measures taken (e.g., a substrate chuck that loses its vacuum), the moving parts should be mounted and positioned in such a way that, in case of rupture, their fragments will be contained. 18.3.3 Both rigid and flexible pipes carrying liquids or gases should be able to withstand the foreseen internal and external stresses and should be firmly attached or protected against external stresses and strains. Based on the application, an appropriate factor of safety should be included.	
	18.4 <i>Moving Parts</i> — The moving parts of equipment should be designed, built, and positioned to avoid hazards. Where hazards persist, equipment should be fitted with guards or protective devices that reduce the likelihood of contact that could lead to injury. 18.4.1 Where the machine is designed to perform operations under different conditions of use (e.g., different speeds or energy supplies), it should be designed and constructed in such a way that selection and adjustment of these conditions can be performed safely. 18.4.2 <i>Selection of Protection Against Hazards Related to Moving Parts</i> — Guards or protective devices used to protect against hazards related to moving parts should be selected on the basis of a risk assessment that includes the: • hazards that are being guarded against; • probability of occurrence and severity of injury of each hazard scenario; and • frequency of removal of guards. 18.4.3 Guards and protection devices. Guards should: • reduce the risk that personnel will contact the mechanical hazard to an acceptable level; and • not give rise to additional risk.	Note: Section 18.4 parallels the Machinery Directive’s Essential Health and Safety Requirements (Annex I), Section 1.3.7, “Prevention of risks related to moving parts”. Note: Section 18.4.1 parallels the Machinery Directive’s Essential Health and Safety Requirements (Annex I), Section 1.3.6. Note: Section 18.4.2 parallels the Machinery Directive’s Essential Health and Safety Requirements (Annex I), Section 1.3.8, “Choice of protection against risks related to moving parts”, except the considerations listed in the bullets have been modified to reflect the philosophy of risk assessment in the semiconductor industry. Note: Section 18.4.3 parallels the Machinery Directive’s Essential Health and Safety Requirements (Annex I), Section 1.4.1, “General requirement”.
	18.5 <i>Lifting Operations</i> — Equipment presenting hazards due to lifting operations (e.g., falling loads, collisions, tipping)	Note: Section 18.5 parallels the Machinery Directive’s Essential Health and Safety

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	should be designed and constructed to reduce the risk to an acceptable level.	Requirements (Annex I), Section 1.3.
	18.6 <i>Extreme Temperatures</i> — Surfaces that are accessible to personnel, and that are at high (per temperature limits in Table 1) or very cold temperatures (below -10°C [14°F]), should be fitted with guards or designed out. 18.6.1 Where it is not feasible to protect or design out the exposures to extreme temperature, temperatures exceeding the limits are permitted, provided that either of the following conditions is met: • unintentional contact with such a surface is unlikely; or • the part has a warning indicating that the surface is at a hazardous temperature.	Note: Section 18.6 parallels the Machinery Directive’s Essential Health and Safety Requirements (Annex I), Section 1.5.5, “Extreme temperatures”. In order to meet the objective of developing ‘measurable’ guidelines, the Working Group researched a number of standards (e.g., MIL-STD-1472, EN 563, IEC/EN 60950, etc.) and developed a surface temperature limit for hot and cold surfaces. Refer to Related Information 13 of SEMI S2-0200 for further details on this research.
	26. Lasers	Note: Section 26 has been added to SEMI S2-0200.
	26.1 Equipment should be identified with a laser product classification based on the laser energy accessible during operation, per the applicable standard. NOTE 115: Class 1 label may be required in some jurisdictions, but is not currently required in the United States.	Note: Even though lasers scientifically fall within non-ionizing radiation, they have unique concerns and are treated quite differently from a regulatory perspective. As a result, the Industrial Hygiene Working Group created a separate section on Lasers. The applicable standards may vary around the world, but the major ones are listed and described in the related information. Note: Note 115 was added because Class 1 labels are required in EN 60825-1 (IEC 60825-1) for equipment in Europe. The US FDA/CDRH does not require a Class 1 label, but the CDRH will accept labels from the IEC with FDA classifications.
	26.1.1 The laser energy (or power), wavelength, and temporal mode (continuous wave or pulsed) should be identified in the documentation provided to the user. NOTE 116: The laser product classification for some equipment will be Class 1 or 2, even though an embedded laser is of a higher hazard classification. 26.1.1.1 If pulsed, the pulse repetition rate, pulse duration and description of the pulse waveform should be identified in the documentation provided to the user.	

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	26.1.1.2 For Class 3b or 4 embedded laser systems, the above information and the physical location of the laser sources within the laser product should be identified in the documentation provided to the user and in the maintenance manual.	
	26.1.2 Equipment should not exceed the laser product classification of Class 2; however, individual lasers may exceed this classification prior to integration into the final equipment assembly.	Note: This Class 2 limit was set because Class 2 is the highest classification without exceeding the Maximum Permissible Exposure (MPE). The working group believed that there was no justification for manufacturing equipment exceeding the MPE.
	26.2 Equipment, including beam diagnostic or alignment tools, should be designed to prevent injury from all lasers during normal operation, and should minimize risk of injury during maintenance or service. Potential exposures should be controlled in the following order of preference: 26.2.1 Engineering controls (e.g., enclosures, shielding, filters, use of fiber optics to transmit energy, interlocks). 26.2.2 Temporary enclosures or control measures for maintenance, service, and non-routine tasks. 26.2.3 Administrative controls (e.g., written warnings, standard operating procedures, labeling).	
	26.2.4 Personal protective equipment. NOTE 117: Temporary enclosures and personal protective equipment are considered to be administrative controls, because they require human action to implement. NOTE 118: Certain classes of laser products are regulated around the world. Regulations and licensing requirements may cover activities such as importing, exporting, distributing, demonstrating, installing, servicing, and using these laser products.	Note: Note 117 highlights the fact that the laser hazards are transitory and are only present when access is required with the laser on. The note also helps to highlight differences between engineering and administrative controls. Note: Note 118 was an addition to highlight to manufacturers that there may be additional local regulatory issues they need to comply with.
	26.3 The equipment supplier should provide the following in the operation and maintenance manuals: a description of laser-related hazards present during operation, maintenance, or service, and methods to minimize the hazard;	Note: Section 26.3 was added because it didn't make sense to have each user develop engineering or administrative controls for each type of tool or installation. This information would provide a basis for the user to make

