# AUX004-1100

# SEMI S2-0200 FIRE SAFETY EVALUATION CHECKLIST FOR SEMICONDUCTOR EQUIPMENT USING HAZARDOUS PRODUCTION MATERIALS

## 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 (EH&S) Committee on October 19, 2000. This action was also approved by the EH&S Global Coordinating Subcommittee on October 27,2000 and by the NA Regional Standards Committee by electronic ballot on November 22, 2000.

The information in this document has been furnished by the SEMI S2 Equipment Evaluation Checklist Task Force, comprised of participants from the hazardous production materials experts, safety professionals, and fire safety professionals.

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NOTE: This auxiliary information is not an official part of SEMI S2 and was derived from practical application by task force members. This auxiliary information was approved for publication by vote of the Environmental Health and Safety committee on October 19, 2000

## 1 Purpose

1.1 The purpose of this checklist is to provide a method that may be used to demonstrate compliance with the intent of the Uniform Fire Code (UFC) and the International Fire Code (IFC) by showing conformance to various sections of S2.

1.2 Many sections of S2 are relevant to specific sections of various codes and standards commonly used in USA jurisdictions. This checklist excerpts these sections of S2.

## 2 Scope

2.1 This checklist is intended to be used to document conformance (equipment approval) with the UFC and IFC for semiconductor equipment defined in both the UFC and IFC as a "workstation." This checklist is intended to be used for equipment that use Hazardous Production Materials (HPM) This checklist does not apply to tools or equipment that are listed by a nationally recognized testing laboratory (NRTL) for the use intended.

2.2 This checklist was developed jointly by members of SEMI, the Semiconductor Industry Association (SIA), and the following regulatory agencies: City of Camas, Washington; City of Gresham, Oregon; and the City of Hillsboro, Oregon.

## 3 Approval of Equipment Using Hazardous Production Materials by Regulatory Agencies

3.1 *Requirements for Approval*

3.1.1 This checklist is based on requirements from the Uniform Fire Code (UFC), 1997 Edition and the International Fire Code (IFC), 2000 Edition. Both codes have a general requirement that equipment using hazardous materials, which includes Hazardous Production Materials (HPM), must be listed or approved.

3.1.2 Some semiconductor equipment that use hazardous production materials are not listed and therefore must be approved by the authority having jurisdiction (AHJ) where the tool is to be used.

3.2 *Method for Approval*

3.2.1 This checklist may be used in conjunction with the SEMI S2-0200 Guideline or as a stand-alone checklist as a method to meet the UFC and IFC requirement for "approval" of semiconductor equipment using hazardous production materials. This checklist should be used in the following manner:

3.2.2 Fully conformant SEMI S2 tools need no further evaluation and should be approved by local AHJ's.

3.2.3 An S2 that identifies a non-conformance should have a risk determination per SEMI S10, verification that the S2 requirement is contained within the checklist and an action plan should be developed in accordance with Section 3.4 of this checklist.

3.2.4 If a tool does not have an S2 evaluation, the checklist may be used as a method of approval when permitted by the local AHJ. The evaluator should be qualified as provided for in SEMI S7, *Safety Guidelines for Environmental, Health, and Safety (EHS) Evaluation of Semiconductor Manufacturing Equipment*.

3.3 The SEMI S2 guideline uses the permissive language “should” and was duplicated in the checklist. However, where the SEMI S2 checklist is being used for approval the enforceable language “shall” applies to the correction of deficiencies that are deemed necessary by the local AHJ.

3.4 *Action Plan for Correction of Nonconformances*

3.4.1 If the S2 evaluation results in an action plan developed by the equipment manufacturer or user to correct non-conformances to SEMI S2 that have been identified and categorized in accordance with SEMI S10, any risk categorized as High or greater should be corrected prior to a permit being issued by the AHJ for use of equipment with hazardous materials. Items categorized as Medium should be evaluated on a case-by-case basis to determine if corrective action is necessary. In any cases in which corrective action is not taken, except for categories of Low or Slight, it should be clearly demonstrated, by the equipment manufacturer or the user, that non-conformance to SEMI S2 will have no impact on suitability for use and is not in conflict with the fire code.

