



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.	Note: The discussion on risk analysis in Section 4.3 of SEMI S2-93 has also been significantly expanded in SEMI S2-0200 to include a hierarchy for resolving identified hazards. This 'order of precedence' is consistent with the philosophy noted in a number of IEC and ANSI standards.
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 or 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.