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	- justification for any procedures that require a laser controlled area and the dimensions of this hazard zone; - administrative controls used in maintenance and service activities; and - a description of necessary personal protective equipment	decisions and provide for the safe maintenance and service of the equipment.
	26.4 The following detailed information should be available for the evaluator: - justification for when engineering controls are not feasible to limit exposure during operation or maintenance tasks, and how administrative controls provide equivalent protection (see Section 26.2); and - documentation showing compliance with an appropriate international laser product safety or industry standard, or the national standard for country of use.	Note: The original intent of Section 26.4 was to allow flexibility when engineering controls were not a viable solution and administrative controls provided effective and equivalent protection. But the Industrial Hygiene Working Group did not want to convey that engineering controls are not to be used. Engineering controls are the primary means of providing protection in most cases.
Appendix 1 – Terminology	5. Terminology	Note: Appendix 1 has been moved to Section 5 of SEMI S2-0200.
ACGIH - American Conference of Governmental Industrial Hygienists ASHRAE - American Society of Heating, Refrigeration, and Air Conditioning Engineers	5.1 <i>Abbreviations and Acronyms</i> 5.1.1 <i>ACGIH®</i> — American Conference of Governmental Industrial Hygienists (ACGIH is a registered trademark of the American Conference of Governmental Industrial Hygienists.) 5.1.2 <i>ASHRAE</i> — American Society of Heating, Refrigeration, and Air Conditioning Engineers 5.2 <i>Definitions</i> 5.2.1 <i>abort switch</i> — a switch that, when activated, interrupts the activation sequence of a fire detection or fire suppression system.	
	5.2.2 <i>accredited testing laboratory</i> — 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.	Note: The term accredited testing laboratory is now used instead of nationally recognized testing laboratory to minimize confusion that only OSHA nationally recognized testing laboratories are acceptable.
	5.2.3 <i>baseline</i> — for the purposes of this document, “baseline” refers to operating conditions, including process chemistry, for which the equipment was designed and manufactured. 5.2.4 <i>breathing zone</i> — imaginary globe, of 600 mm (two foot) radius, surrounding the head. 5.2.5 <i>capture velocity</i> — the air velocity that at any point in	

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	front of the exhausted hood or at the exhausted hood opening is necessary to overcome opposing air currents and to capture the contaminated air at that point by causing it to flow into the exhausted hood. <i>5.2.6 carcinogen</i> — confirmed or suspected human cancer-causing agent as defined by the International Agency for Research on Cancer (IARC) or other recognized entities. <i>5.2.7 chemical distribution system</i> — the collection of subsystems and components used in a semiconductor manufacturing facility to control and deliver process chemicals from source to point of use for wafer manufacturing processes. <i>5.2.8 cleanroom</i> — a room in which the concentration of airborne particles is controlled to specific limits. <i>5.2.9 coefficient of entry (Ce)</i> — the ratio of actual airflow into the exhausted hood to the theoretical airflow if all hood static pressure could be converted into velocity, as would be the case if the hood entry loss factor (K or Fh) were zero. $Ce = (VP/SPH)^{0.5}$ where VP = duct velocity pressure and SPH = hood static pressure (see also Appendix 2). <i>5.2.10 combustible material</i> — for the purpose of this guideline, a combustible material is any material that does propagate flame (beyond the ignition zone with or without the continued application of the ignition source) and does not meet the definition in this section for noncombustible material. (See also the definition for <i>noncombustible material</i>.)	
Conform - To be similar in form and character and to behave in accordance with prevailing modes or customs. Continuous Gas-Detection System - A gas-detection system in which the analytical instrument is maintained in continuous operation and sampling is performed on a cyclical basis at a period not to exceed 30 minutes. Degree of Hazard - (as pertains to chemicals) - The inherent ability of a chemical to do harm due to its toxicity, corrosiveness, flammability, or other characteristic and the potential for that chemical to		