3.5 *Review of S2 Evaluation and Action Plan by Regulatory Agency*

3.5.1 The AHJ may require additional information or technical assistance to determine compliance with the S2 Checklist.

## 4 Precedent for this Method

4.1 SEMI S2 has been used by many jurisdictions in the northwestern United States to meet the “approved” requirement of UFC 8001.4.4.

## 5 Evaluation Report Checklist

5.1 Correlating Requirements - The following checklist consists of applicable paragraphs excerpted from S2-0200, based on correlating requirements found in the UFC and IFC.

5.2 S2 Excerpts - The excerpted paragraphs from S2-0200 are reproduced in their entirety.

5.3 Checklist Information - The following page is a sample format of information that should be submited with each evaluation report.

## SEMI S2-0200 FIRE SAFETY EVALUATION CHECKLIST FOR SEMICONDUCTOR EQUIPMENT USING HAZARDOUS PRODUCTION MATERIALS

**Equipment** _____

**Model** _____ **S/N** _____

**Submitted by** _____ **Date** _____

**I. S2-0200 Fire Safety Evaluation Checklist for Semiconductor Equipment Using HPM:**

Company _____

Address _____

City _____ State ____ Zip _____

Phone _____ E-mail _____

Report No. _____

Report Date _____

Evaluator _____

[ ] Conform [ ] Not Conform

**II. SEMI S2 Evaluation Report, if performed:**

Company _____

Address _____

City _____ State ____ Zip _____

Phone _____ E-mail _____

Report No. _____

Report Date _____

Evaluator _____

[ ] Conform [ ] Not Conform

## 9. DOCUMENTS PROVIDED TO USER

| S2-0200 Section | Provision | Conformance Yes | No | N/A |
|---|---|---|---|---|
| 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. | | | |

## 10. HAZARD WARNING LABELS

| S2-0200 Section | Provision | Conformance Yes | No | N/A |
|---|---|---|---|---|
| 10.1 | Where it is impractical to eliminate hazards through 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.<br><br>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. | | | |

## 11. SAFETY INTERLOCK SYSTEMS

| S2-0200 Section | Provision | Conformance Yes | No | N/A |
|---|---|---|---|---|
| 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.<br><br>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. | | | |
| 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. | | | |
| 11.4 | Upon activation, the safety interlock should alert the operator immediately.<br><br>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.<br><br>NOTE 23: An explanation of the cause is preferred upon activation of a safety interlock. | | | |
| 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.<br><br>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.<br><br>NOTE 24: This section does not address the defeatability of safety interlocks. See Section 11.7 for additional information. | | | |
| 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 evaluation for suitability should take into consideration abnormal conditions such as overvoltage, undervoltage, power supply interruption, transient overvoltage, ramp | | | |

| S2-0200 Section | Provision | Conformance Yes | No | N/A |
|---|---|---|---|---|
| | voltage, electromagnetic susceptibility, electrostatic discharge, thermal cycling, humidity, dust, vibration, and jarring.<br><br>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.<br><br>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.<br><br>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.<br><br>NOTE 27: Solid-state devices include operational amplifiers, transistors, and integrated circuits. | | | |
| 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. | | | |
| 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. | | | |

## 12. EMERGENCY SHUTDOWN

| S2-0200 Section | Provision | Conformance Yes | No | N/A |
|---|---|---|---|---|
| 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.<br>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.<br><br>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.<br><br>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 shutdown condition effectively | | | |

| S2-0200 Section | Provision | Conformance Yes | No | N/A |
|---|---|---|---|---|
| | 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 | Activation of the emergency off circuit should de-energize all hazardous voltage and all power greater than 240 volt-amps in the equipment beyond the main power enclosure.<br><br>EXCEPTION 1: A non-hazardous voltage EMO circuit (typically 24 volts) and its supply may remain energized.<br><br>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.<br><br>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.<br><br>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:<br><br>• separate sources of power and separate supply circuit disconnect means if clearly identified, or<br>• separate EMO circuits, if they are clearly identified. | | | |
| 12.2.1 | The EMO circuit should not include features that are intended to allow it to be defeated or bypassed. | | | |
| 12.2.2 | The EMO circuit should consist of electromechanical components. | | | |
| 12.2.3 | Resetting the EMO switch should not re-energize circuits, equipment, or subassemblies. | | | |
| 12.2.4 | The EMO circuit should shut down the equipment by deenergizing rather than energizing control components. | | | |
| 12.2.5 | The EMO circuit should require manual resetting so that power cannot be restored automatically. | | | |
| 12.3 | The emergency off button should be red and mushroom shaped. A yellow background for the EMO should be provided.<br><br>NOTE 31: Non-lockable self-latching (i.e., twist- or pull-to-release) EMO buttons may be required by regulations. | | | |
| 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. | | | |
| 12.5.1 | Emergency off buttons should be located or guarded to minimize accidental activation. | | | |
| 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 machinery, surfaces or objects operating at high temperatures, or other hazardous equipment. | | | |

## 13. ELECTRICAL DESIGN

| S2-0200 Section | Provision | Conformance Yes | No | N/A |
|---|---|---|---|---|
| 13.4 | Electrical Design — Equipment should conform to the appropriate international, regional, national or industry product safety requirements. | | | |
| 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).<br><br>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. | | | |
| 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).<br><br>NOTE 36: Some facilities may require higher AIC ratings due to electrical distribution system design.<br><br>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). | | | |
| 13.5.2 | Power from the UPS should be interrupted when any of the following events occur:<br>• the emergency off actuator (button) is pushed; or<br>• the main equipment disconnect is opened; or<br>• the main circuit breaker is opened.<br><br>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. | | | |

## 14. FIRE PROTECTION

| S2-0200 Section | Provision | Conformance Yes | No | N/A |
|---|---|---|---|---|
| 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.<br><br>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. | | | |

| S2-0200 Section | Provision | Conformance Yes | No | N/A |
|---|---|---|---|---|
| 14.3 | Reporting<br>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:<br>• the assigned Severity;<br>• the assigned Likelihood; and<br>• the resulting Risk Category. | | | |
| 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.<br><br>NOTE 42: Some jurisdictions require interlocking.<br><br>NOTE 43: Refer to Section 6.5 for criteria for acceptability | | | |
| 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:<br><br>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.<br><br>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. | | | |
| 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. | | | |
| 14.4.4.6 | Activation of trouble or supervisory conditions should result in all of the following:<br>• notification of the operator;<br>• allowing the completion of processing of substrates in the equipment;<br>• prevention of processing of additional substrates until the trouble or supervisory condition is cleared; and<br>• providing, through an external interface, a signal to the facility monitoring system or a constantly attended location. | | | |

| S2-0200 Section | Provision | Conformance Yes | No | N/A |
|---|---|---|---|---|
| 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").<br><br>EXCEPTION: Operability is not required during maintenance of the fire detection system.<br><br>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.<br><br>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 of any fire-related hazard source that could create additional fire risks for the affected module or component.<br><br>NOTE 52: See Sections 14.4.3.3 and 14.4.3.4 for related provisions.<br><br>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.<br><br>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.<br><br>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.<br><br>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.<br><br>NOTE 55: Such certifications typically require that the components of fire suppression systems are readily identifiable and distinguishable from other | | | |

| S2-0200 Section | Provision | Conformance Yes | No | N/A |
|---|---|---|---|---|
| | 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 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.<br>NOTE 56: For the purpose of this section, “inoperable” includes the equipment state after the EMO is activated.<br>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 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.)<br><br>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.<br><br>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.<br><br>NOTE 59: The requirements for back-up power vary among jurisdictions. | | | |

| S2-0200 Section | Provision | Conformance Yes | No | N/A |
|---|---|---|---|---|
| 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.<br><br>NOTE 60: See Sections 14.4.3.1 and 14.4.3.2 for related provisions.<br><br>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. | | | |
| 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.<br>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:<br>• made from corrosion-resistant components,<br>• designed to minimize water accumulation around components and control other conditions that promote corrosion, and<br>• 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. | | | |
| 14.6 | 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. | | | |
| 14.6.2 | 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. | | | |

| S2-0200 Section | Provision | Conformance Yes | No | N/A |
|---|---|---|---|---|
| 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). | | | |

## 15. HEATED CHEMICAL BATHS

| S2-0200 Section | Provision | Conformance Yes | No | N/A |
|---|---|---|---|---|
| 15.1 | Refer to SEMI S3 for the minimum safety design considerations for heated chemical baths. Each heated chemical bath should have the following:<br>• grounded or GFCI-protected heater;<br>• power interrupt;<br>• manual reset;<br>• automatic temperature controller;<br>• liquid level sensor;<br>• fail-safe over-temperature protection;<br>• proper construction materials;<br>• exhaust failure interlock; and<br>• overcurrent protection.<br><br>NOTE 63: See Section 14 for fire protection risk assessment considerations for baths using combustible or flammable chemicals. | | | |