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contact persons or the environment. EMO - Emergency Off Circuit. A control circuit which when de-activated, places the equipment into a safe shut down condition and will restrict all hazardous potentials to the main power enclosure. This is a state in which all hazardous voltage has been removed from the equipment, all hazardous production materials flow has been stopped, any radiation sources de-energized or totally contained, any capacitors grounded, all moving parts stopped, internal and external heat sources shut off, and the equipment presents minimum hazard to personnel or the facility. Enclosures - (a) Ventilated enclosure - An enclosed or partially enclosed space not designed for human occupancy having a ventilation system that is capable of capturing and directing 100% of a released toxic gas into a discharge treatment system. (b) Non-routine access enclosure - An enclosure that is not routinely opened more than once per week for operational or maintenance purposes. (c) Access enclosure - An enclosure that meets the preceding criteria when it is closed but that also provides adequate face velocity to control exposure when the door/access panel is opened for maintenance or process adjustment. (d) Vacuum pump enclosure - An enclosure around a vacuum pump or other process equipment that has no high pressure components. Heat exhaust requirements can generally provide the necessary control.		
	5.2.11 equipment — a specific piece of machinery, apparatus, process module, or device used to execute an operation. The term “equipment” does not apply to any product (e.g., substrates, semiconductors) that may be damaged as a result of equipment failure.	
Excess Flow Control - A fail-safe system designed to shut off flow caused by a rupture in the pressurized piping systems. Excess Flow Valve - A valve inserted in a supply line designed to shut off the flow positively in the event that its predetermined flow is exceeded.		
	5.2.12 face velocity — velocity at the cross-sectional entrance to the exhausted hood.	

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Fail Safe - A system so designed that a failure of any component in the system will stop the equipment and prevent unsafe operation of the equipment.	5.2.13 <i>facilitization</i> — the provision of facilities or services. 5.2.14 <i>fail-safe</i> — designed so that a failure does not result in an increased risk. NOTE 2: For example, a fail-safe temperature limiting device would indicate an out-of-control temperature if it were to fail. This might interrupt a process, but would be preferable to the device indicating that the temperature is within the control limits, regardless of the actual temperature, in case of a failure.	Note: A change in the definition of “fail-safe” so safety is included, but the ‘requirement’ to stop the equipment is no longer called for. However, in some cases stopping the equipment may be required to prevent “an increased risk.”
FDA-CDRH - Food and Drug Administration, Center for Devices and Radiological Health.		
	5.2.15 <i>failure</i> — the termination of the ability of an item to perform a required function. Failure is an event, as distinguished from “fault,” which is a state. 5.2.16 <i>fault</i> — the state of an item characterized by inability to perform a required function, excluding the inability during preventive maintenance or other planned actions, or due to lack of external resources. 5.2.17 <i>fault-tolerant</i> — designed so that a reasonably foreseeable single point failure does not result in an unsafe condition. 5.2.18 <i>flammable gas</i> — any gas that forms an ignitable mixture in air at 20 C (68 F) and 101.3 kPa (14.7 psia). 5.2.19 <i>flammable liquid</i> — a liquid having a flash point below 37.8 C (100 F). 5.2.20 <i>flash point</i> — the minimum temperature at which a liquid gives off sufficient vapor to form an ignitable mixture with air near the surface of the liquid, or within the test vessel used. 5.2.21 <i>gas cylinder cabinet</i> — cabinet used for housing gas cylinders, and connected to gas distribution piping or to equipment using the gas. Synonym: gas cabinet. 5.2.22 <i>gas panel</i> — an arrangement of fluid handling components (e.g., valves, filters, mass flow controllers) that regulates the flow of fluids into the process. Synonyms: gas jungle, jungle, gas control valves, valve manifold.	

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	5.2.23 <i>gas panel enclosure</i> — an enclosure designed to contain leaks from gas panel(s) within itself. Synonyms: jungle enclosure, gas box, valve manifold box.	
GFCI - Ground Fault Circuit Interrupter (for additional information see NEC, Article 100).		
	5.2.24 <i>hazard</i> — a condition that is a prerequisite to a mishap.	
Hazardous Materials - Those chemicals or substances that are physical hazards or health hazards as defined and classified in NFPA 704 whether the materials are in use or in waste conditions.		
Hazardous Voltage - Voltage greater than 50 volts, NEC Article 720	5.2.26 <i>hazardous voltage</i> — 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 3: The specified levels are based on normal conditions in a dry location.	Note: The threshold level for hazardous voltage has now been redefined to align with IEC 61010 and IEC 60950's threshold hazardous voltage for risk of electric shock. Reference: UL 1950/EN 60950, Section 1.2.8.3; UL 1012, Section 3.17; UL 1244, Section 9.2; UL 3101-1, Section 6.3.1, etc.)
Health Hazard - (See OSHA Regulations, 29 CFR 1910.1200.) A classification of a chemical for which there is statistically significant evidence based on at least one study that was conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed persons. The term “health hazard” includes chemicals that are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, and agents that damage the lungs, skin, eyes, or mucous membranes. Highly Toxic Material - (See OSHA Regulations, 29 CFR 1910.1200) - Material that produces a lethal dose or lethal concentration that falls within any of the following categories: (a) A chemical that has a median lethal dose (LD50) of 50 milligrams or less per kilogram of body weight when administered orally to albino rats weighing between 200 and 300 grams each. (b) A chemical that has a median lethal dose (LD50) of 200 milligrams or less per kilogram of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between two and three kilograms each. (c) A chemical that has a median lethal concentration (LC50) in the air of 200 parts per million		