## 16. ERGONOMICS/HUMAN FACTORS

[not covered in the fire code]

## 17. HAZARDOUS ENERGY ISOLATION

| S2-0200 Section | Provision | Conformance Yes | No | N/A |
|---|---|---|---|---|
| 17.1.1 | Lockable energy isolation capabilities should be provided for tasks that may result in contact with hazardous energy sources. | | | |
| 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. | | | |
| 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. | | | |

| S2-0200 Section | Provision | Conformance Yes | No | N/A |
|---|---|---|---|---|
| | 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.<br><br>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.<br><br>NOTE 66: Energy isolation devices for incompatible hazardous energy sources (e.g., electrical and water, incompatible gases) are recommended to be separated.<br><br>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.<br><br>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.<br><br>NOTE 69: See Section 14 for information on fire protection hazardous energies. | | | |
| 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:<br>• shut down the equipment in an orderly manner;<br>• locate and operate all the equipment's energy isolating devices;<br>• affix energy isolating (“lockout/tagout”) devices;<br>• relieve any stored energies;<br>• verify that the equipment has actually been isolated and de-energized; and<br>• 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. | | | |
| 17.3.1 | Electrical Energy Isolation<br>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.<br><br>NOTE 70: For equipment with multiple incoming supply sources, it is recommended that all of the energy isolation devices be located in one area. | | | |
| 17.4.1 | Non-Electrical Energy Isolation<br>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 repair, maintenance, or service work. | | | |
| 17.4.2 | The hazardous energy isolation devices should be in a location that is readily | | | |

| S2-0200 Section | Provision | Conformance Yes | No | N/A |
|---|---|---|---|---|
| | 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

| S2-0200 Section | Provision | Conformance Yes | No | N/A |
|---|---|---|---|---|
| 18.1 | This section covers hazards due to the mechanical aspects of the equipment.<br><br>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.<br><br>NOTE 72: Pressurized vessels must meet applicable codes and regulations. | | | |

## 19. SEISMIC PROTECTION

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.

| S2-0200 Section | Provision | Conformance Yes | No | N/A |
|---|---|---|---|---|
| 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.<br><br>NOTE 75: These criteria are intended to accomplish two things: (1) allow equipment suppliers to design correctly 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. | | | |
| 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).<br><br>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.<br><br>NOTE 77: SEMI S8 contains guidelines for maintainability and serviceability; these may be used to determine accessibility. | | | |
| 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. | | | |

| S2-0200 Section | Provision | Conformance Yes | No | N/A |
|---|---|---|---|---|
| | 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. | | | |
| 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.<br><br>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.<br><br>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. | | | |
| 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.<br>• 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.<br>• The type of feet used and their location on a base frame plan drawing.<br>• The weight distribution on each foot.<br>• Physical dimensions, including width, length, and height of each structurally independent module.<br>• Weight and location of the center of mass for each structurally independent module.<br>• Acceptable locations on the equipment frame for anchorage.<br><br>NOTE 81: A “structurally independent module” reacts to seismic loads by transferring substantially all of the loads to its own anchorages, as opposed to transferring the loads to adjacent modules. | | | |
| 19.4 | The locations of the tie-ins, attachments, or seismic anchorage points should be clearly identified.<br><br>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.<br><br>NOTE 83: It is the responsibility of the user to verify that the vibration isolation, | | | |

| S2-0200 Section | Provision | Conformance Yes | No | N/A |
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| | leveling, seismic reinforcing, and load distribution is adequate. | | | |

## 20. AUTOMATED MATERIAL HANDLERS

[not covered in the fire code]