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by volume or less of gas or vapor, or 2 milligrams per liter or less of mist, fume, or dust when administered by continuous inhalation for one hour (or less if death occurs within one hour) to albino rats weighing between 200 and 300 grams each. Mixtures of these materials with such ordinary materials as water may not warrant a highly toxic classification. While this system is basically simple in application, any hazard evaluation that is required for the precise categorization of this type of material should be performed by experienced, technically competent persons.		
HPM - Hazardous Production Material. A solid, liquid, or gas that has a degree-of-hazard rating in health, flammability, or reactivity of class 3 or 4 as ranked by NFPA 704 Standard and which is used directly in research, laboratory, or production processes which have as their end product materials which are not hazardous.	5.2.25 <i>hazardous production material (HPM)</i> — a solid, liquid, or gas that has a degree-of-hazard rating in health, flammability, or reactivity of class 3 or 4 as ranked by NFPA 704 and which is used directly in research, laboratory, or production processes that have as their end product materials that are not hazardous.	Note: The order of the terminology for HPM has been rearranged between the two versions because SEMI S2-93A uses the term “HPM”, while SEMI S2-0200 spells out the term.
	5.2.27 <i>hood</i> — in the context of Section 22 and Appendix 2 of this guideline, “hood” means a shaped inlet designed to capture contaminated air and conduct it into an exhaust duct system.	
	5.2.28 <i>hood entry loss factor (K or F_h)</i> — a unitless factor that quantifies hood efficiency. If the hood is 100% efficient, then K or F _h = 0. Related equations: $Q = 4.043A[(SP_h/d)/(1+F_h)]^{0.5}$ Where: Q = volumetric flow rate in m ³ /sec, A = cross sectional area of the duct in m ² , SP _h = hood static pressure in mm water gauge (w.g.), and d = density correction factor (unitless). (US units: $Q = 4005A[(SP_h/d)/(1+F_h)]^{0.5}$ where: Q = volumetric flow rate in cfm. A = cross sectional area of the duct in ft ² , SP _h = hood static pressure in inches water gauge (w.g.), and d = density correction factor (unitless).)	
IDLH - Immediately Dangerous to Life or Health. A concentration of airborne contaminants, normally expressed in parts per million (ppm) or milligrams per cubic meter, that represents the maximum level from which one could escape within 30 minutes without any escape-impairing symptoms or irreversible health effects. This level is established by NIOSH.		
	5.2.29 <i>incompatible</i> — as applied to chemicals: in the context	

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	of Section 23 of this guideline, describes chemicals that, when combined unintentionally, may react violently or in an uncontrolled manner, releasing energy that may create a hazardous condition. <i>5.2.30 intended reaction product</i> — chemicals that are produced intentionally as a functional part of the semiconductor manufacturing process.	
Interlocks Hardware Safety - A circuit of electro-mechanical components, wiring, or light links which override associated programmed machine controls. When circuit is interrupted, final control elements are not allowed to operate. Software - A computer-controlled program under which a device may or may not be allowed to operate. Software safety interlocks should be backed up by hardware safety interlocks in all cases involving safety at any level.	<i>5.2.31 interlock</i> — a mechanical, electrical or other type of device or system, the purpose of which is to prevent or interrupt the operation of specified machine elements under specified conditions.	Note: Introduced "other type" of interlocks to allow qualified electronic systems (e.g., certain type of certified safety related controls), to keep pace with state-of-the-art developments in some interlock system areas.
	<i>5.2.32 ionizing radiation</i> — alpha particles, beta particles, gamma rays, x-rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions in human tissue. <i>5.2.33 laser</i> — any device that can be made to produce or amplify electromagnetic radiation in the wavelength range from 180 nm to 1 mm primarily by the process of controlled stimulated emission. <i>5.2.34 laser product</i> — any product or assembly of components that constitutes, incorporates, or is intended to incorporate a laser or laser system (including laser diode), and that is not sold to another manufacturer for use as a component (or replacement for such component) of an electronic product. <i>5.2.35 laser source</i> — any device intended for use in conjunction with a laser to supply energy for the excitation of electrons, ions, or molecules. General energy sources, such as electrical supply mains, should not be considered to be laser energy sources. <i>5.2.36 laser system</i> — a laser in combination with an appropriate laser energy source, with or without additional	

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	incorporated components. <i>5.2.37 likelihood</i> — the expected frequency with which a mishap will occur. Usually expressed as a rate (e.g., events per year, per product, or per substrate processed). <i>5.2.38 local exhaust ventilation</i> — local exhaust ventilation systems operate on the principle of capturing a contaminant at or near its source and moving the contaminant to the external environment, usually through an air cleaning or a destructive device. It is not to be confused with laminar flow ventilation. Synonyms: LEV, local exhaust, main exhaust, extraction system, module exhaust, individual exhaust. <i>5.2.39 lower explosive limit</i> — the minimum concentration of vapor in air at which propagation of flame will occur in the presence of an ignition source. Synonyms: LEL, lower flammability limit (LFL). <i>5.2.40 maintenance</i> — planned or unplanned activities intended to keep equipment in good working order. (See also the definition for <i>service</i>.) <i>5.2.41 mass balance</i> — a qualitative, and where possible, quantitative, specification of mass flow of input and output streams (including chemicals, gases, water, deionized water, compressed air, nitrogen, and by-products), in sufficient detail to determine the effluent characteristics and potential treatment options.	
MSDS - Material Safety Data Sheet. Written or printed material concerning a hazardous material which is prepared in accordance with the provisions of 29 CFR 1910.1200. (Form OSHA 20)	<i>5.2.42 material safety data sheet (MSDS)</i> — written or printed material concerning chemical elements and compounds, including hazardous materials, prepared in accordance with applicable standards. NOTE 4: Examples of such standards are USA government regulation 29 CFR 1910.1200, and Canadian WHMIS (Workplace Hazardous Material Information System).	
Maximum Permissible Exposure - Exposure limit for non-ionizing radiation according to ANSI Z136.1 and ANSI C95.1		
	<i>5.2.43 mishap</i> — 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. NOTE 5: For the purpose of this guideline, a “series of events”	Note: Added term to align S2 risk analysis terms with SEMI's existing risk analysis document, SEMI S10.