## 21. ENVIRONMENTAL CONSIDERATIONS

| S2-0200 Section | Provision | Conformance Yes | No | N/A |
|---|---|---|---|---|
| 21.2.1 | The following design guidelines apply to all phases of equipment life, from concept to decommissioning and disposal.<br><br>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. | | | |
| 21.2.4.1 | Prevention and Control of Unintended Releases<br>Equipment design, including feed, storage, and waste collection systems, should prevent potential unintended releases. | | | |
| 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.<br><br>NOTE 92: In some circumstances secondary containment may be specified by the equipment supplier, but provided by the user. | | | |
| 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. | | | |
| 21.2.4.5 | 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. | | | |
| 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. | | | |
| 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. | | | |
| 21.2.4.9 | Equipment should be able to accept a signal from a monitoring device and stop the supply of chemical, at the first non-manual valve within the affected system. | | | |
| 21.2.4.10 | Chemical distribution systems should be capable of automatic shutoff and remote shutdown. | | | |
| 21.2.5.5 | Segregation of effluents, wastes, and emissions should be provided in the following cases:<br>• where chemically incompatible;<br>• where segregation facilitates recycling or reuse; or<br>• where separate abatement or treatment methods are required.<br><br>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 | | | |

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| | ducts, and replaceable parts (e.g., batteries, vapor lamps, contaminated parts). | | | |

## 22. EXHAUST VENTILATION

| S2-0200 Section | Provision | Conformance Yes | No | N/A |
|---|---|---|---|---|
| 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).<br><br>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. | | | |
| 22.1.2.1 | When a procedure (e.g., cleaning) specified by the supplier requires exhaust ventilation, the supplier should include the minimum criteria for exhaust during the procedure. | | | |
| 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).<br><br>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) 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. | | | |
| 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 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. | | | |
| 22.3 | Documentation should be developed showing the equipment exhaust parameters and relevant test methods, and should include (see also Appendix 2):<br>• duct velocity (where needed to transport solid particles);<br>• volumetric flow rate Q;<br>• capture velocity (where airborne contaminants are generated outside an enclosure);<br>• face velocity (where applicable);<br>• hood entry loss factor $F_h$ or K;<br>• coefficient of entry $C_{e.}$;<br>• hood static pressure $SP_h$; | | | |

| S2-0200 Section | Provision | Conformance Yes | No | N/A |
|---|---|---|---|---|
| | • duct diameter at the point of connection to facilities; and<br>• location(s) on the duct or hood where all ventilation measurements were taken. | | | |
| 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.<br><br>NOTE 99: Sail switches (switches that are connected to a lever that relies upon air velocity to activate) are generally not recommended.<br><br>NOTE 100: It is recommended that the pressure or flow measuring point be located upstream of the first damper.<br><br>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.<br><br>NOTE 102: It is recommended that non-HPM chemical process exhaust be equipped with audible and visible indicators only. | | | |
| 22.4.2 | Exhaust flow interlocks and alarms should require manual resetting. | | | |
| 22.4.3 | Exhaust flow interlocks should be fault-tolerant. | | | |
| 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).<br><br>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") $H_2O$ (see also Section A2-1 of Appendix 2, and Section 8.3.6.1 of SEMI S6-93). | | | |

## 23. CHEMICALS

| S2-0200 Section | Provision | Conformance Yes | No | N/A |
|---|---|---|---|---|
| 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. | | | |
| 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. | | | |
| 23.2.1 | The hazard analysis, at a minimum, should address the following conditions:<br>• potential mixing of incompatible chemicals;<br>• potential chemical emissions during routine operation; | | | |

| S2-0200 Section | Provision | Conformance Yes | No | N/A |
|---|---|---|---|---|
| | • potential chemical emissions during maintenance activities; and<br>• potential key failure points and trouble spots (e.g., 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. | | | |
| 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. | | | |
| 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. | | | |
| 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.<br><br>NOTE 104: The use of direct reading instrumentation under simulated operating, maintenance, or failure conditions is the 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.<br><br>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.<br><br>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). | | | |
| 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. | | | |
| 23.6 | Equipment that uses hazardous gases may require continuous detection and, if so, | | | |

| S2-0200 Section | Provision | Conformance Yes | No | N/A |
|---|---|---|---|---|
| | 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. | | | |
| 23.7 | Appropriate hazard warning labels should be placed at all chemical enclosure access openings. | | | |

## 24. IONIZING RADIATION

[not covered in the fire code]

## 25. NON-IONIZING RADIATION

[not covered in the fire code]

## 26. LASERS

[not covered in the fire code]

## 27. SOUND PRESSURE LEVEL

[not covered in the fire code]