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	is limited to those events resulting from a single point failure. See also Section 6.5.	
MELV - Machine Extra Low Voltage, NFPA 79-4.3 NEC - National Electrical Code, ANSI/NFPA 70 NEC Intrinsically Safe - As defined in NEC Article 504 NEC Low Voltage - Voltage between 50 and 600 volts. NEC High Voltage - Voltage greater than 600 volts. As defined in NEC Article 710. NEC Safe Voltage - Voltage less than 50 volts. As defined in NEC Article 720. NEC Industrial Machinery - As defined in NEC Article 670. NFPA 70 - National Electrical Code, NEC NFPA 79 - Electrical Standard for Industrial Machinery. NIOSH - National Institute for Occupational Safety and Health. A research organization inside the U.S. Department of Health and Human Services.		
	<i>5.2.44 noncombustible material</i> — 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). (See also the definition for <i>combustible material</i>.) <i>5.2.45 non-ionizing radiation</i> — forms of electro-magnetic energy that do not possess sufficient energy to ionize human tissue by means of the interaction of a single photon of any given frequency with human tissue. Non-ionizing radiation is customarily identified by frequencies from zero hertz to 3×10^{15} hertz (wavelengths ranging from infinite to 100 nm). This includes: static fields (frequencies of 0 hertz and infinite wavelengths); extremely low frequency fields (ELF), which includes power frequencies; subradio-frequencies; radiofrequency/microwave energy; and infrared, visible, and ultraviolet energies.	

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	<i>5.2.46 non-recycling, deadman-type abort switch</i> — a type of abort switch that must be constantly held closed for the abort of the fire detection or suppression system. In addition, it does not restart or interrupt any time delay sequence for the detection or suppression system when it is activated.	
NRC - U.S. Nuclear Regulatory Commission.		
	<i>5.2.47 occupational exposure limits (OELs)</i> — for the purpose of this document, OELs are generally established on the basis of an eight hour workday. Various terms are used to refer to OELs, such as permissible exposure levels, Threshold Limit Values, maximum acceptable concentrations, maximum exposure limits, and occupational exposure standards. However, the criteria used in determining OELs can differ among the various countries that have established values. Refer to the national bodies responsible for the establishment of OELs. (Threshold Limit Value is a registered trademark of the American Conference of Governmental Industrial Hygienists.)	
On Board Emission Control - Emission reduction hardware integrated within the equipment footprint.		
	<i>5.2.48 operator</i> — a person who interacts with the equipment only to the degree necessary for the equipment to perform its intended function. <i>5.2.49 parts-cleaning hood</i> — exhausted hood used for the purpose of cleaning parts or equipment. Synonym: equipment cleaning hood.	
PEL - Permissible Exposure Limit. The maximum permitted eight-hour time-weighted average concentration of an airborne contaminant as established by the United States OSHA regulations. The maximum permitted time-weighted average exposures to be used are those published in 29 CFR, 1910, Subpart Z.		
	<i>5.2.50 positive-opening</i> — as applied to electromechanical control devices. The achievement of contact separation as a direct result of a specified movement of the switch actuator through non-resilient members (i.e., contact separation is not dependent upon springs).	Note: This definition of positive-opening is based on International product safety standards, such as IEC 60204, EN 418 and EN 60947-5-1 (3rd part, subclause 2.2).
	<i>5.2.51 potentially hazardous non-ionizing radiation emissions</i> — for the purposes of this guideline, non-ionizing radiation emissions outside the limits shown in Appendix 5 are considered potentially hazardous.	
Pyrophoric Material - A chemical that will spontaneously	<i>5.2.52 pyrophoric material</i> — a chemical that will	

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ignite in the air at or below a temperature of 54.4 C (130 F).	spontaneously ignite in air at or below a temperature of 54.4C (130F).	
RF - Radio frequency (rf). Electromagnetic energy with frequencies ranging from 3 kHz to 300 GHz. Microwaves are a portion of rf extending from 300 MHz to 300 GHz.	5.2.53 <i>radio frequency (rf)</i> — electromagnetic energy with frequencies ranging from 3 kHz to 300 GHz. Microwaves are a portion of rf extending from 300 MHz to 300 GHz.	
	5.2.54 <i>readily accessible</i> — capable of being reached quickly for operation or inspection, without requiring climbing over or removing obstacles, or using portable ladders, chairs, etc.	Note: The definition of readily accessible is based on NFPA 70 (National Electrical Code) and NFPA 79.
	5.2.55 <i>recognized</i> — as applied to standards; agreed to, accepted, and practiced by a substantial international consensus.	Note: Introduced the term ‘recognized’ to help filter the types of standards applied in S2 evaluations. For example, standards that are very local in their development and application are not encouraged to be referenced.
	5.2.56 <i>rem</i> — unit of dose equivalent. Most instruments used to measure ionizing radiation read in dose equivalent (rems or sieverts). 1 rem = 0.01 sievert. 5.2.57 <i>reproductive toxicants</i> — chemicals that are confirmed or suspected to cause statistically significant increased risk for teratogenicity, developmental effects, or adverse effects on embryo viability or on male or female reproductive function at doses that are not considered otherwise maternally or paternally toxic. 5.2.58 <i>residual</i> — as applied to risks or hazards: that which remains after engineering, administrative, and work practice controls have been implemented.	
Risk - An expression of the possibility of a mishap in terms of hazard severity and hazard probability.	5.2.59 <i>risk</i> — the expected losses from a mishap, expressed in terms of severity and likelihood.	
Safe - Free of conditions that can cause occupational illness, injury, or death to personnel or damage to or loss of equipment or property or the environment.		
	5.2.60 <i>safe shutdown condition</i> — a condition in which all hazardous energy sources are removed or suitably contained and hazardous production materials are removed or contained, unless this results in additional hazardous conditions.	Note: The definition for “safe shutdown condition” has been added partly to distinguish between the equipment condition as a result of an EMO activation vs. an interlock activation, which only requires that the equipment be placed in a ‘safe condition’.
	5.2.61 <i>safety critical part</i> — discrete device or component, such as used in a power or safety circuit, whose proper operation is necessary to the safe performance of the system or circuit.	
Secondary Containment - A safeguarding method used to prevent unplanned releases of toxic or hazardous		Note: Although Secondary Containment is no longer defined in SEMI S2-0200, it is now

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compounds into uncontrolled work areas.		discussed in Section 21.2.4.
	5.2.62 <i>service</i> — unplanned activities intended to return equipment that has failed to good working order. (See also the definition for <i>maintenance</i>.) 5.2.63 <i>severity</i> — the extent of the worst credible loss from a mishap caused by a specific hazard. 5.2.64 <i>sievert (Sv)</i> — unit of dose equivalent. Most instruments used to measure ionizing radiation read in dose equivalent (rems or sieverts). 1 Sv = 100 rems. 5.2.65 <i>standard temperature and pressure</i> — for ventilation measurements, either dry air at 21C (70F) and 760 mm (29.92 inches) Hg, or air at 50% relative humidity, 20C (68F), and 760 mm (29.92 inches) Hg. 5.2.66 <i>supervisory alarm</i> — as applied to fire detection or suppression systems; an alarm indicating a supervisory condition. 5.2.67 <i>supervisory condition</i> — as applied to fire detection or suppression systems; condition in which action or maintenance is needed to restore or continue proper function. 5.2.68 <i>supplemental exhaust</i> — local exhaust ventilation that is used intermittently for a specific task of finite duration. 5.2.69 <i>supplier</i> — 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 <i>user</i>.) 5.2.70 <i>testing</i> — the term “testing” is used to describe measurements or observations used to validate and document conformance to designated criteria.	
Threshold Limit Values - As defined by the American Conference of Governmental Industrial Hygienists (ACGIH). Ceiling (TLV-C) - The concentration that should not be exceeded during any part of the working exposure. Short Term Exposure Limit (TLV-STEL) - The		

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concentration to which workers can be exposed continuously for a short period of time without suffering from (a) irritation, (b) chronic or irreversible tissue damage, or (c) narcosis of sufficient degree to increase the likelihood of accidental injury, impair self-rescue, or materially reduce work efficiency, and provided that the daily TLV-TWA is not exceeded. Time-Weighted Average (TLV-TWA) - The time-weighted average concentration for a normal 8-hour workday and a 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect. Toxic Material - (See OSHA Regulations, 29 CFR 1910.1200.) Material that produces a lethal dose or a lethal concentration within any of the following categories: (a) A chemical or substance that has a median lethal dose (LD50) of more than 50 milligrams per kilogram but not more than 500 milligrams per kilogram of body weight when administered orally to albino rats weighing between 200 and 300 grams each. (b) A chemical or substance that has a median lethal dose (LD50) of more than 200 milligrams per kilogram but not more than 1000 milligrams per kilogram of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between two and three kilograms each. (c) A chemical or substance that has a median lethal concentration (LC50) in air of more than 200 parts per million but not more than 2000 parts per million by volume of gas or vapor, or more than two milligrams per liter but not more than 20 milligrams per liter of mist, fume, or dust when administered by continuous inhalation for one hour (or less if death occurs within one hour) to albino rats weighing between 200 and 300 grams each.		
	5.2.71 <i>trouble alarm</i> — as applied to fire detection or suppression systems; an alarm indicating a trouble condition. 5.2.72 <i>trouble condition</i> — as applied to fire detection or suppression systems; a condition in which there is a fault in a system, subsystem, or component that may interfere with proper function.	

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	5.2.73 <i>user</i> — party that acquires equipment for the purpose of using it to manufacture semiconductors. (See also the definition for <i>supplier</i>.) 5.2.74 <i>velocity pressure (VP)</i> — the pressure required to accelerate air from zero velocity to some velocity V. Velocity pressure is proportional to the kinetic energy of the air stream. Associated equation: $VP = (V/4.043)^2$, where V = air velocity in m/s, and VP = velocity pressure in mm water gauge (w.g.). [U.S. units: $VP = (V/4005)^2$, where V = velocity in feet per second, and VP = velocity pressure in inches water gauge (w.g.)] 5.2.75 <i>volumetric flow rate (Q)</i> — in the context of Section 22 and Appendix 2 of this guideline, Q = the volume of air exhausted per unit time. Associated equation: $Q = VA$, where V = air flow velocity, and A = the cross-sectional area of the duct or opening through which the air is flowing at standard conditions. 5.2.76 <i>wet station</i> — open surface tanks, enclosed in a housing, containing chemical materials used in the manufacturing of semiconductor materials. Synonyms: wet sink, wet bench, wet deck.	
Appendix 2 – Referenced Documents	4. Referenced Standards	Note: Appendix 2 has been renamed and moved to Section 4 of SEMI S2-0200.
29 CFR 1910 - Code of Federal Regulations, Title 29, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.		Note: The format and list of referenced standards have changed significantly. Some of the reference documents were removed while others were rearranged in order. As such, it is not always possible to align the referenced documents of the two versions.
ACGIH - American Conference of Governmental Industrial Hygienists, 6500 Glenway, Building D-7, Cincinnati, OH 45211-4438, (513) 661-7881. ACGIH, Threshold Limit Values and Biological Exposure Indices; ISBN: 0-936712-78-3. Industrial Ventilation - A Manual for Recommended Practice, 20th ed. ISBN: 0-936712-65-1		Note: ACGIH is now listed in Section 4.7 of SEMI S2-0200, “Other Standards and Documents”.
	4.1 <i>SEMI Standards</i> SEMI E6 — Facilities Interface Specifications Guideline and Format SEMI F5 — Guide for Gaseous Effluent Handling	

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	SEMI F14 — Guide for the Design of Gas Source Equipment Enclosures SEMI F15 — Test Method for Enclosures Using Sulfur Hexafluoride Tracer Gas and Gas Chromatography SEMI S1 — Safety Guideline for Visual Hazard Alerts SEMI S3 — Safety Guideline for Heated Chemical Baths SEMI S6 — Safety Guideline for Ventilation SEMI S7 — Safety Guidelines for Environmental, Safety, and Health (ESH) Evaluation of Semiconductor Manufacturing Equipment SEMI S8 — Safety Guidelines for Ergonomics Engineering of Semiconductor Manufacturing Equipment SEMI S9 — Electrical Test Methods for Semiconductor Manufacturing Equipment SEMI S10 — Safety Guideline for Risk Assessment SEMI S12 — Guidelines for Equipment Decontamination SEMI S13 — Safety Guidelines for Operation and Maintenance Manuals Used with Semiconductor Manufacturing Equipment	
ANSI - American National Standards Institute. Method of Testing Performance of Laboratory Fume Hoods.	4.2 <i>ANSI Standards</i> American National Standards Institute, 11 West 42nd Street, New York, New York 10036, USA, www.ansi.org ANSI/IEEE C95.1 — Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz ANSI/RIA R15.06 — Industrial Robots and Robot Systems -- Safety Requirements	
ASA - Acoustic Society of America. ASA 47-83, sound; ASA 53-84, sound; ASA 84-89, sound; ASA 4-1975, sound.		
ASHRAE - American Society of Heating, Refrigeration, and Air Conditioning Engineers, 1791 Tullie Circle		Note: ASHRAE is now listed in Section 4.7 of SEMI S2-0200, “Other Standards and

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Northeast, Atlanta, GA 30329. Ventilation methods. 41.2-87, Air Flow measurement; 41.3-89, Pressure measurement; 41.1-86, Standard temperature measurement; Handbook of Fundamentals, 1989 ed. ASME - American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, NY 10017. ASTM - American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.		Documents”.
	<i>4.3 CEN/CENELEC Standards</i> European Committee for Standardization (CEN)/European Committee for Electrotechnical Standardization (CENELEC), Central Secretariat: rue de Stassart 35, B-1050 Brussels, Belgium EN 775 — Manipulating industrial robots--Safety EN 1050 — Safety of Machinery--Risk Assessment EN 1127-1 — Explosive atmospheres -- Explosion prevention and protection -- Part 1: Basic concepts and methodology	
Eastman Kodak Company - Ergonomic Design for People at Work, Vols. 1 and 2, Van Nostrand-Reinhold, 1983. FDA-CDRH - Food and Drug Administration, U.S. Department of Health and Human Services. Laser and Microwave, FDA-CDRH (21 CFR 1000-1050), Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, (202) 783-3238 or (202) 275-3030. FM - Factory Mutual Engineering and Research, 1151 Boston-Providence Turnpike, Norwood, MA 02062.		
IEC - International Electrotechnical Commission, 1 rue de Varembe, Geneva, Switzerland	<i>4.4 IEC Standards</i> International Electrotechnical Commission, 1 rue de Varembe, Geneva, Switzerland, www.iec.ch IEC 61010-1 — Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Equipment, Part 1: General Requirements	
ISO - International Organization for Standardization, C.P.56, CH-1211 Geneva 20, Switzerland	<i>4.5 ISO Standards</i> International Organization for Standardization, C.P.56, CH-1211 Geneva 20, Switzerland, www.iso.ch	



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	ISO 10218 — Manipulating industrial robots--Safety	
MIL STD - Human Engineering Design Criteria for Military Systems, Equipment, and Facilities, MIL-STD-1472D.		
NEC - National Electrical Code ANSI/NFPA 70, An American National Standard, National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269-9101, (800) 344-3555.		
NEMA - National Electrical Manufacturers Association, 2101 L Street, N.W., #300, Washington, D.C. 20037.		
NFPA - National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269-9101, (800) 344-3555.	4.6 NFPA National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, Massachusetts, 02269-9101, USA, www.nfpa.org <i>Standards</i> NFPA 12 — Standard on Carbon Dioxide Extinguishing Systems NFPA 13 — Standard for Installation of Sprinkler Systems	
NFPA 70 - National Electrical Code, An American National Standard, National Fire Protection Association.		
	NFPA 72 — National Fire Alarm Code	
NFPA 79 - Electrical Standard for Industrial Machinery, 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	
NFPA 704 - Standard System for the Identification of Fire Hazards of Materials, An American National Standard, National Fire Protection Association.	NFPA 704 — Identification of the Fire Hazards of Materials	
	NFPA 2001 — Standard on Clean Agent Fire Extinguishing Systems	
NIOSH - National Institute for Occupational Safety and Health, 4676 Columbia Parkway, Cincinnati, OH 45226-1998, 1-800-35-NIOSH (1-800-356-4674) or 404-639-2519.		
OSHA - Occupational Safety & Health Administration. U.S. Department of Labor, Occupational, Safety, and Health Act Regulations, (29 CFR 1910), Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, (202) 783-3238 or (202)		

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275-3030. Salvendy, Gavriel (ed.): Handbook of Human Factors, Wiley, 1987.		
SEMI - Semiconductor Equipment and Materials International, 805 East Middlefield Road, Mountain View, CA 94043-4080.		
	<i>4.7 Other Standards and Documents</i> ACGIH, <i>Industrial Ventilation Manual</i> ACGIH, 1330 Kemper Meadow Road, Cincinnati, Ohio 45240, USA, www.acgih.org ASHRAE Standard 110 — Method of Testing Performance of Laboratory Fume Hoods ASHRAE, 1791 Tullie Circle, NE, Atlanta, Georgia 30329, USA, www.ashrae.org Burton, D.J., <i>Semiconductor Exhaust Ventilation Guidebook</i> IVE, Inc., 2974 South Oakwood, Bountiful, Utah 84010, USA, www.eburton.com	
UBC - Uniform Building Code, ISSN 0896-9655, International Conference of Building Officials and Western Fire Chiefs Association, 5360 South Workman Mill Road, Whittier, CA 90601.	Uniform Building Code™ (UBC) International Conference of Building Officials, 5360 Workman Mill Road, Whittier, California 90601-2298, USA, www.icbo.org	
UFC - Uniform Fire Code. 1988 Edition, ISSN 0896-9736, International Conference of Building Officials and Western Fire Chiefs Association, 5360 South Workman Mill Road, Whittier, CA 90601.	Uniform Fire Code™ International Fire Code Institute, 5360 Workman Mill Road, Whittier, California 90601-2298, USA, www.ifci.org	
UL - Underwriters Laboratories Inc., 33 Pfingsten Road, North Brook, IL 60062.		
Woodson, Wesley, et al - Human Factors Design Handbook, McGraw-Hill, 1992.		
	NOTE 1: As listed or revised, all documents cited shall be the latest publications of adopted standards.	
	28. Related Documents	Note: Section 28 has been added to SEMI S2-0200.
	28.1 The following documents are sources of principles and practices of ventilation design. ACGIH, Hazard Assessment and Control Technology in Semiconductor Manufacturing, 1989, distributed by Lewis Publishers, Chelsea, Michigan. ANSI/AIHA, Standard Z9.5-1992 Laboratory Ventilation Burgess, Ellenbecker, Treitman, Ventilation for Control of the	



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	Work Environment, John Wiley, NY, 1989 Burton, D.J., IVE, Inc., Industrial Ventilation Workbook, 3rd Edition, 1995, Lab Ventilation Workbook, 1994; 2974 South Oakwood, Bountiful, Utah 84010 NFPA 45, Fire Protection for Laboratories Using Chemicals, National Fire Protection Association, 1 Batterymarch Park, Quincy, MA, USA Williams, M. and D.G. Baldwin, Semiconductor Industrial Hygiene Handbook, Noyes Publications, Park Ridge, NJ, 1995, ISBN 0-8155-1369-0	
	Appendix 1 – Enclosure Openings	Note: Appendix 1 – Enclosure Openings is newly created in SEMI S2-0200
	Refer to SEMI S2-0200 for text and drawing of Appendix 1.	Note: Appendix 1 includes a table of enclosure openings, and allows the use of the IEC accessibility (finger) probe as an alternate method of determining suitability of enclosure openings. It also includes drawings and specifications for top enclosure openings. Appendix 1 was developed to satisfy the objective of ensuring that guidelines are 'measurable'.
	Appendix 2 – Design Principles and Test Methods for Evaluating Equipment Exhaust Ventilation	Note: Appendix 2 – Design Principles and Test Methods for Evaluating Exhaust Ventilation is newly created in SEMI S2-0200
	New. Refer to SEMI S2-0200 for Appendix 2	Note: This is a newly created Appendix in SEMI S2-0200.
	Appendix 3 – Design Guidelines for Equipment Using Liquid Chemicals	Note: Appendix 3 – Design Guidelines for Equipment Using Liquid Chemicals is newly created in SEMI S2-0200
	New. Refer to SEMI S2-0200 for Appendix 3	Note: This is a newly created Appendix in SEMI S2-0200.
	Appendix 4 – Ionizing Radiation Test Validation	Note: Appendix 4 – Ionizing Radiation Test Validation is newly created in SEMI S2-0200
	New. Refer to SEMI S2-0200 for Appendix 4	Note: This is a newly created Appendix in SEMI S2-0200.
	Appendix 5 – Non-Ionizing Radiation (Other than Laser) and Fields Test Validation	Note: Appendix 5 – Non-Ionizing Radiation (Other than Laser) is newly created in SEMI S2-0200
	New. Refer to SEMI S2-0200 for Appendix 5	Note: This is a newly created Appendix in SEMI S2-0200.
	Appendix 6 – Fire Protection: Flowchart for Selecting	Note: Appendix 6 – Fire Protection: Flowchart



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	Materials of Construction	for Selecting Materials of Construction is newly created in SEMI S2-0200
	New. Refer to SEMI S2-0200 for Appendix 6	Note: This is a newly created Appendix in SEMI S2-0200.